AFTER THE COMPLETION OF THE FIVE-YEAR STATE PROGRAM FOR RADIATION SANITATION OF THE URAL REGION: RESULTS AND PROBLEMS

V.N. Chukanov and B.A. Korobitsin

Institute of Industrial Ecology, Ural Branch of Russian Academy of Sciences, Sophya Kovalevskaya Str., 20-a, GSP-594, Ekaterinburg, 620219, Russia

In 1989, the Soviet government began disclosing information about the Mayak facility (the Soviet Union's first plutonium production complex). It became known that routine activities of the Mayak facility for over 40 years as well as the radiation accidents that occurred have led to an unprecedented radioactive contamination level in a considerable part of the Ural region. In 1991, the State program focusing on radiation sanitation of the contaminated territories of the Ural and on medical rehabilitation of the radiation-affected population up to the year 1995 was developed.

Leading regional organizations participated in realization of the State programme:

- Mayak facility (Radioactivity monitoring in the environment and radiation sanitation of the territories of Mayak facility site including Lake Karachay and Techa reservoirs, radiation wastes management);
- Radioecological Research Station of the Mayak facility (Radioactivity monitoring in the environment and radioecological studies; agroindustrial production at the radioactively contaminated territories);
- Branch № 1 of the Biophysics Institute (Dose reconstruction for the stuff of Mayak facility; assessment of health effects of radiation exposure);
- Ural Centre for Radiation Medicine (Dose reconstruction for the inhabitants of the contaminated territory; assessment of health effects of radiation exposure);
- Institute of Industrial Ecology (Analysis of all scientific results of all organizations which participate in the realization of the State program; radioecological studies; assessment of health effects of radiation exposure).

The prime objects of the State programme were defined as follows:

1. Environmental remediation, social and economic rehabilitation of the radioactively contaminated territories and medical rehabilitation of the exposed population;
2. Reduction of the risk of new radiation accidents due to accumulation of the huge amount of radioactive waste within the boundaries of the Mayak facility.

The part of the State programme dealing with problems of the territory outside the boundaries of the Mayak facility, was aimed on rehabilitation of the territory and population suffered from two radiation accidents:

1. Dumping of radiochemical waste with an activity of 2.8 million curies into the Techa River in 1949-1952 resulted in the radioactive contamination of the Techa-Iset-Tobol river system in Chelyabinsk and Kurgan Oblasts. Some 28 thousand people received substantial external and internal radiation dose. The greatest effective dose, estimated to be up to 2.0 Sv, was received by the critical age cohort of inhabitants of the village of Metlino. More than 900 cases of chronic radiation disease were observed among the population. Approximately 5500 inhabitants of 22 riverian localities were resettled. So far, the regime of normal vital activities along the river has not been restored, with 8000 ha of farming land abandoned to date.
2. In the September of 1957 a storage tank for liquid high activity waste at the Mayak site exploded. Radionuclides with an activity of two million curies were discharged outside the territory of the Mayak facility, thereby giving rise to the East-Ural Radioactive Trace (EURT). The northern part of the Chelyabinsk Oblast and the southern part of the Sverdlovsk Oblast suffered a radioactive con-

tamination. For an activity of up to 2.0 Ci $^{90}Sr/km^2$ the length of the trace was about 150 km and the width was 10-15 km. The average effective dose received by inhabitants of the three most contaminated villages reached 0.6 Sv. Twenty-three rural localities within the radioactive contamination zone were abandoned and 10,400 dwellers were resettled.

The State programme was started more than 30 years after these radiation accidents. But it turned out that in spite of such long period, there were no reliable data on the radioactive contamination of the territory and health consequences of the radioactive exposure that could be used as a basis for the realization of practical rehabilitation measures. The existing information was isolated, incomplete and contradictory. So the main efforts were aimed on the following investigations which had not been considered as of the highest priority when the State programme had been designed:

1. Determination of contemporary and reconstruction of initial levels of the radioactive contamination, assessment of trends of the radiation situation;
2. Reconstruction of the accumulated doses received by people living on the contaminated territory, estimation of contemporary annual doses;
3. Research on health effects of chronic exposure of population and risk assessment.

