Kyshtym

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Abstract

The first nuclear reactor of the Sowjet Union (SU) started operations in 1948 In the Mayak/Kyshtym complex at the Eastern side of the Ural mountain range. It was used for the production of plutonium that was destined to fuel the first Soviet plutonium-based atomic bomb. In 1949, the first batch of plutonium from Mayak was presented to Stalin and shortly thereafter the first Soviet nuclear bomb was detonated. Not even ten years later, a serious accident happened and the number of deaths from it remains unknown.

The «Kyshtym catastrophe» of 1957 is frequently considered as one in a series of civil nuclear accidents. However, this is not quite correct, as contrary to other nuclear accidents, such as those of Three Mile Island or Fukushima, neither the complexity of the technology nor an external factor triggered the catastrophe. Rather the fatal explosion in one of the plutonium tanks was caused by ignorance associated with deepest human disrespect. Technical safety, protection of human life and of the environment had been unconditionally sacrificed in the SU by the race to nuclear rearmament.

In principle, this practice did not differ from the one of other nations developing nuclear weapons; however, its dimension was way more drastic. Until today, Russia refuses to recognize survivors and their families as victims and to honour their claims.

The lack of complete workup of such events can lead to the reintroduction of human-despising methods in the hands of authoritarian regimes. The critique of both, the civil and military use of nuclear energy, therefore remains an important and urgent task.

Short historical breakdown of the accident

The origins of the Kyshtym accident, its clearing-up and consequences are incompletely known and rely almost exclusively on Russian data. The information made available by the International Atomic Energy Agency (IAEA) in 1989 does not allow a detailed analysis. It must be assumed that much information has been withheld or destroyed over time. For instance, photographs are not publicly available.

The facilities of Kyshtym were part of the Combine Mayak. Referring to the nearest city, the term Kyshtym is mainly used in the context of the accident. Information about the facility was kept strictly confidential. The city of Osjorsk built around the facility, for example, was not shown on geographic maps until the 1990s. It still has the status of a closed city with restricted access rights.

The first military nuclear reactor in the SU opened In Mayak with the aim to produce plutonium for atomic bombs. In parallel, a radiochemical plutonium separation plant was put into operation, which separated the material produced for atomic bombs from the fuel rods used in the reactor.

As early as in 1952, the US-American army was aware of the location and character of the facility (Figure 1).

