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ANALYSIS OF THE MEDVEDEV REPORT OF A SOVIET RADIOACTIVE WASTE INCIDENT

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I. Introduction

The first public indication that a serious radioactive accident had occurred in the Soviet Union appeared in the Western Press in the November 4, 1976 issue of New Scientist, in an article by Dr. Zhores Medvedev entitled, "Two Decades of Dissidence," (p. 264-267, Appendix I). The main thrust of the article was the degree of dissidence among elite Soviet scientists. In the article Dr. Medvedev discusses the accident which occured in 1958 as an example of the fight against Lysenko's theories and how classical genetics was legitimatized for radiology, radio-biology, and medicine as a result of the accident. He describes the accident: "nuclear reactor waste had been buried in a deserted area, not more than a few dozen miles from the Urals town of Blagoveshensk... Suddenly there was an enormous explosion like a violent volcano. The nuclear reactions had led to overheating in the underground burial grounds. The explosion poured radioactive dust and materials high up into the sky." (p. 265) See Figure 1 for Location Map.

The report of the accident according to Dr. Medvedev in his article in New Scientist of June 30, 1977, entitled, "Facts Behind The Soviet Nuclear Disaster," (Appendix II) caused a sensation: "My New Scientist article created an unexpected sensation because this nuclear disaster was absolutely unknown to Western experts" (at least in the general scientific community outside the intelligence community). Sir John Hill, the chairman of the United Kingdom Atomic Energy Authority "tried to dismiss my story as both scientific fiction, rubbish and a figment of the imagination." Dr. Medvedev's story was confirmed by Professor Lev Tumerman who said that he had visited the area between the two cities in the Urals, Cheliabinsk and Sverdlovsk, in 1960, and was able to see hundreds of square miles that had been heavily contaminated by radioactive waste. The article details how Dr. Medvedev

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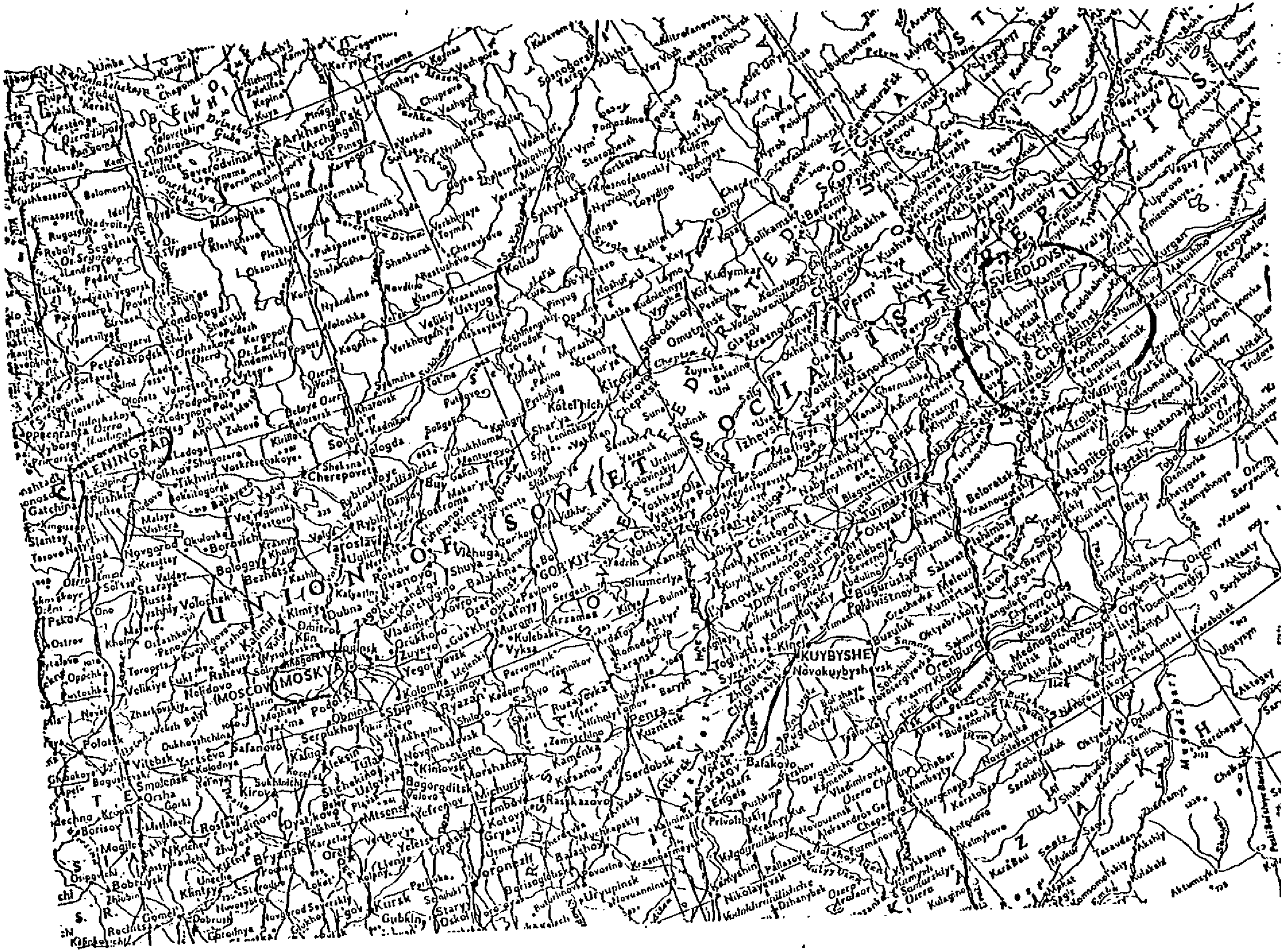


FIGURE 1 LOCATION MAP

went through the Soviet biological literature and found veiled references to the accident and the biological studies that resulted from it. He claims in the article that more than one hundred articles have been published since 1958 which detail the effects of strontium-90 and cesium-137 in natural and plant and animal populations. He says the length of time that populations were exposed to the radiation corroborates reports of the accident occurring in late 1957 or early 1958.

II. Analyses of the Article

Dr. Medvedev quotes a paper by F. Rovinsky in Atomnaya Energiya (p. 379, 1965). In this report Rovinsky states that the experimental lakes used to corroborate his mathematical model for movement of radioactive isotopes were 11.3 and 4.5 square kilometers in size, and almost round in shape. They were of the eutrophic type. These are equivalent to lakes with radii of 6000 and 4000 feet, respectively. Dr. Medvedev points out that "it is hard to believe that anyone in his right mind would contaminate two such large lakes just to confirm some mathematical calculations." This seems a reasonable enough conclusion but shows the deductive method of analysis used by Dr. Medvedev. The concentrations of radio isotopes in water or in sediments are not given in the English version of this publication though the relative concentrations of Sr-90, Ru-106 and Ce-144 are given. The article is found in Appendix III.

The rest of the Soviet literature referred to or documented is not available in the Vanderbilt library though the Union List of serials indicates that these journals are all subscribed to by various libraries in the United States. It would be possible to obtain copies of the original articles.

The next references are a series of papers by Il'enko which were published in Voprosy Ichtilogii (problems of ichthyology). Il'enko found that the concentration of strontium-90 in water was 0.2 micro curies per liter and cesium-137 was 0.025 micro curies per liter. Medvedev states, "both figures are 100 times higher than contamination levels in ponds created specifically for research purposes both in the U.S.S.R. and other countries." These concentrations compare with maximum concentrations of strontium-90 in the Columbia River at Vernita in 1972, of 2.8(10^{-6}) micro curies per liter as shown in ERDA-1538 Waste Management Operation - Hanford Reservation (p. II-3-65). Open ponds on the Hanford site had concentrations of cesium-137 listed as high as 220(10^{-6}) micro curies per liter (p. II-3-67) in comparison to the levels of 0.025 micro curies per liter in the Il'enko article. Strontium-90 in the groundwater in areas under the disposal sites reached concentrations as high as 19.2 pico curies per milliliter or .019 micro curies per liter, an order of magnitude lower than the concentrations found in the Il'enko open ponds. (p.II.1-73) The activity of the intermediate radioactive waste generated at Oak Ridge National Laboratory is listed as 0.005 curies per gallon or 1320 micro curies per liter. This is taken from WASH-1532, Environmental Statement on Radioactive Waste Facilities - ORNL, August, 1974 (p. 23).

During the period of the Clinch River study the highest concentration discharged from White Oak Creek into the Clinch River was listed as 0.017 micro curies per liter in ORNL-3721 Suppl. 1,"Concentrations, Total Stream Loads and Mass Transport of Radionuclies in the Clinch and Tennessee Rivers," M.A. Churchill, et al, 1965 (p. 7), which indicates that the concentration in this Russian "experimental pond" was 10 times higher than that in White Oak Creek which drains the Oak Ridge National Laboratory facilities. I think one must agree with Dr. Medvedev that the concentrations in the pond were far higher than one would utilize in ponds created specifically for experimental purposes.

Dr. Medvedev calculates that since more than 100 pike were sampled, the lake must have had at least ten to twenty times that number in order not to affect the population balance. The lake contained only four different species as reported in Il'enko's work (which we have not been able to look at yet). From this Medvedev assumes that to hold this many pike the lake must have been ten to twenty square kilometers in size. In conversations with the Tennessee Wildlife Commission, the fisheries people there say that it is impossible, based upon this sketchy evidence to indicate the size of the lake. It would depend a great deal upon the type of lake, the other fisheries presently in the lake and the feed material available. Therefore, though Medvedev's calculations may be correct there certainly is no way of concluding this from his article. One must, of course, go to Il'enko's articles and search those more carefully than is possible from Medvedev's treatment. Medvedev also points out that the concentration in the sediment was at least ten times that in the water.

To contaminate a lake of size with 0.2 micro curies per liter would require more than 50,000 curies of Sn-90. Il'enko points out that the total amount of Cs-137 and Sr-90 in water, plants, plankton, and silt is 1000 times higher than in the water. Therefore, Medvedev concludes that the amount of strontium-90 and cesium-137 in the lakes must have been at least 50 million curies. This amount would have had to flow into the lake from its basin. Therefore, the total amount of contamination must have been much higher than this.

The soil contamination in that area ranged as high as 3.4 millicuries of strontium-90 per square meter. This contrasts with fallout concentrations of 83.7 millicuries of Sr-90 per square kilometer (83.7×10^{-6} milli curies/m^2) in the most contaminated region, 40 to 50^{o} north latitude, till 1970 (UNSCEAR 1972, p. 26). Obviously, the average concentrations around the globe were much lower than those found in the test areas. These should be compared with the concentrations in the soil at the Nevada test site. Twenty one deer were killed in the contaminated area. From this Medvedev concludes that there must have been at least 100 deer available and they would have required 100 square miles for their range.

Both the extrapolations by Medvedev from the number of animals sampled are very tenuous. The original literature, Zoologicheskii Zhurnal (Zoology Journal) and the Zhurnal Obschei Biologii (Journal of General Biology) should be consulted. The range of the animals needs to be investigated further to see how valid are the estimates by Medvedev. They, of course, would not prove that these were in fact the ranges but could show if they are reasonable values.

Medvedev goes on to state that "many millions of curies of strontium-90, cesium-137, and other radioactive isotopes did contaminate a very large area of the South Urals region where the first Soviet military reactors were built in the late 1940's. The nature of the contamination certainly excludes the possibility that it was a reactor accident or a real atomic explosion. The facts in the published materials agree much better with an accident in a nuclear waste disposal site."

III. Analysis Of The CIA Documents

This view can be contrasted with the information made available in the CIA documents which were released on November 11, 1977 to Mr. Richard B. Pollock, Director of the Citizens' Movement For Safe And Efficient Energy (Critical Mass) (Appendix IV). The unevaluated information does corroborate, to some extent, some of the information presented by Medvedev. It indicates that there was an incident at a nuclear plant near Kyshtym, a town 70 kilometers northwest of Chelyabinsk on the Chelyabinsk- Sverdlovsk Railroad line. In the first report, identified as CSK-3/465,101, dated February 16, 1961, it is indicated that an explosion occurred in March, 1958 and wrecked part of the nuclear power plant.

In the report 00B-3, 202,034, dated 5 December 1961, it is stated that "in May, 1961, a terrific explosion occurred in the Chelyabinsk region." In the report identified as OOB-3,204,092, 21 December 1960, it is stated that "in May, 1960...all the leaves on the trees in and around Yemanzhelinskaya were completely covered with a fine layer of red dust. Very quickly the leaves on the poplar trees became extremely shiny brown, curled up, and fell off. The leafy green vegetables were covered with the same type of dust and curled up and died." In the Report OOK-323/20537-76 dated 27 September 1976, the statement is made, "In about 1956 there was an explosion at Chelyabimsk-40; the explosion lighted up the sky for a great distance... The chief evidence of the explosion was the tremendous number of casualties in the hospital of Chelyabinsk. Many of the casualties were suffering from the effects of radiation." The Report OOE-324/01015-77 dated 24 January 1977 states that a 20 megaton device was deliberately dropped from an airplane in this region in the 1957-1958 period to test the effect on a subway as well as the usual civilian and military facilities. In the Report OOB-321/06645-77, 25 March 1977, it is stated that the 'Kyshtym Disaster' occurred in 1958 and "was caused by a blast at the storage site of nuclear waste from military reactors. I was told that the accident was caused by the negligent storage of plutonium wastes." In the Report entitled, "Plant Summary, IR Firm Nobzr 8014401, it is stated, "In the spring of 1958 hundreds of persons were exposed to radiation and injured as a result of an explosion at the Kyshtym plant. In early October 1959 an atomic test reportedly took place in Kyshtym."