In the results of field investigations performed in 1992-1995 by combined efforts of a number of organizations, a detailed impartial information about contemporary radioactive contamination of the territory neighbouring the Mayak facility was received for the first time. At present the first official maps on ^{137}Cs and ^{90}Sr contamination of the Ural based of these data are near completion. It was found out that the initial and contemporary levels of radioactive contamination of the Ural are higher than was considered when the State programme was developed. In 1957 initial ^{90}Sr contamination of the west part of the town Kamensk-Uralsky (with the population about 160,000 people) exceeded 4 Ci/km^2, not 0.2 Ci/km^2 as was reported before. Up to now the contamination of the Techa River is extremely high. Within the village of Muslumovo (78 km downstream from the discharge point) the ^{137}Cs contamination of floodlands is 10^2-10^3 Ci/km^2, ^{90}Sr contamination is 10^1-10^2 Ci/km^2, plutonium contamination is 0.1-1.0 Ci/km^2. The radiation situation at the EURT is quite stable, the only factor conducive to changing the radioactive contamination of the territory is the physical decay of ^{90}Sr. In the Techa River basin the situation is more complicated. The radioactively contaminated bottom sediments are moved downstream. Radioactive waters from the Mayak facility continue to enter the river.

Dose reconstruction studies were carried out in two directions. First, an official guide for calculation of accumulated and current doses for residents of the Techa riverside and the EURT territory was prepared. So calculated doses are the official background for administrative decisions on social protection of the victims of the radioactive accidents. Such official dose calculations are fulfilled for 15 riverian Techa villages, which exist at present. It terns out that in all these villages there are age cohorts with the accumulated doses exceeding 70 mSv. Accumulated doses for people who were born in 1935-1937 and have been living since that time in the village of Muslumovo are more then 350 mSv. At present, current annual dose rates for all population cohorts in all riverian Techa villages are less then 0.1 mSv. For the settlements at the territory of the EURT the official dose reconstruction will be fulfilled after the official map on ^{90}Sr contamination of the Ural will be issued.

Secondly, individual doses were reconstructed for estimation of excess cancer risk and other health consequences of radiation exposure. By this time individual measurements of ^{90}Sr in the skeleton were carried out on more than 12,000 people who lived on the Techa River banks during the period of the massive release. Individual doses resulting from ^{90}Sr internal exposure were reconstructed for 7620 residents of the Techa riverside. Individual doses due to external exposure and internal exposure from incorporated plutonium were also reconstructed for more than 4,000 workers of the Mayak facility. However, there are no reliable data about individual doses resulting from external exposure for the Techa residents. Reconstruction of individual doses resulting from 1957 accident and from routine emission of radionuclides in the atmosphere at the beginning of the Mayak activity also seems to be unsolvable problem.

The combination of a dose reconstruction studies and epidemiological analysis of cancer morbidity and mortality of workers at the Mayak facility and exposed population have been used to estimate risk of long-term consequences of chronic radiation exposure. These studies are based on the following registers:

1. Register of the Mayak facility's workers (more than 6,000 persons, about 150,000 person-years of observation);
2. Register of the exposed population (more than 90,000 persons, including exposed at the Techa River, at the EURT territory in Chelyabinsk Oblast, their children and grandchildren);
3. Register of persons who participated in liquidation of the Mayak accident in 1957 (40,000 persons, collective dose about 13,200 Sv).

The excess relative risk factors of external chronic gamma-exposure for hemoblastosis, breast cancer and the sum of malignant tumours, as well as the risk factor of internal exposure from incorporated plutonium for lung cancer were founded for the Mayak workers. For the inhabitants of the Techa River and the EURT settlements the excess relative risk factor for leukaemia was founded. These risk factors are used for estimation of additional cancer cases in the cohorts of exposed workers and population.