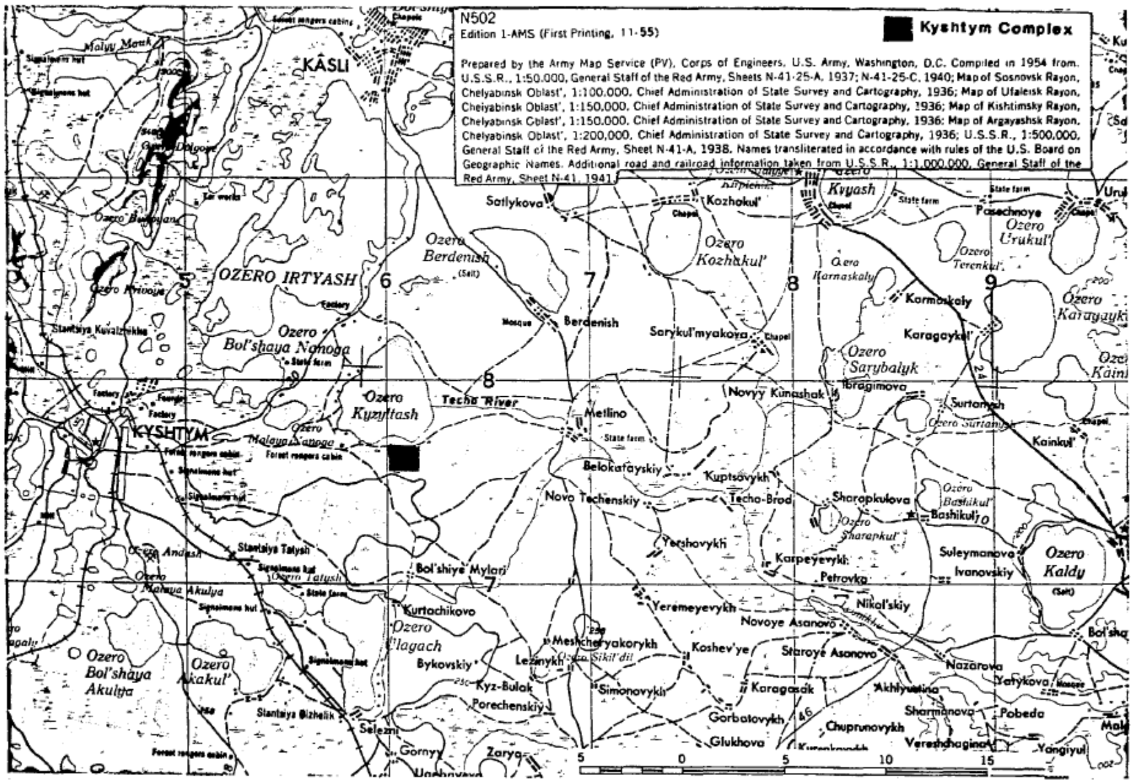

Figure 1: Copy of a US Army Map map printed in November 1955.
The data used to compile it were Soviet data from 1936-41.
Source: Diane M. Soran and Danny B. Stillman: An analysis of the alleged Kyshtym disaster.
Los Alamos National Laboratory, Jan. 1982, page 9.

Regarding technology and design, the facility in Mayak resembled the nuclear weapons forge in Hanford, WA, USA. From today's point of view, a particularly striking technical feature was the open cooling circuit that used natural waters as coolant; In the USSR, it was lake Kyzyltash near Mayak; in the USA, it was the Columbia River. In a similar manner, the unfiltered and radioactively contaminated outflow of the plutonium separation plant was released into the environment using the principle of dilution with water: In the USSR, the river Techa was used, in the USA, again the Columbia River. The big difference was that the Columbia River, which, compared to the Techa, carried a thousand times more water and the dilution was correspondingly higher. The air was contaminated by volatile radioactive waste and chemicals, such as nitric oxides and various acids, known to affect the vegetation in the vicinity as acid rain.
The workers of Mayak operated under the most difficult circumstances, often exposed to radiation, and without dosimeters. The technical facilities were built in a fast-paced manner and without the necessary care; the protection of humans and the environment was not a criterion in the Stalinist state (Figure 2). There was no environmental monitoring or an emergency protection concept. On the contrary: employees, residents and later soldiers were a kind of guinea pig (as in the USA and the other emerging nuclear power states) and later served research purposes. In short, everything was subjected to the premises of the military atomic program. The motto was to produce as much plutonium as possible in the shortest time possible. In addition to the workers, other victims were the nearby inhabitants, of which Bashkirs and Tatars were the largest groups. They lived from agriculture.

Figure 2: Test of an atomic bomb. Some 6'000 soldiers were exposed to its radiation; according to military information "only to low levels". Source: Markow, Sergey: Totskoye exercise in 1954 and safety measures, (In the picture probably a test of an American nuclear bomb accompanied by unprotected soldiers. In the SU the first tests took place near Orenburg.)
http://actualhistory.ru/tozk_nuclear