IV. Evaluation Of The Documents

The quantities of wastes involved can be compared with the total inventory of strontium-90 at the Hanford site which was estimated (in the National

Academy of Sciences Report, "Radioactive Wastes at the Hanford Reservation, 1978) to be approximately 127 million curies of strontium-90. If we assume that Hanford has approximately two thirds of the defense radioactive wastes, this would make a total of approximately 200 million curies in U.S. storage. This certainly casts some doubt about the 50 million curies of strontium-90 and cesium-137 that Dr. Medvedev indicates were in one lake.

If, as appears possible, there were two incidents, one can make calculations on the production of strontium-90 from a 20 megaton bomb. If one assumes that the bomb is all fission then one would arrive at approximately 3 million curies of strontium-90 produced in the 20 megaton explosion. More likely, only about 5% of that energy released was due to fission and therefore only about 150,000 curies of strontium-90 were produced, not all of which, of course, would fall to the ground in the immediate vicinity. If the bomb was exploded close to the ground, and incorporated soil in the fireball much of it would be deposited locally.

One might compare these quantities of strontium-90 with the strontium-90 produced by all weapons tests through 1970, 14.4 megacuries. Of this amount 14.1 megacuries had fallen to the ground, 1.8 megacuries as local fallout, and 12.2 megacuries as global fallout. (UNSCEAR, 1972, p. 84)

From this information one can conclude that most likely one or more radioactive incidents occurred in the Soviet Union in the 1956-1958 time period. The amounts of strontium deposited as deduced by Medvedev seem to be excessive.

V. Implication For The U.S. Nuclear Program

Why should we be interested in the further examination of these Soviet incidents? I believe there are four major reasons why we should be interested.

1. It is likely to be one of the major questions raised by the intervenors in the future. We need to have answers. Could it happen here? There are three

particular items that we might investigate. First, what would be the effects of a hydrogen explosion in one of the waste tanks? We could calculate the amount of build-up of radiolytic hydrogen in the tank and assume that this, combined with sufficient oxygen, could cause a hydrogen explosion to take place. This should be relatively straight-forward. Secondly, we could estimate the effect of inadvertent nuclear excursion. For example, if the Soviet reprocessing technology was less sophisticated than ours and left as much as 3% of the plutonium-uranium in the waste stream and stored this in a neutralized solution, then it might be possible to concentrate sufficient fissile material in the sludge to have critical mass. What would be the effect of such an explosion? Once again, this should be relatively easy to calculate if we do not insist upon a very sophisticated scenario. Thirdly, if the waste were stored in trenches such as Z-9, could an inadvertent criticality take place? These questions could, I think, be resolved in a simple fashion relatively quickly.

2. It might give us further information on the migration of nuclear wastes released to the environment. What would be the effect of a nuclear waste explosion on the environment? What would be the movement in the environment? To do this, it seems to me there are three major things we could do. One is that we need to read the Soviet literature that Medvedev has, and which he details, only briefly, in his article in New Scientist. It would be useful to be in contact with him to see his bibliography on one hundred or so articles he says that he has read. It would be even more useful if he would make copies of those available to us. The translation of this should be a relatively minor matter and we, as engineers, might correlate and evaluate this information in a different way that he, as a biologist has. Secondly, we need to read the Soviet literature in the health physics field and in the fields of hydrology, meteorology, etc., which are not the

areas that, it appears from the article, that Medvedev has looked at. In that case, we would tend to look for the same sorts of coincidences that he found in his look through the biological literature. From this we would try to obtain a coherent picture of what has actually taken place - the specific kinds of nuclides that have moved, how far they moved, the rate of decrease, etc. The initial clues are found in the article, "Atomic Energy" that Medvedev quotes and is attached here. (Appendix IV) And finally, we might compare this movement with the Oklo phenomena and see if the movements seem to be similar.

A lot of this evaluation, of course, was based upon supposition. For example, in the "Atomic Energy" article detailed information on the movement of Ru-106, Ce-144, and Sr-90 are presented. Their fission yields are 3.8, 6.1 and 5.9%, respectively. Yet, their concentrations in lake water vary by a factor of 10 with Ru-106 and Sr-90 being approximately the same concentration and Ce-144 being approximately a factor of 10 greater. This does not seem logical. We expect Ruthenium-106 as a complexed ion, as frequently is the case, to flow to the lake fairly quickly. The strontium would be the intermediate flow, and the cerium as a rare earth, to be tied into the sediments in a very short order. This is corroborated by the studies at Hanford as shown in Figure 2 (P.II.1-46).

3. One could do an independent check to see if such nuclear incidents took place in late 1957 and 1958. Using fallout data and meteorological maps, it would be possible to determine when and where the incidents took place. I did this in my thesis in the early 1950's. This certainly should be checked.

4. What sort of remedial measures could be take to avoid such incidents? Should the depth of the high-level liquid radioactive waste tanks be sufficient to prevent the release of this radioactive material to the atmosphere in the event of a criticality incident? What is the maximum energy release to be expected from a criticality incident? Are we making a mistake in having our

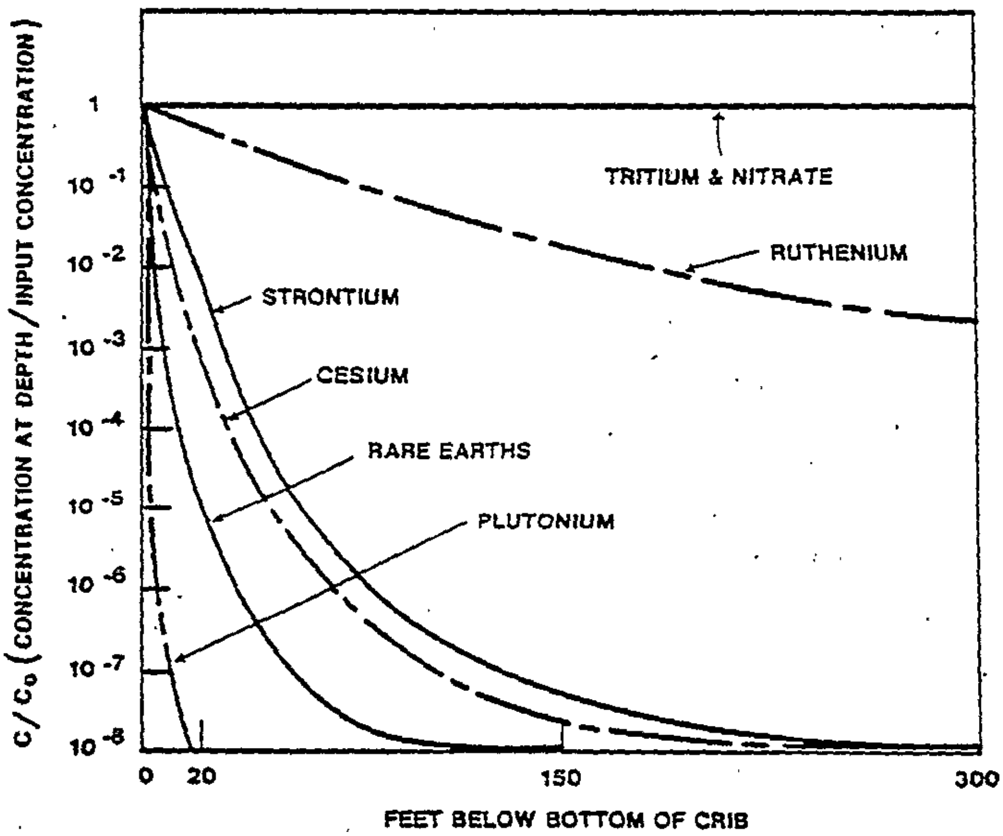


Figure 2 - Approximate Sorption Patterns For Typical Hanford Disposal Crib

9 1 1 2 5 1 0 3 4 7

tank storage so near to the surface? There is an indication in the CIA unevaluated reports that a 20 megaton bomb was exploded over that region for a training film. Would this be sufficient to remove the earth and the tops of the tanks? If so, what depth would one have to go before this would be impossible? This study might then also change the criteria for the storage of the liquid waste prior to the time of solidification if we did reprocessing. It might also indicate whether or not we wish to store the irradiated fuel elements at the surface for a period of time prior to the decision to store irretrievably in deep geological formations.

The cost of such studies would be small in comparison to the value of the information to be obtained. I urge that these studies be undertaken.

APPENDIX I

Two decades of dissidence

Khrushchev's speech to the 20th Party Congress in 1956 forced scientists, among others, to reappraise their role within society. Some of the scientific elite then linked up with the rank and file to form a unique and highly significant part of the dissident movement

Dr Zhores Medvedev is a biochemist working at the National Institute for Medical Research and a prominent Soviet dissident

The repression of scientists and intellectuals during Stalin's time could create the impression that dissidence was widespread among them. However, this was not the case. There were different reasons for repression. Some were persecuted for their political views, others were victims of the struggle with pseudo-scientific trends, but many were repressed for purely random reasons.

Stalin was an anti-intellectual in many of his actions. He often supported badly educated or just primitive people, considering them to be "great" scientists because they had declared their intention of carrying out some extraordinary achievement. Sometimes this support was justified and the achievements of these unknown pioneers were later recognised throughout the world. Examples include D. Papanin's successful expedition to the North Pole, and V. Chkalov's first transarctic flight from the USSR to America.

But very often Stalin's anti-intellectual support was given to semi-educated pseudoscientists like T. D. Lysenko and O. Lepeshinskaya. Such scientists then tried to establish a dominating position through ideological pressure and by using the apparatus of terror. It was just this cruelty and the terror of the state machine which made organised dissidence in science impossible.

Individual cases of dissent among scientists were possible. One example was the direct refusal of academician Peter Kapitza to participate in research related to the atomic bomb—an action which cost him his position and job, but not his life. This kind of dissent was very risky, not only from the point of view of the individual's scientific position, but from that of his life and freedom as well.

Khrushchev's bold denunciation of the Stalin terror in 1956, and his rudimentary attempts to establish some legal justice in the country, gradually stimulated a better intellectual climate, including the scientific. Representative groups of the scientific community began to oppose some aspects of government and party policy. But the inertia of fear aborted many such attempts. The scientific opposition did, however, play an important part in changing developments that had already been approved by the party. Cybernetics was not the only useful science rehabilitated after Stalin's death. Many other new technologies, previously suppressed, now struggled to the surface with the help of political pressure.

Khrushchev's initial measures in support of science, encouraging scientific exchange with the West and developing new science centres, together with his policy of "destalinisation" and the rehabilitation of political prisoners, won enthusiastic support among scientists. During this period (1953-57) he was even sensitive to demands about Lysenko. In 1956 Lysenko was dismissed from his position as president of the Lenin Academy of Agricultural Sciences of the USSR. He was reinstated in 1961 when Lysenko sided with Khrushchev in his quarrel with agricultural experts and scientists.

Khrushchev also abolished the annual "Stalin Prizes" which had been awarded for the best achievements in science and technology. He introduced the "Lenin Prizes" in their stead. These were to be awarded once every two years, there would be fewer of them, and they would involve less money. This reform was, however, not very significant.

Khrushchev's real conflict with the scientific community began to be felt after 1958-59 when the "anti-party" opposition had been eliminated and he had become the "de facto" dictator of the Soviet Union. In accordance with the long standing tradition of the communist movement, this meant that he now wanted to be thought of not only as a political leader—the first secretary of the party—but also as a "super scientist" who knew all the answers.

Opposition to Lysenko

An important centre of scientific and political opposition arose in the agricultural and biological sciences around the Lysenko issue. Hundreds of scientists—not only biologists but chemists, physicists and others—united against Lysenko and against Khrushchev's support of Lysenko. This struggle was reflected in many official meetings and countless speeches by Khrushchev, where he attacked those scientists who opposed the "fruitful and revolutionary Michurin-Lysenko biology".

In 1963 a number of scientists challenged Khrushchev's unrealistic 70 to 80 per cent annual growth target for the chemical fertiliser industry. Their open letter had some effect and the "chemicalisation" programme was modified.

Awareness of environmental problems also started around the 1960s, scientific groups often pointing out the environmental dangers of industrial projects. In some cases the government made concessions, but more often it was reluctant to alter its industrial plans.

Even Khrushchev's reasonable attempt to reorganise the Academy of Sciences in 1960, by hiving off the numerous industrial, technological and agricultural research institutes, was strongly opposed. Members of the Academy and the Academy Praesidium refused to cooperate with the government. It took more than a year to settle the dispute. When it became clear that it was impossible to carry out the reform simply, the government decided to go ahead without the Academy's cooperation. The president of the Academy, A. N. Nesmejanov, was forced to resign.

Khrushchev's conflict with the scientific community contributed to his downfall in 1964. Some episodes in this conflict—such as his closure of the Moscow Timiriazev Agricultural Academy, his support for Lysenko's pseudoscience, and his attempt to reorganise the Soviet Academy of Sciences into a Committee of Science in 1964—were mentioned by Suslov, in his report to the Party Plenum, as among the reasons for Khrushchev's dismissal.

Two tragic episodes exposed the explosive relations between Khrushchev and the scientific community, and were of particular importance. They strained Khrushchev's relations with two groups of very influential scientists. Both these groups—the *nuclear physicists* and the *spacecraft and rocketry technologists*—were the elite of the elite. They were also essential for the country's strength—probably more essential than Khrushchev himself.