On the base of highly sensitive biochemical diagnostic tests for premorbidity identification of the malignancy increase, groups of high cancer risk were selected from exposed workers and population for permanent observation, deep examination and early treatment.

The main points, characterizing the results of the realization of the part of the State programme dealing with problems of the territory outside the boundaries of the Mayak facility are:

1. The results of investigations carried out in 1992-1995 are of the great scientific importance and provides essential information foundation for decision making on environmental remediation, social and economic rehabilitation of the radioactively contaminated territories, medical rehabilitation and social protection of the exposed population;
2. Because of the State programme was realized during the period of severe troubles in Russian economy, funding was extremely scarce. That is why the most part of the planned practical measures has not been realized. The State programme failed in the social and economic development of the contaminated territories up to the average level of Russia.
3. The most severe problem is the contamination of the Techa river system within riverian settlements. The river and its floodlands (8,000 hectares) are excluded from use by people. For the environmental restoration of the Techa river system it is necessary first to solve a problem of the cascade of artificial reservoirs in the upper reaches of the river (about 1000 Ci of radionuclides leek annually from these reservoirs into the Techa River) and to improve radically the low-level waste management practice at the Mayak facility.

As for reduction of the risk of new radiation accidents due to accumulation of the huge amount of radioactive waste within the boundaries of the Mayak facility, the following problems were considered as of the highest priority when the State programme had been designed:

1. Some 120 million Ci of long-lived radionuclides is accumulated in drainless Lake Karachay. Radioactivity from the lake enter the ground water, radioactive underground flow reach the Mishelyak River. Dispersion of radioactivity from the shores of the lake is the cause of contamination of the neighbouring territories.
2. A cascade of four artificial reservoirs was created along the Techa to isolate the most contaminated part of the river from the open hydrographic network. 400 million m3 of radioactive water with the activity of 200,000 Ci are accumulated in the cascade. Because of filtration through the dam this water enter the Techa River. The Mayak facility used contaminated water to cool reactors, thus increasing evaporation. After the shut down of five reactors a new danger was identified – overfilling the reservoirs with natural water and even failure of the dams, sending contaminated waters into the rivers of the Ob basin.

3. About 550 million Ci of liquid high-level radioactive solutions and 150 million Ci of high-level radioactive waste sediments are stored in waste tanks.
4. In 1992-1995 the following was done:
5. Two-thirds of Lake Karachay was filled by concrete blocks and covered over.
6. The dam of the last reservoir of the Techa cascade was increased 1 m up; To catch the underground flow of natural water into the cascade and prevent its overfilling a number of wells were set in exploitation.
7. A technology for reprocessing and vitrification of old high-level radioactive waste solutions and sediments from storage tanks was designed and prepared for industrial exploitation.
8. About 60 million Ci of old radioactive wastes were vitrificated.

But in spite of these results the problem of the risk reduction as a whole is not solved. The reason is not only the lack of funding but also the extremely difficulty of the situation. The most serious unsolved problems are:

1. One-third part of Lake Karachay is not filled. Efforts to eliminate the lake are paused now.
2. The construction of the plant for reprocessing and vitrification medium-level liquid radioactive waste is not finished. Today medium-level waste is still being added to Lake Karachay. It dos not enable to finish the elimination of the lake.
3. Underground radioactive water continues to migrate from the lake. Radioactive underground flow reaches the Mishelyak River and radionuclides enter the river contaminating it. Radioactive flow also reaches the drinking wells of the settlement Novogornyi which force to shut down their exploitation. The are no realistic projects on localization of contaminated halo.
4. In spite all efforts to stabilize the level of the Techa cascade reservoirs, water continue to rise. Also increases the filtration of radioactive water through the dam into the Techa River.
5. The most part of old high-level radioactive waste solutions and sediments from storage tanks is not vitrificated.

That is why new Federal program up to the year 2000 was developed and adopted by the Russian Government in 1996.s