The Kyshtym accident
In the evening of September 29, 1957, the nuclear catastrophe known as the "Kyshtym accident" occurred in a plutonium separation plant (1). Overheating of a wastewater tank containing highly radioactive waste led to the formation of dry nitrate and acetate salts, causing an explosion. The cooling system failed due to technical errors during the monitoring and a subsequent failure of the heat dissipation system. From a technical point of view, these faults were easily avoidable. In a similar way, the open cooling circuit and the unfiltered emission of radioactivity, points to the subordinate importance taken regarding the safety of the installation.
This explosion led to the emission of radioactive material. The resulting aerosol flag reached an altitude of about 1000 m and resulted in a widespread contamination of the surrounding area. About 90% of the 740 petaBq of cleavage products were deposited within 5 km of the site. The remaining 74 petaBq were transported as dry fallout over an area of about 30-50 km wide and partly over 300 km long in north-north-eastern direction from Kyshtym (2; Figure 3).
The major portion of the fallout contained nuclides with relatively short half-lives, such as caesium-144, zirconium-95 and niobium-95. Reasons for the evacuation and the later destruction of the villages and of agricultural products were, however, due to the impact of strontium-90 and, to a lesser extent, of cesium-137, both of which have longer half-lives of about 30 years.

This is today's reading according to Russian data. The figures on the suspected release

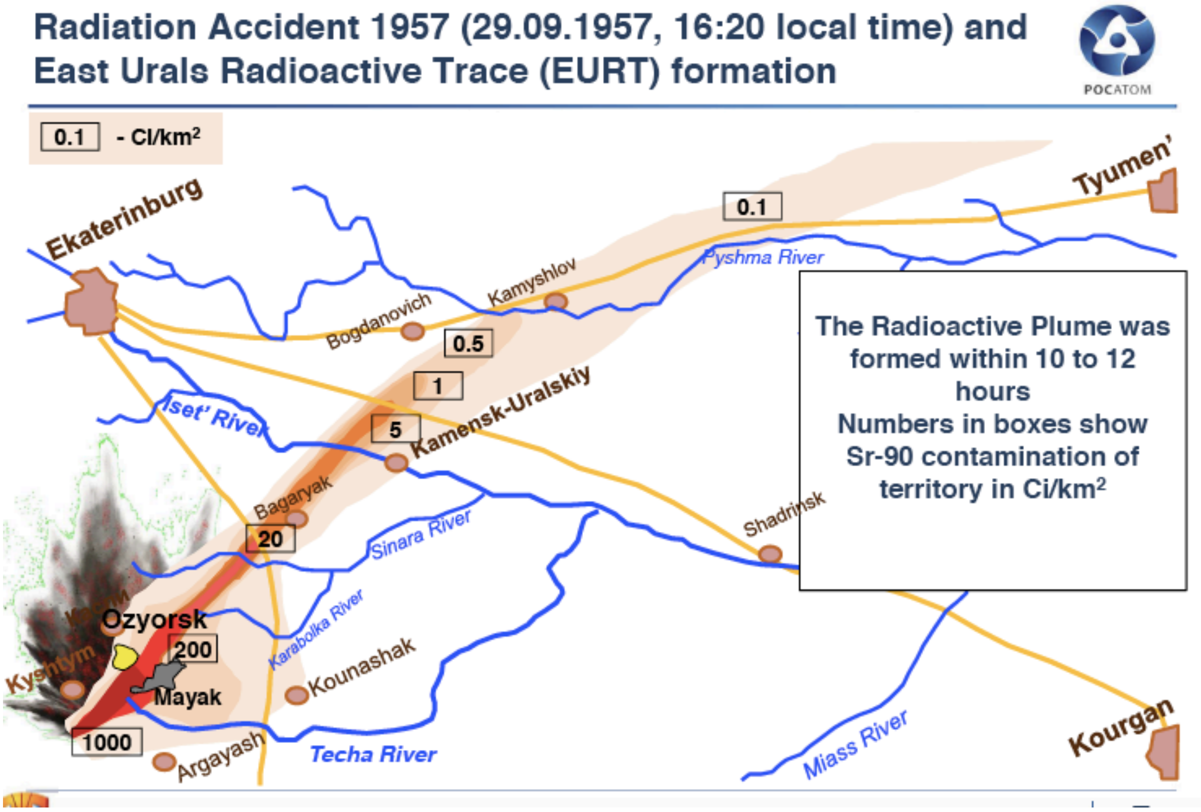

Figure 3: The Kyshtym accident.