It was suppressed geneticists who originally started the conflict with the nuclear physicists. In 1955-56 they made a number of attempts to arouse the physicists to the genetic dangers of radioactivity. This underground propaganda, which emphasised the dangers of radiation and the need for classical genetics to control it, was rather successful. By 1956 several hundred signatures had been collected on an appeal calling for the restoration of genetics and radiation genetics in particular. The tsar of the nuclear physicists, Igor Kurchatov, handed this appeal in person to Khrushchev. Khrushchev was furious, but he could not touch Kurchatov who had too strong a backing. Finally Khrushchev made some small concessions, including the removal of Lysenko from the presidency of the Agricultural Academy, though he returned to favour later.

A tragic catastrophe occurred in 1958, which made nuclear physicists extremely sensitive to the radiobiological and genetics issue. The *catastrophe itself* could have been foreseen. For many years nuclear reactor waste had been buried in a deserted area not more than a few dozen miles from the Urals town of Blagoveshensk. The waste was not buried very deep. Nuclear scientists had often warned about the dangers involved in this primitive method of waste disposal, but nobody took their views seriously. The alternative of drowning the containers in the very deep waters of the Pacific or Indian Oceans had been rejected as too expensive and protracted. Dispersing the highly radioactive materials over other parts of the country was also considered unnecessary. The large nuclear industry, concentrated in the Urals, just continued to bury its waste in the same way it had done since the beginning of the atomic race. Suddenly there was an enormous explosion, like a violent volcano. The nuclear reactions had led to overheating in the underground burial grounds. The explosion poured radioactive dust and materials high up into the sky. It was just the wrong weather for such a tragedy. Strong winds blew the radioactive clouds hundreds of miles away. It was difficult to gauge the extent of the disaster immediately, and no evacuation plan was put into operation right away. Many villages and towns were only ordered to evacuate when the symptoms of radiation sickness were already quite apparent. Tens of thousands of people were affected, hundreds dying, though the real figures have never been made public. The large area, where the accident happened, is still considered dangerous and is closed to the public. A number of biological stations have been built on the edge of this—the largest gamma field in the world—in order to study the radioactive damage done to plants and animals.

The irradiated population was distributed over many clinics. But no one really knew how to treat the different stages of radiation sickness, how to measure the radiation dose received by the patient, how to predict what the effects would be both for the patients and their offspring. Radiation genetics and radiology could have provided the answer, but neither of them was available. There was no laboratory in the whole of the country which could make a routine investigation of chromosome aberrations—the most evident result of radiation exposure; marrow stocks did not exist; there was no chemical protection against radiation exposure available for immediate distribution.

Dissident scientists

The older generation—some of the elite of Soviet science who opposed aspects of government and party policy:


Axel Berg—cybernetician, academician;


Ivan Knunyants—organic chemist, academician;


Vladimir Sukachev—botanist, academician;


Igor Tamm—physicist, nobel prize winner, academician;


Andrei Sakharov—physicist, nobel peace prize, academician

The younger generation—some of the members of the democratic political opposition:


Valery Chalidze—physicist, former member of Human Rights Committee, now in exile in US;


Sergei Kovalev—biologist, active in the 'Defence of Human Rights', now in a labour camp in Perm region;


Kronid Lyubarsky—astrophysicist, member of civil rights movement, now in a labour camp in Mordovia;


Yuri Orlov—physicist, head of Helsinki Monitoring Committee, dismissed from job;


Andrei Tverdokhlebov—physicist, secretary of Soviet Amnesty Group, now in exile in Yakutia

Many towns and villages, where the radioactive level was moderate or high, but not lethal, were not evacuated. The observation medical teams established in them were not well prepared for serious tests.

All this greatly shocked the nuclear scientists, and their opposition to Khrushchev's anti-genetic stand became too strong to resist. The government was forced to legalise classical genetics, at least for radiology, radiobiology, and medicine. Lysenko's only remaining power base was agriculture.

The nuclear physicists were now well aware of the real dangers of nuclear explosions. They were no longer just an obedient group of experts. Their strong opposition to government policy contributed considerably to the final agreement to end atmospheric tests of nuclear devices.

The other line of resistance developed in space research after 1959. Khrushchev's misuse of space research to boost Soviet political prestige led to an irreparable catastrophe. The space and military experts then started to resist political pressures and wanted a significant role in the decision-making process.

In October of 1960 Khrushchev decided to head the Soviet delegation to the General Assembly meeting of the United Nations. He and some other heads of East European countries were to make the trip on the ship "Baltika". Always obsessed with the idea of showing the Americans Soviet superiority in at least some areas of technology, Khrushchev issued a directive that a Soviet rocket to the Moon should be launched to coincide with the time of the Baltika's docking in New York. It would be some kind of space "salyut" for the arrival of such an important communist group to the United States.

Lunar rocket blows up

The elite of Soviet rocket technology was, of course, at the "cosmodrome". However, when the start was ordered and the button was pressed the ignition did not work. According to the safety regulations, any inspection could only take place after the fuel had been removed. This was a long process and would mean postponing the whole spectacle. Marshal Nedelin, who was in charge and under an obligation to fulfil the ambitious order, irresponsibly decided to investigate the fault immediately. The special ladders and platforms were moved to the rocket and dozens of engineers and experts started to explore the different parts of the multi-rocket system. Suddenly the ignition started to work. The rocket fell because it was blocked by the ladders. All the men and women in the area were killed. They were some of the best representatives of Soviet space technology.

This tragedy was not the only event to make the space technologists aware of the dangers of political "salyuts". The government's attempt to hide the real story—the official press referred to Nedelin's death as being due to a plane crash!—meant that the tragic death of many prominent scientists and technical experts passed without even short obituaries. The duplicate rocket was later launched and declared a great achievement. But this would not heal the wounds of those who had lost their relatives, friends and colleagues.

These are just a few examples that show how Khrushchev began to lose the confidence of Soviet scientists. They also show that the dissent started not only among the rank and file, but also at the level of the highest scientific elite. The culmination of this conflict was a special Party Plenum held in June 1963, to discuss the ideology and ideological orientation in science, literature and art. This Plenum was ominously reminiscent of the notorious decisions taken by Stalin and A. Zhdanov on the superiority of ideology and its relevance to all aspects of science, literature and art. Their decisions had initiated the repressive measures against intellectuals in 1946.

However, the conflict between Khrushchev and the top ranking scientific elite not only contributed a lot of fuel to the anti-Khrushchev move, made by the Party Praesidium in October 1964, it also created a unique situation where the highest scientific support became available for *political dissidents*, who had never belonged to the elite.

Political dissidents within the scientific community were usually at the lower levels of the scientific hierarchy. The young students and junior scientists, not the privileged academicians, tried to explore some political alternatives and ideas during the post-war period. Their fate under Stalin was usually tragic. During Khrushchev's time the first wave of arrests among young scientists and student dissident groups came after the military intervention in Hungary in October 1956. These arrests are not well known, because the rehabilitation of millions of victims of the Stalin terror was under way at the same time. When millions were being released, the hundreds of new arrests could easily pass unnoticed.

These young dissidents had been brought into existence by the new policy of "destalinisation". However, they wanted more serious reforms in society. They were stunned by the details of the Stalin terror; they wanted a more complete investigation and the punishment of those others who had also been guilty of such crimes. In 1956-57, there were few such dissidents, and they were isolated from almost all groups in society—from workers and peasants because of the lack of any means of communication; from higher sections of the intelligentsia, because of the latter's privileged "elite" position and their satisfaction with the half-measures of Khrushchev's regime toward liberalisation. Too many of the intellectual elite of 1956-60 were still famous from Stalin's time.

The situation changed around 1962-63. A certain cooperation grew up between the democratic *political* opposition and the scientific elite opposition group.

By then the prestige of the numerous state orders, the signs of political recognition, the titles, prizes, degrees—and even high positions—were all tremendously eroded and devalued. The question naturally arose—what had one done to receive the title Hero of Socialist Labour? Was it for the development of a good new variety of wheat, or a new version of the nuclear bomb, or had one overfulfilled the construction programme for a hydroelectric dam being built by slave labour from the prison camps? The same questions could be asked about prizes and degrees. As a rule the most decorated scientists came from the Lysenko camp, with himself well in the lead—nine orders of Lenin, Hero of Socialist Labour, several Stalin Prizes, full membership of three academies (USSR, Ukraine and Agricultural), member of the Academy Praesidium, director of the Institute of Genetics and of the Gorky Leninskoe Experimental Station, Deputy of the Supreme Soviet, etc.

The devaluation of the scientific hierarchical pyramid made closer contacts between the younger politically active groups and the more honest representatives of the "elite" much easier. In many cases the high ranking "elite" scientists were themselves looking for such contact. Right up to 1957-58 the politically orientated younger dissidents would have considered any kind of friendly relations with such scientific celebrities as academicians I. Tamm, P. L. Kapitza, A. D. Sakharov, N. N. Semenov, V. A. Engelhardt, I. L. Knunianz and A. I. Berg, as quite unthinkable. But by 1962-64 links had started to appear. Not only did cooperation and friendship between the two generations become possible, but the older and more privileged group gave direct support to the political dissent of their younger colleagues. They gave financial aid to help organise the samizdat network; they sometimes made facilities available for safeguarding and reproducing samizdat works; they also strongly encouraged and defended those in trouble. In a few cases, members of the highest scientific tists became outspoken political dissidents themselves—the case of Andrei Sakharov is one of the best known examples.

The cooperation between prominent scientists and political dissidents became especially evident in 1966-67. Many joint statements were prepared and sent as high as the 23rd Party Congress. These opposed the then current attempts to rehabilitate Stalin and also protested against some of the political trials. The government was not yet ready to deal with this kind of dissent. The spring of 1968 was not only the famous "Prague spring", it was also the honeymoon of intellectual dissent in the USSR. Many hoped that this was the beginning of real democratisation. However, the tragic events of August 1968 changed the situation dramatically within the Soviet Union as well. The group of young activists, who tried to demonstrate in Red Square, was arrested. Special measures to suppress dissident activity in science became official policy. The previously more-or-less united movement of politically minded scientists started to split up under this pressure into several trends, each with its own methods and own programmes of reform.

The whole phenomenon of dissent in the USSR became well publicised in the West at this time. But this does not mean that the West properly understood the complexity of the situation. Publicity was mostly centred around some prominent figures—the western "press" publicity is always individually orientated. However, the main streams of the widespread but moderate dissent among scientists and technological experts remained unseen. It was nevertheless, influential. The new policy of detente was, to a significant extent, the result of internal pressure from these scientific and technological groups. They made it clear that the development of the Soviet Union as an advanced power was not possible in isolation or with its science divided ideologically into "socialist" and "bourgeois" sections. But this complex and contradictory chapter in the history of Soviet science needs special consideration. □

In the footsteps of John Logie Baird

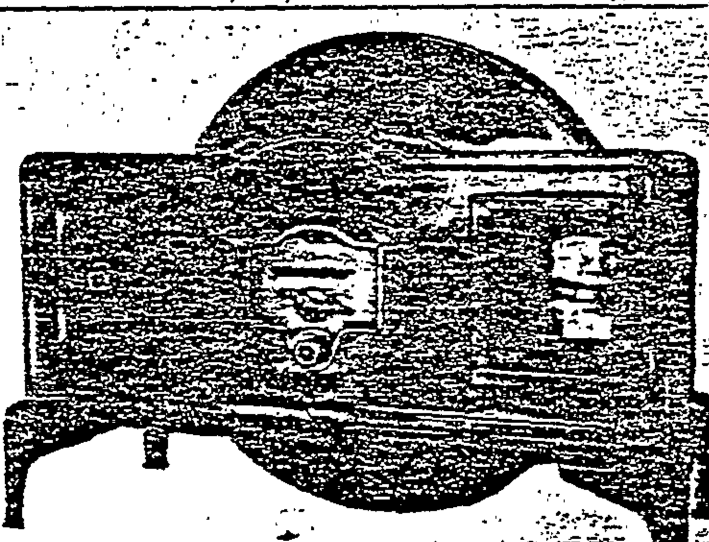
Retracing the early history of television, one man has built his own mechanically scanned system—and met, along the way, some of the people involved in the early days of Baird's work

Bill Elliot
is a retired television engineer, now living in the Isle of Man

My first foray into television was in 1936, when TV was based on mechanical scanning and my elder brother and a friend decided to experiment with the new hobby. A year or so previously, my brother had *heard* on a radio set the vision signals then being put out by the BBC, and was fired with schoolboy enthusiasm to try to get a picture. Unfortunately, by the time the requisite motor parts etc had been collected by the use of fair means or pocket money, the 30 line transmissions were terminated. Rumour had it that the BBC was experimenting with 120 line and 180 line TV, so we went on working on the mechanical system in the vague hope that by running the system at some unspecified but incredibly high speed some sort of picture might be resolved. I was told off at one stage to count the number of turns being put on the motor windings by one of my elders by counting the revolutions of the handle of the winder. We soon found it was far better for the winder operator to count his own revolutions—my first lesson in work study! The final blow (apart from 6d per week pocket money not stretching far enough) came when the BBC announced that the new transmissions from Alexandra Palace would be 240 lines and 405 lines alternately for a trial period. Various distractions, such as the need to pass exams, came along, and I gave up television construction for the time being.

During the next ten years, I collected bits and pieces of Bairdiana, and after the war joined Scophony-Baird Ltd as a very junior engineer. There I met J. D. Percy, one of the early Baird team, then a director. I saw some remains of Baird's activities, including one of his colour test cards (a picture of Popeye the Sailor). Unfortunately, I lost track of these relics, but I hope they still exist somewhere and will come to light some day.