Source: Experience in eliminating the consequences of the 1957 accident at the Mayak Production Association. G.S. Batorshin, Y.G. Mokrov, Mayak PA, Russia, Overhead Nr. 7 International experts meeting on decommissioning and remediation after a nuclear accident. IAEA, Vienna, 28.01. - 01.02.2013

of nuclear fission products, however, vary greatly depending on the source. In the case of the 20 million curie, which the Russian authorities indicate as released radioactivity, should be taken as a cautious estimate. The credibility of the information derived from military circles was questioned early on (3), but still serves as a starting point for many studies. It is certain that the contaminated area covered at least 20’000 km^2 and was inhabited by over a quarter of a million people (4).

Measures taken

Production at the plant in Mayak (Figure 4), which had been affected by the accident but remained intact, was not interrupted. The evacuation of the workers into safer, less contaminated buildings went on slowly and the affected villages were evacuated weeks or months later. Firstly, the undamaged tanks were secured, liquidators decontaminated parts of the plant and barrier zones were built on the premises. According to official data, there were no fatalities. Regarding restoration work, strict adherence to the then valid limits (150 mSv maximum exposure) was observed. However, the Mayak operators concede that in individual cases, exposures of 600 to 1200 mSv have occurred (4). Other testimonies state that at that time there was neither environmental monitoring nor dosimetry or protective measures. Mayak workers were exposed to daily doses of 30 - 120 mSv on certain days during the first years of production. Inhabitants of the Techa River valley, who used the river water for drinking, accumulated annual doses of 0.5 - 1 Gray - 500-1000 Sv - corresponding to the maximum levels for workers described in the previous section (5).
Even the most affected places were evacuated only weeks after the accident and the radioactive precipitate that followed. There was no monitoring; radioactivity levels were

estimated using the results of field measurements.

Figure 4: Air view of Mayak. Source: www.kommersant.ru/gallery/2441317#id=1006293

The intensity of the radioactive precipitate was assessed by field measurements. After the evacuation, villages, agricultural facilities and products were destroyed. This work had to be carried out by residents from neighbouring villages. An eyewitness report describes how entire school classes from the non-evacuated Tatarskaia Karabolka had to carry out the clean-up work in the evacuated village Russkaia Karabolka. The children worked in the fields without protective suits and dust masks (6). Because officially, no nuclear accident took place, protective measures would have been traitorous. The secrecy also ensured that the persons concerned never knew about the dangers associated with their work let alone of the accumulated individual doses.

The secrecy

The Kyshtym accident remained top-secret for more than 30 years. How could such an event be hidden from the public over decades? The concealment was favoured by the strictly secret development of the military nuclear program in an inaccessible production facility at an isolated location.

The causalities of the catastrophe were concealed, sick persons were isolated and the population was left in uncertainty. This was still possible in the post-Stalinist period despite the political thaw. In addition, the interest of the Western nuclear powers to educate their citizens about possible risks of nuclear armament was probably rather low.

How did the world know about the catastrophe? On April 14, 1958, the New York Times reported about a serious accident referring to Danish sources (7) without describing the place or the type of accident.

In 1960, the scientist Lev Tumerman told the Times and the Jerusalem Post about his trip to Chelyabinsk: "About 100 kilometres from Sverdlovsk, a highway sign; no villages, no towns, no herds, no people ... nothing." The population informed him about an explosion. Nobody could tell him about its nature and its location. It was not until 1976 that Zhores Medvedev, an exiled Russian scientist, described the explosion as the nuclear catastrophe of Kysthym, which led to hundreds of deaths and contaminated large stretches of land. The official side did not confirm his portrayals and some of them were also questioned.

In 1979, at an international conference on the topic of decontamination (8), evidence of exiles was documented for the first time, describing how auxiliaries were built on stilts at a distance from the contaminated soil around Kyshtym. In vernacular language, they were called "tombs of the earth". It is also known that intensive research on decontamination was carried out in Russia. At the conference mentioned, it was assumed that an accident in 1957/58 must have been the cause of this intensive research. It was regretted that the SU was not ready to share results with the international nuclear community.

Officially, the Kysthym catastrophe was not announced until June 1989, three years after Chernobyl and Perestroika and Glasnost, at a meeting of the Supreme Soviet of the USSR by Deputy Minister L.D. Riabew. The public heard about the background and the extent of the catastrophe at a meeting of the IAEA in November of the same year. At the beginning, there was talk of about 2 Mio Curie; this figure was apparently unconditionally accepted by the Commission of the European Communities (1). Six months later, in December 1989, the figure was corrected by a factor of ten, to 20 Mio Curie.

This means that the event was only uncovered after thirty years and figures were published that are no longer verifiable and could not possibly have been determined at the time of the accident because of the lack of precise analytical technology. This fact opens up a great range for interpretation in the investigation of the consequences on health. A close examination is difficult because a large number of the victims died and too little is known about their lives and their causes of death.

Consequences of secrecy

Repeated mutual visits and exchanges with Mayak victims and others involved left me and other NGO representatives often with questions. The attachment to sacrificing, the feeling of complete surrender, mixed with anger and fatalism, and - at the same time - a never-ending activism, appeared contradictory to us. There were, however, explanations, such as the discrimination of the Tartaric and Bashkir minorities, which were among the main victims of the accident, the consequences of Stalinist terror, and the disappointed hope after the thaw under Khrushchev, and after Perestroika and Glasnost. These factors certainly play a role. I believe, however, that the most serious reasons for the disappointment were the secrecy and its aftermath, a hardly changing state. A whole population group has been stolen from its history. To date, the consequences of the Mayak disaster remain diffuse, unclear, and without convincing information. The victims were left in the contaminated area in a state of uncertainty. For them, the only reliable evidence was, and still is, the health of their families and the memory of the victims. If something in Mayak worked perfectly, it was the system of secrecy and nebulization.

Where there was no problem, none could develop. Accordingly, the forms of secrecy were perfidious. The civilian victims of the Kyshtym disaster were isolated. They were neither informed of about the causes of their illness nor were they told about their diagnosis. An eyewitness reports: *"The victims of the blast were placed in one wing of the hospital. None of them were permitted to leave this wing or to talk with other patients. Other patients were not permitted to talk with these victims or even visit with them. Those who promenaded around the hospital grounds were all by themselves and the area was sectioned off so no one could get near them"* (9).

The clean-up work was also done with secrecy. The freedom of movement of the workers in the military complex was restricted. In addition, prisoners were deployed as liquidators and subjected to the greatest burdens - most of them did not survive their

captivity. This method was also used later during the draining and stabilization of Karachai Lake - another major accident in the Mayak complex.
The victims of the "quite normal" releases into the Techa River were treated in a similar manner. They were repeatedly examined at institutes, dismissed without diagnosis and, if necessary, "supplied" with a painkiller. Affected persons called their decaying state of health, which occurred in practically all, “the river sickness". The embargos imposed subsequently - no drinking water from the Techa, no fishing and prohibition of building construction near the river - were merely a confirmation that something was wrong with this river.
What awakening it must have been just a few years later to discover the truth, even if only fragmentarily, after Chernobyl and Glasnost and to uncover that ones own habitat was still contaminated? The minimal compensation received or the resettlements, such as the one from Muslyumovo to “New Muslyumovo”, two kilometers farther from the riverbank, had to be perceived as blank cynicism by the victims.
Since 1989, no new facts about the accident have been made available from the archives of the Russian army. Apart by those affected, there seems to be little interest in dealing with violations of human rights and of the environment. On the contrary, under Putin, the past and ongoing radioactive contamination is whitewashed and thus, indirectly, the expansion of the military power under Stalin and Khrushchev is justified and celebrated as an achievement (1).