After some years of wandering through the electrical and radio industry, in 1968 I again joined Baird Television, which by this time was a subsidiary of Radio Rentals Ltd. Several members of the staff of the parent company had been in the TV business since the early days, and talking to them re-awakened my interest in mechanical TV, so much so that we decided to build a camera, using a very scattered receiver as the starting point. We also had a complete disc receiver made by Baird International Television Ltd. This worked perfectly from the start, and has never given any trouble since—not a bad record for a 46-year-old (Figure 1, above).



Disc receiver made by Baird International Television Ltd

To transmit an image over a single communication channel, the image has to be scanned line by line, in a way analogous to the reading of a page of a book. A typist listening to the reading can reproduce the page exactly if told when each line starts. In TV, the words on the page are equivalent to "picture elements" and these are sent one after the other, line by line, to the receiver as instructions to produce more or less light corresponding to the brightness of these elements in the original scene. The start-of-line information is called synchronisation and this enables the receiver to keep in step with the transmitter.

A scene can be *scanned* mechanically in several ways, notably by dissecting the image into lines, or by flying spot scanning. The original Baird cameras of 1926 vintage used a disc carrying a spiral of lenses, each of which produced a complete image of the scene which was swept vertically

APPENDIX II

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Facts behind the Soviet nuclear disaster

When the story first came to light last year, Western nuclear experts were sceptical that a large accident, involving nuclear waste materials, could have occurred in the south Urals in late 1957 or early 1958. However, published Soviet research into the effect of radioactivity on plants and animals confirms that a nuclear disaster did contaminate hundreds of square miles of the region

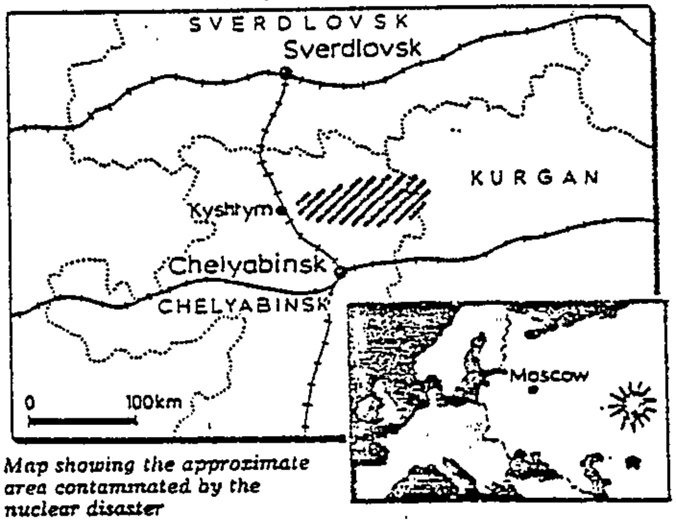
Dr Zhores Medvedev is a biochemist working at the National Institute for Medical Research, London

In my article "Two decades of dissidence" (*New Scientist*, vol 72, p 264), I mentioned the occurrence at the end of 1957 or beginning of 1958 of a nuclear disaster in the southern Urals. I described how the disaster had resulted from a sudden explosion involving nuclear waste stored in underground shelters, not far from where the first Soviet military reactors had been built; how strong winds carried a mixture of radioactive products and soil over a large area, probably more than a thousand square miles in size; and how many villages and small towns were not evacuated on time, probably causing the deaths later of several hundred people from radiation sickness.

I was unaware at the time that this nuclear disaster was absolutely unknown to Western experts, and my *New Scientist* article created an unexpected sensation. Reports about this 20-year-old nuclear disaster appeared in almost all the major newspapers. At the same time, some Western nuclear experts, including the chairman of the United Kingdom Atomic Energy Authority, Sir John Hill, tried to dismiss my story as "science-fiction", "rubbish" or a "figment of the imagination".

However, about a month later my story was confirmed by Professor Lev Tumerman, former head of the biophysics laboratory at the Institute of Molecular Biology in Moscow, who had emigrated to Israel in 1972. Tumerman visited the area between the two Ural cities—Cheliabinsk and Sverdlovsk—in 1960. He was able to see that hundreds of square miles of land there had been so heavily contaminated by radioactive wastes that the area was forbidden territory. All the villages and small towns had been destroyed so as to make the dangerous zone uninhabitable and to prevent the evacuated people from returning. Tumerman's eye-witness evidence did not, however, convince all the experts, including Sir John Hill, of the truth of this disaster. Doubts remained that the story was exaggerated. These doubts convinced me of the need to collect more information that would throw light on the real scale of this nuclear disaster.

Different kinds of nuclear accidents release different kinds of radioactive products into the environment. If *reactor nuclear waste* is scattered from a storage area the result will be quite specific. The numerous short-lived radioactive isotopes, with very intensive gamma and beta radiation, will already have disappeared during the storage period. Only long-lived isotopes, which constitute about 5 to 6 per cent of the initial radioactivity, remain dangerous after the first two to three months. Radioactive strontium-90 and caesium-137 are the most important of these. Both have half-lives of about 30 years. Caesium-137, as an isotope with gamma radiation, is more dangerous for external irradiation. However, it is less cumulative and, because it is more soluble and is not fixed permanently in biological structures, it disappears more rapidly from animals and the soil. Strontium-90 is a close analogue of calcium and is able to substitute for calcium in both bones and soil. Since calcium forms part of permanent body structure, this means that strontium-90 can be fixed in animals for many years, while it may remain for hundreds of years in the soil. This is why strontium-90, which emits beta radiation,



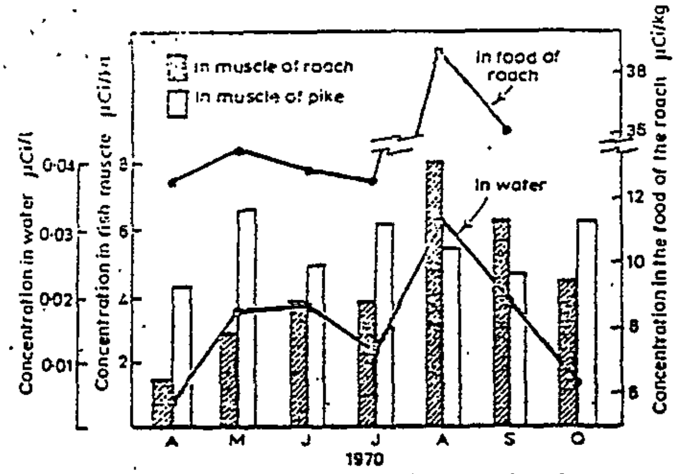
Map showing the approximate area contaminated by the nuclear disaster

is considered the most dangerous product from nuclear bomb tests and the nuclear industry.

If the nuclear disaster in the Urals really caused the contamination of hundreds or thousands of square miles of territory, this area must still be polluted today—heavily by strontium-90, and partly by caesium-137. The soil, soil animals, plants, insects, mammals, lakes, fish and all other forms of life in this area would still contain significant amounts of strontium-90 and caesium-137. The random distribution of radioactive isotopes during an accident of this type would cause the isotope concentration level to vary enormously from place to place. In many areas the external and internal radiation would seriously threaten the life of many species—increasing their mutation load and mortality, and inducing many other changes. The extremely large contaminated area would also create a unique community of animals and plants, where genetic, population, botanical, zoological and limnological research into the influence of radioactive contamination could be studied in its natural conditions.

Critics of Tumerman's and my story can obviously ask: why then did Soviet scientists miss this chance to study the unique radiobiological and genetic problems, which this enormous (certainly the largest in the world) radioactive environment provided for long-term study?

The answer is very simple—the Soviet scientists *did not miss this chance*. More than 100 works on the effect of strontium-90 and caesium-137 in natural plant and animal populations have been published since 1958. In most of these publications, neither the cause nor the geographical location of the contaminated area are indicated. This is the unavoidable price of censorship. However, the specific composition of the plants and animals, the climate, soil types and many other indicators leads to the inevitable conclusion that it lies in the south Urals. (In one publication, the Cheliabinsk region is actually mentioned—a censorship slip.) The terms of observation—10 years in 1968, 11 in 1969, 14 in 1971, and so on—reveal the approximate date of the original accident. Finally, the scale of the research (especially with mammals, birds and fish)



Variations in the concentration of caesium-137—based on the research of A. I. Il'enko

indicates clearly that rather heavy radioactive contamination covered hundreds of square miles of an area containing several large lakes.

I had known about the nuclear waste explosion in the Urals area since 1958. My professor at that time, Vsevolod Klechkovsky, who was a leading expert in the use of radioactive isotopes and radiation in agricultural research, was given the job of setting up an experimental station within the contaminated territory. The station was to study the effect of radioactive isotopes on plant and animal life and to monitor the so-called "secondary distribution" of the contamination. Radioactive pollution of this type cannot be confined within the initial area, since soil erosion and biological distribution constantly widen the radioactive region. The specific activity of the contamination declines with time both in the original area and the new neighbouring ones. Klechkovsky offered me a job at this station, but I did not accept it as the work was classified. A number of junior researchers from his department of agrochemistry and biochemistry at the Timiriazev Agricultural Academy, however, did go to work there, and still do today.

At the beginning all work associated with this nuclear disaster was considered as highly classified. There was no chance of publishing any research results. The situation changed slightly after Krushchev's demise, because blame could then be laid on the nuclear authorities appointed by him. The chairman of the State Committee for Atomic Energy of the USSR, Professor Vasily Emelyanov, was dismissed from his post in 1965; some other high officials in both the peaceful and military branches of the atomic energy industry went as well.

It was too late in 1965/1966, and it was considered unnecessary, to acknowledge the catastrophe that had taken place years before. But at least the high level of secrecy which had surrounded the disaster was lifted. Many experts from the Soviet Academy of Sciences and other research establishments were allowed to start comprehensive research in the contaminated area and to publish their results in Soviet academic journals. The ending of Lysenko's domination in biology and genetics also helped this change in attitude. Several new research institutes and units specialising in genetics, radiobiology and ecology, set up in 1965 and 1966, pressed hard for access to this unique radioactive environment.

These studies started, unfortunately, several years *after* the initial impact of the radioactive hazard on the community which comprised all levels of life—from soil bacteria through to large animals, plants and trees. Farm animals and plants, as well as the human population, were included in places of "secondary distribution" where the radioactivity level had not been so high as to force evacuation.

One of the first works that pointed to a possible serious industrial nuclear disaster was published in 1966 (see *Atomnaya Energiya*, vol 18, p 379). At first glance the paper appeared to be purely mathematical. Its title—"The calculation method for the distribution of radioactive contamination in water and bottom deposits of non-running water lakes"—was rather theoretical, and the whole text was saturated with mathematical equations. This study was based on measurements that had been taken in two lakes contaminated by industrial radioactive waste five years previously. (Since the paper had been submitted for publication in May, 1964, the work must have been completed some time in 1963.) The author, F. Rovinsky, found that the isotope composition was complex at first, but after the first few months strontium-90 became dominant. The water radioactivity (the level in absolute figures was not given) fell quickly during the first two years because of absorption by the silt. Then some kind of equilibrium was established between the bottom silt deposits and the water. The theoretical calculations and the experimental picture were almost identical. One can find hardly anything wrong with the whole work or the "experimental contamination", except for the size of the two lakes referred to. "The experimental lakes were," wrote Rovinsky, "eutrophic types, the first was 11·5 sq. km in size and the second was 4·5 sq. km, both almost round in shape." It is rather hard to believe that anyone in his right mind would contaminate two such large lakes just to confirm some mathematical calculations. However, I did not find any other research on these two particular lakes.

A third contaminated lake appeared in two papers by A. I. Il'enko, published at the beginning of the 1970s (see *Voprosy Ichtiologii*, vol 10, p 1127; vol 12, p 174). Il'enko had studied the distribution of caesium-137 and strontium-90 in water, plankton, water plants, and different species of fish between 1968 and 1970, but the lake had been contaminated many years before. He gave the actual isotope concentration of both isotopes in this lake. It varied every month depending very much on seasonal conditions, and with maximum peaks during October and July. Such variations could only be typical of a running water lake with a contaminated basin. During the summer of 1969, the concentration of strontium-90 in the water was 0·2 microcurie per litre (µCi/l.), and that of caesium-137 was 0·025 µCi/l. Both figures are 100 times higher than contamination levels in ponds created specifically for research purposes, both in the USSR and other countries.

A lake with 50 000 000 curies

The purpose of Il'enko's work was to study food chains among different forms of life in the lake. Pike were the largest and final link in the chain. Il'enko had measured the isotope concentration in the bones and muscle of more than 100 pike, some weighing as much as 25 to 30 lbs. The lake was not a rich one, since only four species of fish were found there. And as it is important for food chain studies that the population balance is not seriously affected, the number of pike in the lake must have been at least 10 to 20 times the number studied. A lake containing this number of large pike must be between 10 to 20 square kilometres in size. One would need at least 50 000 Ci to contaminate such a lake with strontium-90 up to the level of 0·2 µCi/l, that is if it were non-running and not too deep. For a running water lake the amount would have to be much greater. But in either case such a level of radioactivity is far too high to handle for experimental purposes.