Kyshtym was not the only disaster

The Kyshtym accident was not the only disaster and it would be wrong to reduce the situation around Mayak to this incident. Already in 1948, when production was initiated and up to the middle of the fifties, a lot of radioactive waste from the plutonium separation plant was purged into the river Techa. In 1951, some villages along the Techa had to be evacuated after a devastating flood because the radioactive wastewaters contaminated the landscape and the fields. Muslyumovo, 70 km downstream from Mayak, is today the closest inhabited village from the plant (Figure 5).

Figure 5: Evacuated and inhabited settlements along the Techa River. Source: Overview of dose assessment and health of riverside residents close to the Mayak PA facilities, Russia.

As a countermeasure, dams were built to create artificial lakes, the so-called "Techa water cascade". Strontium and caesium salts partly sedimented in these "Reservoirs"

that had an area of more than 60 km^2, thus reducing the radioactivity level of the overflow into the Techa.
In 1967, the third disaster occurred. The Karachai Lake, which had been used as a depot for medium radioactive waste since the beginning of the 1950s, largely dried up. A storm distributed the radioactive dust over a vast area. Lake Karachai was later dry-laid and stabilized with concrete blocks (Figure 6). This is an inadequate measure since it does not prevent continuous contamination of the groundwater.

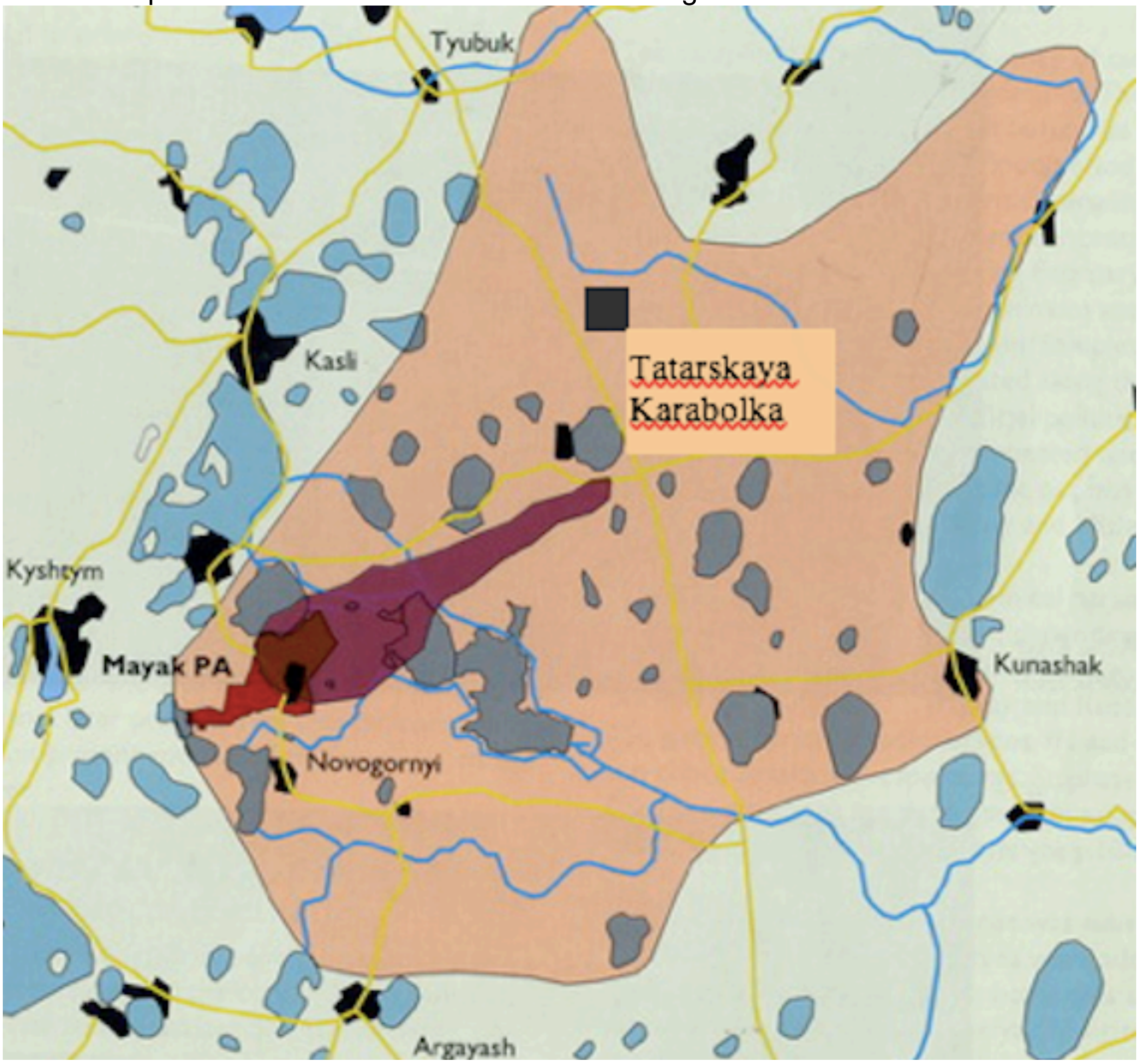

Figure 6: Massive exposure of the area after the Karachai disaster.
Indications for caesium-137, red: ≤ 5.7 Ci/km^2, light orange: ≤ 0.3 Ci/km^2).

Table 1 gives an overview of the three major disasters in the Mayak area. It is noticeable that the greatest release of radioactive materials took place via the water route into the Techa. However, the IAEA does not classify the Kyshtym accident as “serious accident with significant release”, the second highest level, on its assessment scale for nuclear accidents (the so-called INES table). The no less important releases by Mayak into the Techa River and Karachai Lake remain unmentioned.

Table 1. Parameters of radioactive contamination of the Urals (Nikipelov et al., 1990; Academy of Science, 1991; Sources, 1997; Kryshev et al., 1997; 1998b; Ilyin and Gubanov, 2001).

Contaminated area	Time period	Pathway of contamination	Activity (Bq)	Radionuclide composition (%)	
Techa River	1949-1956	Aquatic	10^{17}	^{89}Sr	8 (1-12)
				$^{90}Sr + ^{90}Y$	21 (8-42)
				^{137}Cs	11 (8-18)
				$^{95}Zr + ^{95}Nb$	12 (8-24)
				$^{103}Ru + ^{106}Ru$	24 (12-51)
				U + Pu	2
				Others [a]	22 (13-27)
Eastern Ural radioactive trace resulting from the Kyshtym accident	1957	Aerial	7.4×10^{16}	$^{90}Sr + ^{90}Y$	5.4
				$^{95}Zr + ^{95}Nb$	24.9
				$^{106}Ru + ^{106}Rh$	3.7
				^{137}Cs	0.036-0.35
				$^{144}Ce + ^{144}Pr$	65.96
Wind resuspension from the banks of Lake Karachai	1967	Aerial	2.2×10^{13}	$^{90}Sr + ^{90}Y$	34
				^{137}Cs	48
				$^{144}Ce + ^{144}Pr$	18

[a] Other radionuclides include primarily ^{91}Y, ^{140}Ba, ^{141}Ce, and ^{144}Ce.

Consequences on health

The inhabitants along the Techa River can be regarded today as one of the most studied cohorts in the world. The secrecy until 1989 negated possible radiation sacrifices with the result that the intensity of the radiation, the quantity and distribution of the released and incorporated radioactive substances remained in the dark. The extent of the impairments on health remained hidden. The data collected after 30 years were based on available figures but did not include all those who had died or left the area during the 30 years before.