The lakes in the Urals region usually have very thick bottom silt deposits. The total amount of strontium-90 in the bottom silt of the two lakes which Rovinsky studied was at least 10 times higher than in the water, once equilibrium was reached. However, these were non-running-water type lakes. The lake studied by Il'enko, had an intensive turnover of its water supply—the strontium-90 concentration could vary up or down by more than 400 per cent within one month. These conditions meant that the bottom silt and the water plants became the main accumulators of radioactive materials—a process which had started many years before Il'enko's experiments. Il'enko calculated that the total amount of caesium-137 and strontium-90 in the water plants, plankton and silt was about *1000 times higher than in the water*. For example, the concentration of caesium-137 in water plants varied from 10 to 38 μCi/kg.

This means that the total minimum amount of strontium-90 and caesium-137 in the whole lake must be around 50 million curies. And this enormous amount of radioactivity filtered into the lake from the lake's basin! It is well known that soil fixes strontium very strongly, so only a small fraction could have filtered through with the soil water—probably some five to six per cent over several years.

It is, of course, impossible to know precisely how many hundreds of millions of curies of strontium-90 and caesium-137 would have to be fixed in its basin for such an enormous amount of radioactivity to accumulate in a running water lake. There are no precedents for such research. This radioactivity is equivalent to thousands of tons of radium. Could anyone imagine that this amount of radioactive material would be distributed over the area surrounding the lake, just for "experimental" purposes?

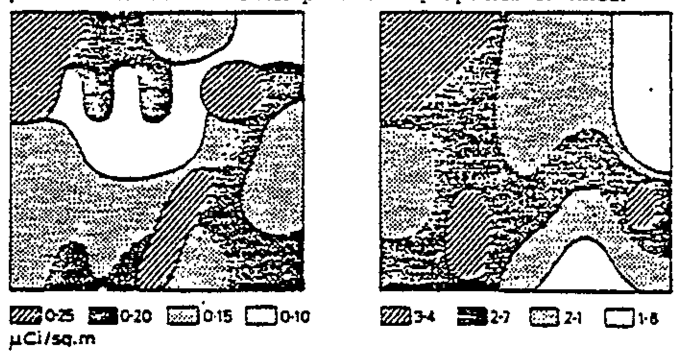
Many papers have been published on the different species living in the contaminated area. The levels of soil contamination were usually the same with the different experiments—from 0·2 to 1·0, from 1·0 to 1·5 and from 1·8 to 3·4 mCi of strontium-90, and 4·0 to 7·0 μCi of caesium-137 per square metre between 1965 and 1969. Il'enko and his collaborators also carried out several studies of mammals *at the same time* as they were doing their work on the lake's population, between 1968 and 1970. Since the samples of fish and animals were taken continuously, the whole research was certainly carried out in the same environment. In two studies of mammals, where food chains were also the main research aim, about 2000 individual animals from 15 different species were killed (see Zoologicheskii Zhurnal, vol 49, p 1370; Zhurnal Obschei Biologii, vol 31, p 698). Small animals, such as mice, rats and rabbits, are poor indicators of the size of a research area. However, these two papers reported killing 21 deer from the contaminated area. This final link of the food chain is indeed rather revealing. Since the shooting had to be done without causing any serious depletion in the natural population or species ratios, at least 100 deer must have been available. Deer migrate normally over large distances, especially during winter, so the area covered should have been at least 100 square miles.

The level of soil contamination by strontium-90, of between 1·8 and 3·4 mCi/sq. m, is also much higher than any possible "experimental" contamination. About one million curies of strontium-90 would be necessary to obtain such an "experimental" field.

Works by other authors, in which the plants, soils and soil animals were studied, also indicated an area on a geographical scale, not just a fenced-off field. Their identical levels of radioactivity and cross-references to Il'enko's work indicate that it was in fact the same "experimental" area these authors were studying. The contaminated territory had many different soil types, consisting as it did of meadows, hills, plains and various kinds of forests. In general, within any contamination area there were at least six or seven ecological groups.

A large research team, headed by academician N. P. Dubinin, has carried out work on the population genetics of the area—the frequency and pattern of chromosomal aberrations, comparative radio-sensitivity, selection of radio-resistant forms, and so on. It is clear that they were working in the same contaminated area as the one used for the other studies. The authors refer to Il'enko's work when quoting the level of radioactivity as being 1·8 to 3·4 and 1·0 to 1·5 mCi/sq. m. They also acknowledge that the area was not contaminated on purpose for their experiments, and that they had only been able to start their radiobiological and genetical observations *seven years after the organisms, selected for research purposes, had already been living in the radioactive environment.* (see Uspekhi Sovremennoi Genetiki, vol 4, p 170).

This lapse of time was a definite research disadvantage. The early adaptation stages had been missed and the initial level of irradiation by the mixture of short-lived and long-lived isotopes was unknown. Despite these methodical aberrations, the authors were able to find a selection of more resistant forms and some other genetical population changes in soil algae (chlorella), many plants (mostly perennial), and rodents, particularly species of mice.



Left: average concentration of strontium-90 (μCi/g of dry weight) in plants in a section of the contaminated area; and right: contamination of the soil with strontium-90 (μCi/sq.m)—based on the work of A. I. Il'enko in 1967. The distributions are random and therefore probably accidental

The special aspect of the work, which I wish to emphasise here, is the size of the research area. For example, the research team started their work on rodents with a population that had *already lived 30 generations in a radioactive environment*. One has to be certain for population genetics work that the individual animals being used for the different measurements are the true ancestors of those animals which lived in the area when the original radioactive contamination occurred. Rodents do not migrate very far during their adult life, perhaps about 1000 metres. However, with each new generation the migration from the ancestral environment will be even further. During 30 generations, migration could reach as much as 20 to 30 kilometres, which means 400 to 900 square kilometres of radioactive environment. Dubinin and his colleagues do not give the exact size of their research area, but they do admit that all the animals they studied had really lived in the radioactive zone over all these years.

Single-cell soil algae (chlorella) are extremely resistant to radioactive contamination, so their level of genetical damage should be much higher than for those species which just could not survive. Dubinin and his team took samples of chlorella some five years, or 200 generations, after the radioactive contamination had occurred. The work was clearly carried out in a different area, one perhaps where only the algae could have survived. The radioactivity of the soil was much higher, its maximum activity being $1 \cdot 0^{11}$ disintegrations per kilogramme of soil per minute. This activity calculated per square metre is about five curies for a surface layer of 8 to 10 cm depth!

There was a very uneven distribution of radioactive contamination over the area used for this research. The work that has been published on plants and animals was carried out in places where these animals and plants could live for many generations. Other areas, where they were not able to survive, were certainly not explored so thoroughly. But the existence of such areas in this general geographical location has been acknowledged by Dubinin. In his autobiography, *Vechnoe Dvizhenie*, he describes how his group carried out long-term research in an area "contaminated by high doses of radioactive substances", where "some members of the species have died out, some are suffering and declining slowly, while others have evolved a higher resistance".

The nature of the plant and animal species referred to in these research papers—there are more than 200 species in all—can easily indicate the approximate geographical location of the area under study. The mixture of European and Siberian species points to the Urals. This conclusion is confirmed by the accidental acknowledgement in one of the recent works of Il'enko and his collaborators that *the animals for their work had been collected in the Cheliabinsk region*. This particular research was done during the autumn of 1971 and the animals had been living in a radioactive environment for 14 years—in other words since the autumn of 1957.

The papers, that I have referred to, represent only a small fraction of the research data that has been published on this contaminated environment in different Soviet scientific journals. The nuclear authorities in Britain and the US probably put more trust in the expensive information they receive from monitoring global fall-out or from space-satellite surveillance. They certainly do *not read* such Soviet journals as *Voprosy Ichtiologii*, *Genetika* or *Zoologicheskii Zhurnal*. There are probably very few foreign scientists who read these journals regularly either. And even fewer who can understand the meaning of the many methodical omissions.

This is why so many experts were puzzled and doubtful about my article in *New Scientist* last November. Science fiction or not, many millions of curies of strontium-90, caesium-137 and other radioactive isotopes did contaminate a very large area of the South Urals region, where the first Soviet military reactors were built in the late 1940s. The nature of the contamination certainly excludes the possibility that it was a reactor accident or a real atomic explosion. The facts in the published materials agree much better with an accident in a nuclear waste disposal site. How it happened, and what was the real human price of this accident, has not yet been revealed. Soviet secrets can often be extremely long-lived. But whether the sceptics, who felt that the burial of nuclear waste in the USSR or elsewhere could not have led to an accident remotely resembling the one I described in my previous *New Scientist* article, believe it or not, there are no doubts that this nuclear disaster in the Urals did happen around 1957/58. And we must take this accident as a warning to ensure that such a tragedy does not happen again. □

APPENDIX III

CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

11 NOV 197

Mr. Richard E. Pollock, Director
The Citizens' Movement for Safe and Efficient Energy
(Critical Mass)
P.O. Box 1538
Washington, DC 20013

Dear Mr. Pollock:

This is in reply to your letter of 2 September requesting, under the Freedom of Information Act, all information in our files relating to a nuclear disaster alleged to have occurred in the Ural Mountains in the Soviet Union in 1958. This reply also will cover documents forwarded to us by the Energy Research and Development Administration on 23 September 1977. These CIA documents were found in ERDA files while they were processing a similar FOI request you had levied on them.

We have reviewed all the items concerned and I am enclosing copies of 14 of them for your retention. The first three, sent in their entirety, are:

1. Newsclipping, Christian Science Monitor, dated 12 January 1977.

2. Foreign Broadcast Information Service item, dated 11 November 1976.

3. Foreign Broadcast Information Service item, dated 11 November 1976.

You will note in each of the remaining items portions have been deleted under the provisions of the Freedom of Information Act. I am listing the items below, and alongside each is the appropriate exemption from the Freedom of Information Act which explains why the deletion had to be made. An explanation of the exemptions follows later in this letter.

Documents	Exemptions
4. CS-3/389,785, dated 4 March 1959.	(b)(1), (b)(3)
5. CS-K-3/465,141, dated 16 February 1961.	(b)(1), (b)(3)
6. Memorandum, dated 27 December 1976.	(b)(3), (b)(6)
7. TDCS-3/356,555, dated 21 May 1958.	(b)(1), (b)(3)
8. CS-3/407,678, dated 5 August 1959.	(b)(1), (b)(3)
9. 00-B-3,202,034, dated 5 December 1961.	(b)(1), (b)(3), (b)(6)
10. 00-B-3,204,092, dated 21 December 1961.	(b)(1), (b)(3), (b)(6)
11. 00-K-323/20537-76, dated 20 September 1976.	(b)(1), (b)(3), (b)(6)
12. 00-E-324/01015, dated 24 January 1977.	(b)(1), (b)(3)
13. 00-B-321/06645-77, dated 25 March 1977.	(b)(1), (b)(3), (b)(6)
14. Plant Summary, undated.	(b)(1), (b)(3)

There were also a number of documents which could not be released, even with deletions. I am listing them below, and alongside each is the number of the appropriate exemption from the Act which gives the reason why the item could not be released.

Documents	Exemptions
15. 00-B-3/256,712, dated 5 April 1963.	(b)(1), (b)(3), (b)(6)
16. CS-K-3/507/314, dated 16 April 1962.	(b)(1), (b)(3)
17. Briefing, dated 8 December 1976.	(b)(1), (b)(3)
18. OSI-SD-SC/61-7, dated 3 April 1961.	(b)(3)
19. Weekly Surveyor, dated 14 May 1973.	(b)(3)
20. OSI-SD-KH/75-5, dated May 1975.	(b)(3)

21. TDCS-3/416,488, dated 26 October 1959. (b)(1), (b)(3)

22. TDCS-3/418,792, dated 18 November 1959. (b)(1), (b)(3)

23. CS-3/380,057, dated 4 December 1958. (b)(1), (b)(3)

24. CS-3/468,269, dated 23 March 1961. (b)(1), (b)(3)

25. CS-3/477,050, dated 14 June 1961. (b)(1), (b)(3)

26. CS-3/478,158, dated 17 June 1961. (b)(1), (b)(3)

27. CS-3/496,952, dated 26 December 1961. (b)(1), (b)(3)

28. CSLT-K-3/704,634, dated 2 December 1962. (b)(1), (b)(3)

29. CS-3/508,773, dated 27 April 1962. (b)(3)

The applicability of the Freedom of Information Act subsections cited is explained as follows:

(b)(1) applies to material which is properly classified pursuant to Section 1 of Executive Order 11652, and is exempt under Section 5(B) of the same Order;

(b)(3) applies to the Director's statutory obligations to protect from disclosure intelligence sources and methods, as well as the organization, functions, names, official titles, salaries or numbers of personnel employed by the Agency, in accord with the National Security Act of 1947 and the CIA Act of 1949, respectively; and,

(b)(6) applies to information release of which would constitute an unwarranted invasion of the personal privacy of other individuals.

As I mentioned in my letter of 30 September, we are waiving search fees for this request. We are also waiving copying fees of $2.50 for the 25 pages enclosed.

There were also in our files documents pertaining to your request which originated in the Departments of State and Defense. I recommend that you contact them for copies of documents relating to the accident which they authored.

The CIA official responsible for the actions on items 4, 5, 15, and 16 was Mr. Charles A. Briggs, former DDO Information Review Officer; of the actions on item 18 through 20, was Dr. Herbert Rothenburg, Acting Director of the Office of Scientific Intelligence; of item 6, was Mr. Noel Firth, Director of the Office of Imagery Analysis; of item 17, was Mr. Philip A. Waggener, Deputy Director of Strategic Research; and of items 7-14 and 21-29 was Mr. Robert E. Owen, DDO Information Review Officer.

Under the terms of the Freedom of Information Act you have the right to appeal their actions to the CIA Information Review Committee. If you choose to do so, please write to me, stating in full the basis of your appeal.

I have decided to waive all fees normally charged for the processing of such requests.

Sincerely,

Gene F. Wilson
Information and Privacy Coordinator

Enclosures

IPS/JOE/cb/31 Oct 77
Orig. - Adse.
1 - IPS Chrono
1 - IPS F-77-0765 GIP
1 - IPS F-77-0664 GIP
1 - Dept. of Energy (ex-ERDA) (Attn: John A. Griffin, Dir. Div. of Classification)
1 - DDO
1 - OSI
1 - OIA

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INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

(4)

USSR

REPORT NO. CS-3/389,785

Accident at the Kasli Atomic Plant

DATE DISTR. 4 March 1959

NO. PAGES 1

REFERENCES RD CS-3/380,057

1957-1958

SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

In the winter of 1957, an unspecified accident occurred at the Kasli (N 55-54, E 60-48) atomic plant. All stores in Kamensk-Uralskiy which sold milk, meat, and other foodstuffs were closed as a precaution against radiation exposure, and new supplies were brought in two days later by train and truck. The food was sold directly from the vehicles, and the resulting queues were reminiscent of those during the worst shortages during World War II. The people in Kamensk-Uralskiy grew hysterical with fear, with an incidence of unknown "mysterious" diseases breaking out. A few leading citizens aroused the public anger by wearing small radiation counters which were not available to everyone.

CENTRAL INTELLIGENCE AGENCY

This material contains information affecting the National Defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C. Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

COUNTRY	USSR	REPORT NO.	CSK-3/465,141
SUBJECT	Miscellaneous Information on Nuclear Installations in the USSR	DATE DISTR.	16 February 1961
		NO. PAGES	5
		REFERENCES	RD
DATE OF INFO.	1954 to 1960		
PLACE & DATE ACQ.		FIELD REPORT NO.	

THIS IS UNEVALUATED INFORMATION. SOURCE GRADINGS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

SOURCE:

1.

2.

3.

Attachment

(1)

Kyshtym

3. In spring 1958, [redacted] he heard from several people that large areas north of Chelyabinsk were contaminated by radioactive waste from a nuclear plant operating at an unknown site near Kyshtym, a town 70 kilometers northwest of Chelyabinsk on the Chelyabinsk-Sverdlovsk railroad line. It was general knowledge that the Chelyabinsk area had an abnormally high number of cancer cases. To go swimming in the numerous lakes and rivers in the vicinity was considered a health hazard by some people. Food brought by the peasants to the Chelyabinsk market (rynok) was checked by the municipal health authorities in a small house at the market entrance where the peasants also paid their sales tax. How radioactive food was destroyed was unknown to source. Food delivered to the plants, schools, etc., by the kolkhozy and sovkhozy was probably examined by the latter themselves. Until 1958 passengers were checked at the Kyshtym railway station, and nobody could enter the town without a special permit. By what authority the permit was issued and why the checking was discontinued in 1958, source was unable to say. In addition, some villages in the Kyshtym area had been contaminated and burned down, and the inhabitants moved into new ones built by the government. They were allowed to take with them only the clothes in which they were dressed.

4. The plant was probably processing radioactive deposits found in the Urals, among which were huge deposits of zirconium. Source was told this by a friend [redacted] who, in 1953-1954, had a job [redacted] in the Kyshtym-Argayash area. He also told source that [redacted] as early as 1954 that the water of the Techa River, running from Lake Kyzyltash and Lake Ulagach and emptying into the Iset River at Dalmatovo, had become highly radioactive.

5. In late August 1960, source with some 100 other office workers was sent for ten days to help harvest at the Bolshaya Taskina Sovkhoz south of Lake Kaldy, about 50 kilometers north of Chelyabinsk. At the Nadyrov Bridge which crossed the Techa River, he saw a few posters with the inscription: "Drinking strictly prohibited, water polluted" (Pit strogo vospreshchayetsya, voda zagryaznena). While working at the sovkhoz, he did not approach the Techa, because the river bank was a prohibited area. Some distance north of the river there was a continuous ditch about one meter deep and one meter wide, with posters: "No passage, polluted zone" (Prokhod vospreshchayetsya, zagryanennaya zona). Source did not discuss pollution of the Techa with persons on the sovkhoz. In Chelyabinsk he mentioned it t[o] a friend, [redacted] and was told that according to [redacted] father who lived on the Techa somewhere in the Tyumen Oblast, the river was polluted on its lower course als[o].

6. Source vaguely remembered having heard that the Kyshtym area nuclear installation was known as the Post Box 40 installatio[n] ... was managed by (fnu) Sorokin,

7. In March 1958, an explosion wrecked part of the nuclear plant at Kyshtym. Whether the explosion was nuclear or chemical, source could not tell, nor did he have information on casualties. The matter was openly discussed among employees of the Urals Branch of the Academy of Construction and Architecture.

8. Source knew of one case in which work at the Kyshtym plant allegedly resulted in the sexual impotence of an engineer (name unknown) and subsequent divorce. The divorcee was Alina Loy (maiden name), an engineer with the trust Metallurgstroy at Chelyabinsk, who left her husband in 1956 or 1957 after a few months of married life. In summer 1960, she married (fnu) Chulkov, an officer with the combat engineers, who was transferred to Novaya Zemlya in August 1960.

9. While working at the Urals Branch of the Academy of Construction and Architecture, source heard that in 1957 its laboratory of reinforced-concrete construction (chief, /fnu/ Bershtein) had investigated an accident, fall of a smokestack from a huge plant which was being built by the MVD Glavpromstroy or Ministry of Medium Machine Building in the Argayash area.

10. Source was not certain but thought that a second plant might also have been built in the Argayash area by the MVD Glavpromstroy or Ministry of Medium Machine Building.

OIA/TSD 282/76
27 December 1976
Copy

CENTRAL INTELLIGENCE AGENCY

MEMORANDUM FOR: Chief , Division, OSI

SUBJECT : Nuclear Waste Burial Grounds near Blagoveshchensk, USSR

1. This memorandum is in response to your request a nuclear waste burial ground in the western Ural mountains near the town of Blagoveshchensk, USSR.

2. No nuclear waste burial site was identified within the area.

This project is considered complete.

CENTRAL INTELLIGENCE AGENCY

TELETYPED INFORMATION REPORT

This material contains information affecting the National Defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C. Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

TDCS-3/356,555

CLASSIFICATION	DISSEMINATION CONTROLS
COUNTRY: USSR	DATE DISTR. 23 May 1958
SUBJECT: Accidental Atomic Explosion in Chelyabinsk Oblast	PLACE ACQUIRED
DATE OF INFORMATION: May 1958	REFERENCES
APPRAISAL OF CONTENT TENTATIVE	
SOURCE EVALUATION DEFINITIVE	

1. Various Soviet [illegible] and visitors to the Brussels Fair [illegible] independently but consistently, that the occurrence of an accidental atomic explosion during the spring of 1958 was widely known throughout the USSR.

2. The site was identified as (being in) Chelyabinsk Oblast.

3. Rumors are current that many people were killed, however the generally accepted version is that only several score (individuals) died.

[illegible] end of message.

APPROVED FOR RELEASE
DATE [illegible] SEP 1977

TO

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COUNTRY	USSR (Chelyabinsk Oblast)	REPORT NO.	CS-3/407,678
SUBJECT	Radioactive Contamination of an Area in Chelyabinsk Oblast	DATE DISTR.	5 August 1959
		NO. PAGES	1
	II Atomic Accident	REFERENCES	RD
DATE OF INFO.	Prior to June 1959		
PLACE & DATE ACQ.		FIELD REPORT NO.	

SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

SOURCE: [redacted]

On an unknown date prior to June 1959 an accident occurred in Chelyabinsk Oblast which caused radioactive contamination of the soil. As a result, the authorities were forced to take measures to resettle the inhabitants of several populated places in other areas.

(3)

APPROVED FOR RELEASE
27 SEP 1977

Note: Washington distribution indicated by "X"; Field distribution by "#".

COUNTRY USSR

SUBJECT Mysterious Explosion in Chelyabinsk Oblast/Possible Radioactive Fallout Causing Destruction of Trees and Vegetation/Many People Burned as Result of Explosion

DATE OF INFO. Early Spring 61

PLACE & DATE ACQ. Yemanzhelinsk (Chelyabinsk Oblast) Nov 61

REPORT NO. 00B-3,202,034

DATE DISTR. 5 Dec 61

NO. PAGES 2

REFERENCES

THIS IS UNEVALUATED INFORMATION

SOURCE

1.

2.

3. In talking with her she told me that in early May 1961 a terrific explosion ("vzriv") occurred somewhere in the Chelyabinsk Oblast. However, she did not see the explosion or any flash but said that the explosion was so terrific that the ground and buildings shook. A short time after this explosion occurred all the leaves on the trees in and around Yemanzhelinsk and surrounding areas were completely covered with a heavy layer of red dust (in Ukrainian it is called "rzha" and in Russian it is called "korichnyaviy" - brown).

4. Very quickly all the leaves curled up and fell off the trees. (Trees in the Siberian region start blooming during the latter part of April.) She also added that all leafy green vegetables were covered with this same type of dust and curled up and died. However, nothing happened to the populace.

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ARMY | NAVY | AIR | FBI | AEC

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hair and clothes in soft water. However, nothing was mentioned as to [illegible] water wells, streams or rivers.

6. had been in a hospital in Chelyabinsk for medical attention at the time of the explosion and she said that after this blast occurred she saw many people, both men and women, brought to this hospital for medical attention. The hospital was completely filled with victims of the explosion. said that some were bandaged and some were not. She said that the skin on their face, hands and other exposed parts of the body was sloughing off. This is all she could tell me at this time.

7. She said the area in which the explosion occurred is a restricted area, open only to die-hard Communist Party members.

-end-

COUNTRY: USSR

REPORT NO.: COB-3,204,092

SUBJECT: Mysterious Explosion in Chelyabinsk Oblast/Possible Radioactive Fallout Causing Destruction of Trees and Vegetation/Many People Burned as Result of Explosion/US Accused of Transmitting Poison Through the Air Causing People to be Burned and Destruction of Trees & Vegetation.

DATE DISTR.: 21 Dec 61

NO. PAGES: 2

REFERENCES: Supplement to 3,202,034

DATE OF INFO.: May 60

PLACE & DATE ACQ.: Yemanzhelinskaya/Chelyabinsk (Chelyabinsk Oblast) Nov 61

THIS IS UNEVALUATED INFORMATION

SOURCE:

1. In May 1960, I mentioned to her that something unusual was occurring in Yemanzhelinskaya. I told her that all the leaves on the trees in and around Yemanzhelinskaya and surrounding areas were completely covered with a fine layer of red dust. Very quickly all the leaves on the poplar trees became extremely shiny brown, curled up and fell off. Leafy green vegetables were covered with this same type of dust and curled up and died.

2. I also told her at that time that there were announcements over the radio and also through the newspaper media accusing the US of transmitting poison through the air which was carried by the rain falling all over the Chelyabinsk Oblast causing people to be burned and destroying trees and vegetation. The people were advised not to wash their clothes or hair in the rain water nor bathe in this water because they would be burned. The newspaper which I received in Yemanzhlinskaya was called the "Trud". Water for the homes was supplied by pipe lines which came from Chelyabinsk.

3. had been in this new hospital for approximately three months. She entered the hospital around May 1960 and was released in July 1960. I do not remember if this hospital had a name but it was new, four stories high, and as of July 1960 it was not completely constructed. The hospital was located on Zeleniy Magazin ulitsa (Green Magazine Street) which is in the southern section of Chelyabinsk.

4. told me that in talking with other patients in the hospital, including the employees, she was advised that sometime in April 1960 a terrific explosion (vzriv) occurred somewhere in the Chelyabinsk Oblast. Unfortunately, no one knew where this blast occurred but there was talk

that there was a "secret zone" approximately 50 to 60 kilometers from Chelyabinsk and where this explosion occurred. Also that this secret zone was supposed to be in dense woodlands and cleverly camouflaged. Unfortunately I have no idea as to what direction this zone is located from Chelyabinsk.

5. Both and I saw some of the people in this hospital who we were told came from the area where the explosion had occurred. Some of them were bandaged and some were not. We could see the skin on their face, hands and other exposed parts of the body to be sloughing off. These victims of the blast were brought into this hospital during the night. It was a horrible sight. From room, which was on the fourth floor of the hospital, we were able to see these people walking around on the hospital grounds, some of whom were bandaged and some were not.

6. 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.

7. Both and I had no idea what the cause of the explosion was nor did we know of any destruction or damage to any facilities or town where the explosion may have occurred. I have no idea where this explosion occurred, nor what time of day or date, except that told me that this blast occurred sometime in April 1960.

8. The prohibited zone where the explosion occurred is "only" open to die hard Communist Party members and workers who also lived there.

[redacted]

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DIRECTORATE OF OPERATIONS

Foreign Intelligence Information Report

(11)

COUNTRY	USSR	DCD REPORT NO.	OOK-323/20537-76
SUBJECT	Nuclear Explosion at Chelyabinsk-40/	DATE DISTR.	20 September 1976
		NO. PAGES	2
		REFERENCES	

DATE OF INFO. 1956-

THIS IS UNEVALUATED INFORMATION

SOURCE

1.

2.