In summary, the nuclear programs of the former Soviet Union led to uniquely high radiation exposure levels and partly resulted in high cumulative doses of the affected population. Compared to the survivors of Hiroshima and Nagasaki, the workers of Mayak, the inhabitants of the valley of the Techa as well as those in the downfall area of the bomb trial site of Semipalatinsk were exposed to higher collective - and in some cases - also to higher individual doses (10).

As a consequence, the extent of the damaging effects of high and long-lasting radiation doses should be assessed and relief and adequate compensation should be provided to those affected. This task has not been seriously tackled in Russia under any government, just as little as the rehabilitation of the environment. The attitude of the government, of the state-owned nuclear group Rosatom and its operators is reflected by the observation: *"Not a single case of chronic or acute radiation disease resulting from the accident among the Mayak workers or the population was recorded*." (1).

This view of facts has apparently been unconditionally accepted and published without comment by the IAEA.

Because radiation epidemiology is not part of my professional knowledge, I will not comment on the countless studies. The descriptions of the families of victims (6), their helplessness, and their manifold diseases, which are due to a weakened immune system and manifest themselves in the poor health, should not remain unmentioned. As with children from Chernobyl, even relatively short stays in non-contaminated areas -

such as 2-month holidays in Western families - had a visible effect on their health status. The same observation was made with patients from the vicinity of Mayak. Mira Kossenko, a scientist from Chelyabinsk, interpreted the weakened immune system as causal reason for the poor general health condition of the Techa inhabitants that went beyond the well-known pattern of radiation diseases after incorporation of high doses of radioactive strontium and caesium. She summarized the findings in a study entitled "Chronic Radiation Sickness (CRS) among Techa Riverside Residents". Researchers did not accept the concept of CRS because such a notion was new and not verifiable. Kossenko countered the argument by pointing out that there is no comparable group with this specific long-lasting radiation exposure anywhere in the world (5).

Mayak today

Since 1977, burnt fuel from Russian-style reactors and the submarine fleet has been processed in Mayak. Reprocessed uranium is also being used in new fuel rods for Western reactors; another part is likely to be enriched for military uses.
The Combine Mayak thus produces products for civil and military use. Western customers are told that these activities are necessary to finance the renovation of the plant and of its surroundings in a multi-year campaign; Greenpeace Switzerland drew attention to the abuses in Mayak and expressed doubts that today's operation reaches the required environmental standards. The Swiss operator AXPO first tried to justify the production and assured that the operator himself would check the production conditions. This was, however, prevented by the Russian side, and access was also forbidden to representatives of Swiss federal offices. Only a series of measurements along the Techa with the participation of NGO's were tolerated (11).
Nowadays, Mayak's reprocessing facility does not supply fuel elements for Swiss nuclear power plants. This is because "the results of the measurement campaigns [...] do not give clear indications of an infringement of the valid environmental limits by today's facility", but "this can not be completely excluded". Thus, the conditions that would justify an acquisition are not fulfilled (11).
In the near future, more than 20'000 spent fuel elements, unsafe nuclear waste from the ailing nuclear submarine fleet, will be transported from the Andreeva Bay at Murmansk to Mayak for treatment.
The reprocessing plant "RT-1" is to be continued until at least 2030. This will further increase the inventory of nuclear waste in Mayak. The rehabilitation of the environment, including the huge lakes filled with liquid waste is not in sight. Mayak will continue to pose a tremendous risk to humans and the environment for decades, if not centuries. In this light, the Kyshtym accident appears as a link in a long chain of innumerable environmental and human rights violations. The refusal to carry out serious humanitarian measures and to recognize and deal with its consequences by the Russian state is to be condemned, as is the uncritical acceptance by the IAEA. The lack of reconsideration legitimates such practices and can lead to the reintroduction of inhuman methods in the hands of authoritarian regimes.

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