3. According to the prevailing opinion in Chelyabinsk, Chelyabinsk-40 was a production site for nuclear devices. Chelyabinsk-40 is actually located in Kyshtym which is some one hundred kilometers northwest of Chelyabinsk. In about 1956 there was an explosion at Chelyabinsk-40; the explosion lighted up the sky for a great distance and the newspapers in Chelyabinsk made a flimsy attempt to proclaim the event an unusual occurrence of the northern lights. The chief evidence of the explosion was the tremendous number of casualties in the hospitals of Chelyabinsk. Many of the casualties were suffering from the effects of radiation. Shortly after the explosion a scientific research institute to study effects of radiation was established in Chelyabinsk, presumably as a result of the accident at Chelyabinsk-40. [Collector's comment: Source did not actually witness the explosion and could provide no details on its cause.]

4.

5.

- end -

OPERATIONS

COUNTRY	USSR/	REPORT NO.	OOE-324/01015-77
SUBJECT	Soviet Detonation of 20 Megaton Device in 1950's in Above-Ground Test/ Possible Explanation for Recent News Reports on Nuclear Accident and "Vast Nothing" Area in Ural Mountains	DATE DISTR.	24 January 1977
		NO. PAGES	1
		REFERENCES	

DATE OF INFO. 1959 - 1960

THIS IS UNEVALUATED INFORMATION

SOURCE

1. Recently there have been accounts in US newspapers concerning comments made by two former citizens of the USSR on a "vast nothing", an area within the USSR where it is speculated a nuclear accident occurred in the late 1950's. There was a top secret Soviet film/ which showed a nuclear test that had occurred in an unspecified region of the Ural Mountains. It is likely, although not certain, that the test occurred in the 1957-58 period, and this may account for the "vast nothing" mentioned in the news accounts.

2. According to the film, the USSR constructed a completely new city in a valley in the Ural Mountains region for the test. A subway was constructed under the village, and one of the major purposes of the test was to see if the subway could withstand a nuclear attack. The inhabitants of the village were goats and sheep, and the post-explosion photography showed the effects of a nuclear blast upon animal life as well as building materials. Military equipment was placed around the village, and the effects of the explosion upon armaments of war also were depicted in the film.

3. The bomb itself was described as a 20 megaton device which was dropped from an airplane. The flash of the explosion illuminated the mountains which surrounded the village. The city virtually was eliminated, but the subway survived the explosion. Because of the film's classification, those who saw it were instructed to treat the whole matter as highly classified.

4. Recent newspaper accounts quote two Soviet emigres, one in London and the other in Israel, who knew something about the "vast nothing". One of the emigres said a 60 square mile area in the Ural Mountains was desolate and still heavily radioactive in 1961. It is possible the

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DIRECTORATE OF OPERATIONS

Foreign Intelligence Information Report

COUNTRY	USSR	REPORT NO.	OOB-321/06645-77
SUBJECT	1958 "Kyshtim Disaster"/Nuclear Accident Involving Plutonium Wastes from Military Nuclear Reactors	DATE DISTR.	25 March 1977
		NO. PAGES	1
		REFERENCES	

DATE OF INFO. June 1961

THIS IS UNEVALUATED INFORMATION

SOURCE

This information is related in the first-person as stated by the [redacted]

1. In June 1961, I near Chelyabinsk, an industrial town in the Urals a few hundred kilometers south of Sverdlovsk. , we headed north towards Sverdlovsk and Beloyarsk by car.

2. About 100 kilometers from Sverdlovsk, we crossed a strange, uninhabited and unfarmed area. Highway signs along the way warned drivers not to stop for the next 20 to 30 kilometers because of radiation. The land was empty. There were no villages, no towns, no people, no cultivated land; only the chimneys of destroyed houses remained. I asked the driver to stop because I wanted to drink water. The driver refused. "One doesn't stop here. You drive quickly and cross the area without any stops," he said.

3. In conversations with people in the area, I was told that the area was the site of the "Kyshtim Disaster," so called after a town about 200 kilometers south of Sverdlovsk and 250 km. east of Blagoveshnsk. An accident had occurred three years earlier, that is, in 1958, that was caused by a blast at the storage site of nuclear waste from military nuclear reactors. I was told that the accident was caused by the negligent storage of plutonium wastes. Hundreds of people perished and the area became and will remain radioactive for many years. One of the current topics of conversation at the time was whether eating fish or eating crabs from the radioactive rivers of the area was more dangerous.

— end —

491,3 (14)

PLANT SUMMARY

1. Name

Atomic Energy Installation
[redacted]

2. Location

KYSHTYM 55 44 N 60 35 E

a. Address
N/A

b. Pinpoint
The restricted area of Kyshtym is approximately 60 km N/S and 45 km E/W. The railroad from Kasli to Karabash runs diagonally from the NE corner to the SW corner with Kyshtym in the center. It includes the installations at Techa (reactor) and Sungul (radiological institute).

3. History

A large atomic plant and a workers' settlement were established about 15 km NE of Kyshtym, probably at Techa on Ozero Irtyash, during the period 1945 to 1948. Approximately 70,000 inmates of 12 labor camps, participated in the construction. In the spring of 1948, the entire population, including all PWs and forced laborers had to evacuate the Kyshtym restricted area. The population was replaced by Communists and their dependents who came to Kyshtym from all over the USSR. They were reportedly never to leave the area again.

4. Physical Plant and Equipment

The restricted area covers 2700 sq. km containing eight small lakes with interconnecting watercourses. The atomic plant (reactor) is situated in a tunnel which extends beneath a river, with only a smoke stack visible above ground. One of the lakes was drained and a building of undetermined size was built on its bed with cement, rubber, and lead. Then the lake was refilled with water. A double tracked RR line was built to the area. The underground factory was 30 to 40 meters below the surface and were as follows:
8 small shops all the same size (approx. 50 by 25/28m). They had been blasted out from the slate rock. The vertical walls were coated with reinforced concrete up to a height of approx. 3 - 4 m. They supported a reinforced concrete three center arch roof 6 - 7 m high in the middle of the shop. The ceiling was more strongly armoured than the walls by the addition of cross bond iron bars.
A large shop approx. 100 by 40 m was built in the same way as the smaller shops. The ceiling was supported in the middle of the room by 4 concrete pillars of 1,20 by 1,20 m cross section.

4. Physical Plant and Equipment (Continued)

Construction of the shops was finished and the building of machine foundations started a few days before informant left the camp; these foundations were 1 by 2 m or 0,80 by 1,50 m.
All underground rooms were electrically lighted.
Steel brackets were cast in the walls of the large shop, which should possibly support the rails of cranes.
The thickness of the walls (consisting of the rock and concrete coating) between the shops was approx. 5 m.

5. Production

It is reported this plant contains atomic piles and supplies Sungul. Radiological Institute with radio-active materials. This plant has been reported to be manufacturing components for atomic weapons
In the spring of 1958 hundreds of persons were exposed to radiation and injured as a result of an explosion at the Kyshtym plant.
In early October 1959, an atomic test reportedly took place in Kyshtym.
After the test, such foodstuffs as meat, fish and milk were removed from the retail stores in Sverdlovsk and Chelyabinsk and destroyed. Residents were ordered to turn in food stocks in their houses. Residents were warned against buying agricultural products from farmers.

6. Labor

In this area in 1956 there were military personnel from various army units and arms. With them 16 labor battalions of about 1,000 men each were activated. There were also 25,000 Soviet soldiers of General Vlasov, who had collaborated with the Germans. These men were actually considered as prisoners and were likewise organized into labor battalions. In addition, about 60,000 Soviet convicts of both sexes were employed in the Project.

7. Key Personalities and Organization

N/A

8. Security

Strict security observed. Movement was restricted in the vicinity of the plant. The surrounding fences were considerably removed from the enterprise itself, but the entrances were under permanent military guards. Special passes required.

9. Visits by American and/or Western Observers

N/A

10. Photos Available

N/A

APPENDIX IV

METHOD FOR CALCULATING THE RADIOACTIVE IMPURITY CONCENTRATION IN THE WATER AND THE BOTTOM LAYER OF STAGNANT RESERVOIRS

(UDC 621.039.7:628.515)

F. Ya. Rovinskii

Translated from Atomnaya Énergiya, Vol. 18, No. 4,
pp. 379-383, April, 1965
Original article submitted May 17, 1964

The present article is concerned with certain trends in the migration and redistribution of radioactive impurities in stagnant reservoirs after they have been contaminated only once. The capture of the dissolved impurities by the bottom layer occurs as a result of ion-exchange and molecular adsorption processes. On this basis, we derived equations describing the variation in the concentration of radioactive isotopes in dependence on the time of their presence in the water and the bottom layer. The derived equations make it possible to calculate the impurity percentages in the components of stagnant reservoirs.

It was shown in [1] that radioactive isotopes are distributed among the basic reservoir components (the water, the bottom deposits, and the biological mass) in such a manner that the amount of radioactive isotopes in the biological mass can be neglected. Consequently, a stagnant reservoir can be considered as a two-component system.

In order to predict the contamination levels of the water and the bottom deposits, we shall consider a reservoir where the water volume is V m^3, the surface area of the bottom layer is S m^2; while the average depth is small, not exceeding 4-5 m. Such a reservoir, which has the shape of a shallow basin, is characterized by intensive turbulent and convective mixing of the water mass, which leads to the interaction of the entire water mass with the bottom layer [2].

We shall assume that the radioactive impurity was introduced only once in an amount equivalent to A Ci, which initially entered only the water mass in the reservoir, so that this amount was instantaneously distributed throughout the entire volume V. We shall denote by Q(t) the amount (supply) of the radioactive impurity in the water and by P(t) the amount (supply) of the radioactive impurity absorbed by the bottom layer, which vary during the time t. Then, we can use the following initial conditions:

$$t=0, \quad Q_0=A, \quad P_0=0,$$

where Q_0 and P_0 are the initial impurity amounts in the water and the bottom layer, respectively. Since the impurity introduced in the reservoir will be subsequently redistributed only between water and the bottom layer, then, without considering for the moment radioactive decay, we obtain

$$A=Q(t)+P(t). \tag{1}$$

The capture of the dissolved impurity by bottom deposits occurs as a result of ion-exchange and molecular adsorption processes, and, therefore, in the general case, the change in the amount of impurity in the bottom layer (Fig. 1) can be described by the following equation:

$$\frac{dP(t)}{dt}=\mu_1 Q(t)-\mu_2 P(t), \tag{2}$$

where μ_1 and μ_2 are constants determining the sorption and desorption rates, respectively.

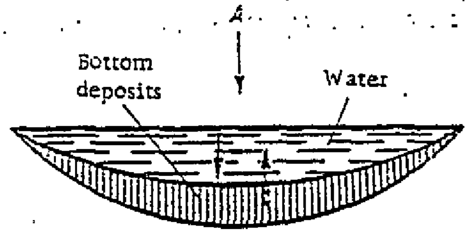

Fig. 1. Scheme of the migration of isotopes in a stagnant reservoir.

With a consideration of the initial conditions and Eq. (1), the solution of Eq. (2) is given by

$$P(t)=\frac{A}{1+\frac{\mu_2}{\mu_1}}\left(1-e^{-\mu_2\left(1+\frac{\mu_1}{\mu_2}\right)t}\right), \tag{3}$$

$$Q(t)=\frac{A}{1+\frac{\mu_2}{\mu_1}}\left(\frac{\mu_2}{\mu_1}+e^{-\mu_2\left(1+\frac{\mu_1}{\mu_2}\right)t}\right). \tag{4}$$

We shall respectively denote by $p(t)$ and $q(t)$ the mean values of the radioactive impurity's surface density in the bottom layer and its volume concentration in water:

$$p(t)=\frac{P(t)}{S}=\frac{A}{S}\cdot\frac{1}{1+\frac{\mu_2}{\mu_1}}\left(1-e^{-\mu_2\left(1+\frac{\mu_1}{\mu_2}\right)t}\right), \tag{5}$$

$$q(t)=\frac{Q(t)}{V}=\frac{A}{V}\cdot\frac{1}{1+\frac{\mu_2}{\mu_1}}\left(\frac{\mu_2}{\mu_1}+e^{-\mu_2\left(1+\frac{\mu_1}{\mu_2}\right)t}\right). \tag{6}$$

After finding the limiting values of these quantities for $t\to\infty$, we reach the conclusion that, in the course of time, equilibrium with respect to the impurity is established between the water and the bottom layer in the reservoir:

$$\mu_1 V\bar{q}=\mu_2 S\bar{p}, \tag{7}$$

where $\bar{q}$ and $\bar{p}$ are the equilibrium concentrations in the water and the bottom layer, respectively.

By using Eqs. (1) and (7) and introducing a correction for the decay, we finally obtain:

$$p(t)=\bar{p}\left(1-e^{-\mu_2\frac{A}{A-\bar{p}S}t}\right)e^{-\lambda t}, \tag{8}$$

$$q(t)=\left(\bar{q}+\frac{A-\bar{q}V}{V}e^{-\mu_2\frac{A}{\bar{q}V}t}\right)e^{-\lambda t}. \tag{9}$$

Consequently, if the values of A, V, and S are known, the prediction of the impurity concentrations in the water and the bottom layer consists in determining $\bar{q}$, $\bar{p}$ and μ_2 (or μ_1).

We shall assume that we know q_1 and q_2—the results of measurements of the volume concentration at the instants of time t_1 and t_2. Then, after eliminating μ_2, we obtain

$$\frac{(q_2-\bar{q})V}{A-\bar{q}V}=\left(\frac{(q_1-\bar{q})V}{A-\bar{q}V}\right)^{t_2/t_1}. \tag{10}$$

TABLE 1. Hydrochemical Composition of the Lake Waters

Reservoir	Composition, mg/liter								
	Na^{+1}	K^{+1}	Mg^{+2}	Ca^{+2}	Cl^{-1}	HCO_3^{-1}	SO_4^{-2}	SiO_2	Total
First	105.3	9.3	56.4	25	57.1	354	125	4.7	759
Second	943	45.6	110.5	8.5	866	1282	127	3	3493

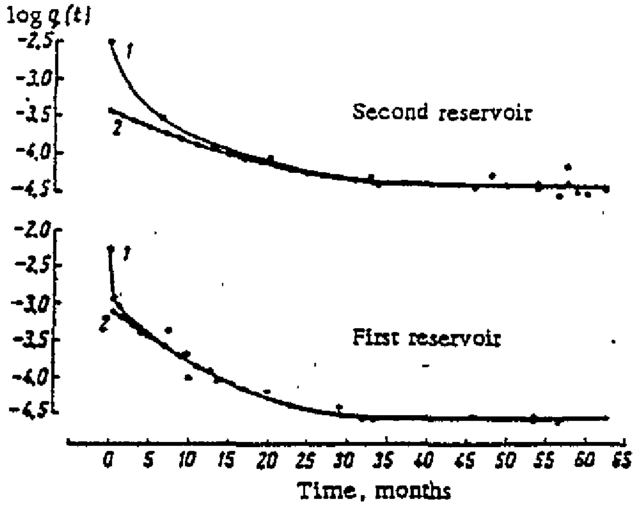

Fig. 2. Comparison between the actual (●) variation (1) of the concentration of isotopes in the water and the calculated (○) curve (2) of Sr^{90} concentration in the waters of the experimental reservoirs.

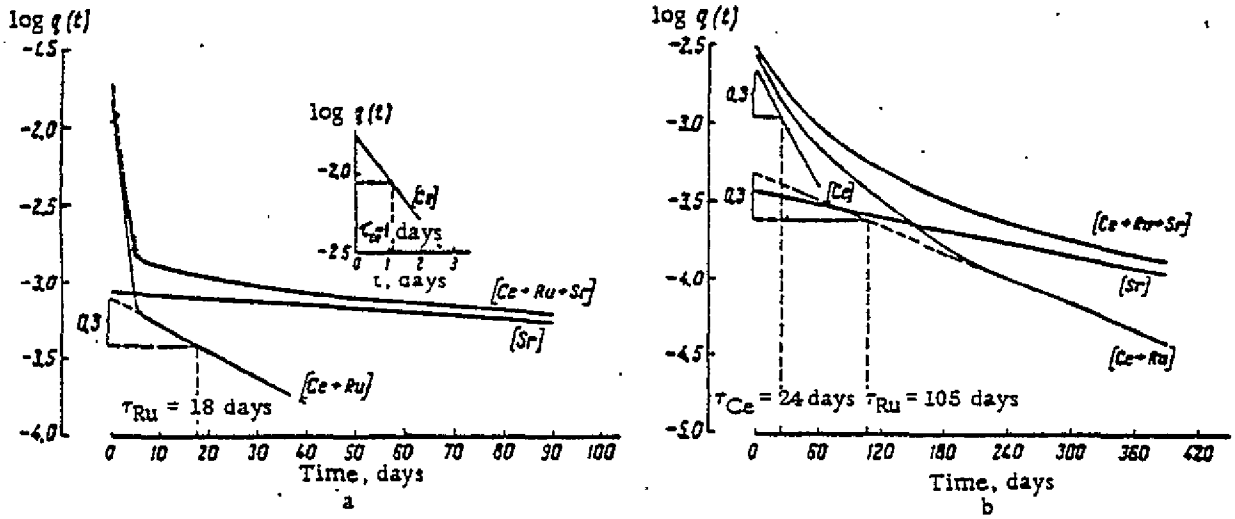

Fig. 3. Determination of the half-life of Ru^{106} and Ce^{144} in the first (a) and the second (b) reservoirs.

It is convenient to express q in explicit form if $\frac{t_2}{t_1} = 2$. In this case,

$$\bar{q} = \frac{Aq_2 - Vq_1^2}{A + Vq_2 - 2Vq_1}, \tag{11}$$

$$\mu_2 = \frac{V(Aq_2 - Vq_1^2)}{At_1(A + Vq_2 - 2Vq_1)} \ln \frac{A - \bar{q}V}{(q_1 - q_2)V}. \tag{12}$$

In practice, it is, of course, advisable to perform more than two measurements of q(t), while the times of measurement should be chosen in the form of terms of a geometric progression with a denominator equal to 2.

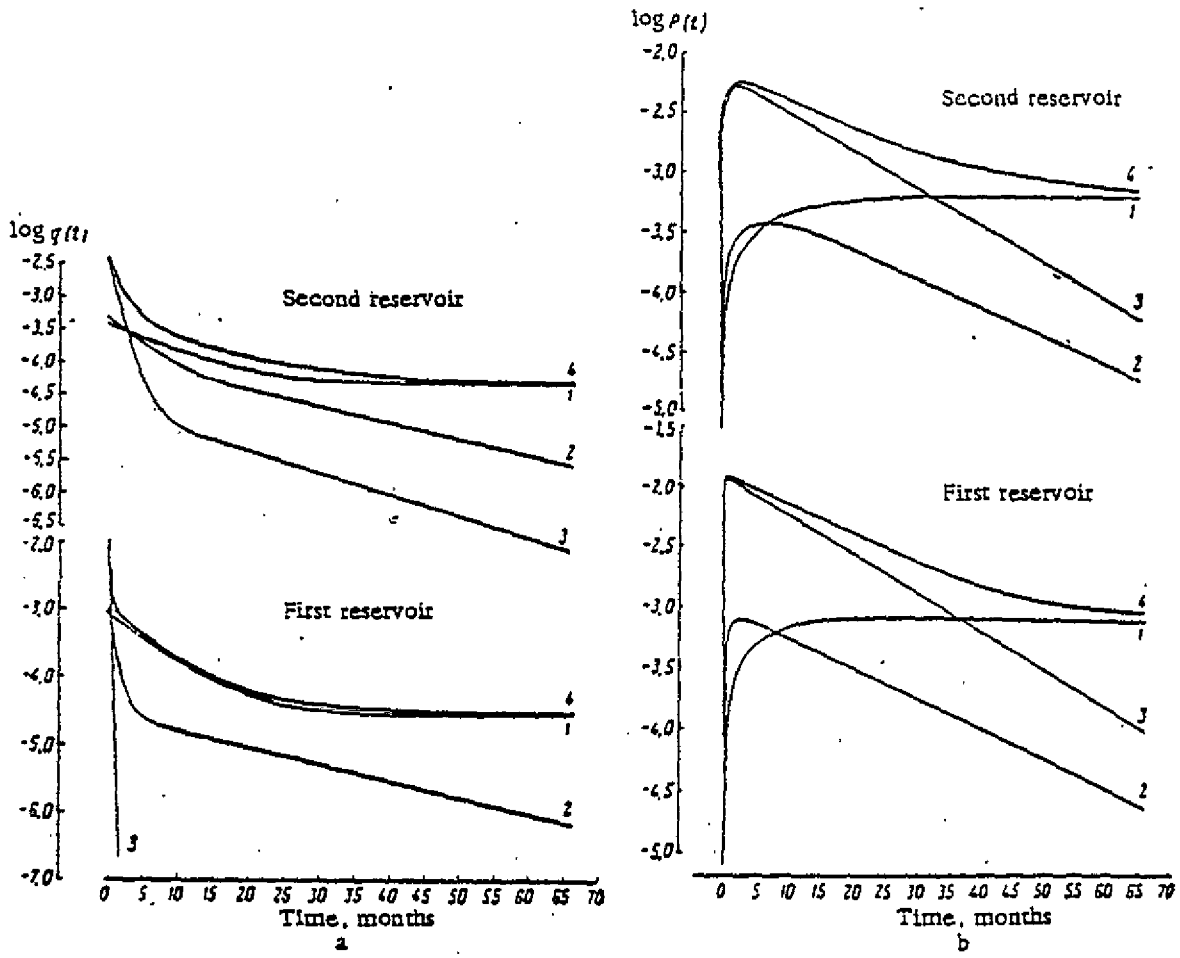

Fig. 4. Calculated concentration curves for radioactive isotopes in water (a) and in the bottom layer (b) of the experimental reservoirs. 1) Sr^{90}; 2) Ru^{106}; 3) Ce^{144}; 4) sum of three isotopes.

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Thus, the above scheme of redistribution of the radioactive impurity in a stagnant reservoir makes it possible to calculate the percentages of the radioactive impurity in the reservoir components at any time after a single instance of contamination.

We shall apply the derived equations to the case of artificial contamination of two stagnant reservoirs by a mixture of Sr^{90}, Ru^{106} and Ce^{144} isotopes.

Eutrophic lakes, one with a surface area of 11.3 km^2 (the first reservoir) and the other with a surface area of 4.5 km^2 (the second reservoir), were used for the experiments. The lakes have shallow, saucershaped bottoms. They have large silt deposits, which have completely smoothed out the initial bottom relief. The shores are partially overgrown with reed; there is an abundance of submerged plants: milfoil (Myriophyllum), aquatic plant (Ceratophylium demersum), and pond weed (Potamogeton). Good conditions for the development of the biological mass prevail in the lakes: the summer temperatures are high, there is a sufficient amount of oxygen and organic matter in the water, the water is well illuminated throughout its depth, etc. The hydrochemical composition of the lake waters is given in Table 1.

The results of the measurements of the concentration of isotopes in the water, which were performed over a period of five years after the isotopes were introduced in the lakes, were made available to us. The total activity of water samples was determined during the first three years, and radiochemical determinations of Sr^{90} were performed during the next two years. The results of these experimental observations are given in Fig. 2.

TABLE 2. Half-Life τ of Some Isotopes in Stagnant Water Reservoirs

Reservoir	Average depth m	τ, days			
		Y^{90}	Ce^{144}	Ru^{106}	Sr^{90}
First	1.0	1.1	1.0	18	116
Second......	1.9	10.9	24	105	180

Moreover, the constants A, V, S, $\overline{q}$, and $\overline{p}$ (besides μ_2) were found experimentally for calculation by means of the derived equations. The μ_2 constant for Sr^{90} was determined by means of Eq. (9), where the q(t) and t values found from curves 1 of Fig. 2 were substituted. It was assumed here that, beginning with the third year after the introduction of radioactive isotopes in the reservoirs, the contribution of Ru^{106} and Ce^{144} to the total activity of water was small in comparison with the contribution of Sr^{90} because of their radioactive decay and adsorption by the bottom layer. This assumption was confirmed by special analyses of the percentages of the above isotopes in the water.

The values of the μ_2 constant for Sr^{90} for the first and the second reservoir were equal to $1.9 \cdot 10^{-4}$ and $3.9 \cdot 10^{-4}$ day^{-1}, respectively.

Then, on the basis of the known constants, the Sr^{90} concentration for the entire period of time was calculated. A comparison between the actual variation of the isotope concentrations in the water and the calculated q(t) curves for Sr^{90} is given in Fig. 2.

The constant μ_2 for a certain isotope is connected with its half-life in water (τ)[1] by the following simple relationship:

$$\mu_2 = 0.693\,\frac{\overline{q}V}{A\tau}.$$

The value of τ for Ru^{106} and Ce^{144} for the first and the second reservoirs can be found by the well-known method of graphical analysis of a complex curve. The points on the curves for instants of times sufficiently close to t_0 represent the concentrations of three isotopes, i.e., [Ce + Ru + Sr]. If we subtract the calculated curves 2 from curves 1 (see Fig. 2), the thus obtained difference curves will correspond to the variation in the concentration of two components in the water [Ce + Ru] (Fig. 3a and b). The rectilinear section of the curves [Ce + Ru] corresponds to the variation of [Ru] in time due to migration (since a correction for the decay of Ru^{106} has been introduced here). The slope of this section of the curve can be used for determining the τ value for Ru^{106}.

Furthermore, if we subtract the [Ru] straight line from [Ce + Ru], we can separate the straight line corresponding to changes in the Ce^{144} concentration in water due to migration: the τ value for Ce^{144} can readily be found with respect to the slope of this straight line (see Fig. 3, a and b).

The half-life constitutes the quantitative characteristic of the migration of radioactive isotopes from the water to the bottom layer in stagnant reservoirs.

The Eq. (9) given above consists of two parts: a certain constant $\overline{q}$ and the variable

$$\frac{A-\overline{q}V}{V}\,e^{-\mu_2\frac{A}{\overline{q}V}t} = \frac{A-\overline{q}V}{V}\,e^{-0.693t/\tau}.$$

It is obvious that τ characterizes the rate at which q(t) tends to $\overline{q}$. The larger the τ value, the slower the rate at which equilibrium between water and the bottom layer is established in the reservoir, and, conversely, the smaller the τ value, the higher the rate at which the equilibrium state is established. Consequently, τ characterizes the equilibrium establishment time, but does not determine the equilibrium concentrations of isotopes in the reservoir.

[1] The term half-life of an isotope in the water of a stagnant reservoir denotes the time interval during which the isotope concentration in the water is reduced by one half solely as a result of isotope migration in the reservoir.

Table 2 provides the τ values for four isotopes, where the τ values for Ce^{144}, Ru^{106} and Sr^{90} were determined with respect to the experimental data given in Fig. 2, while the τ value for Y^{90} was found independently with respect to the shift of radioactive equilibrium between Sr^{90} and Y^{90} [3].

It is obvious from the table that the τ values for Y^{90} and Ce^{144} are close to each other for both reservoirs. This was to be expected, since the above isotopes are chemically similar, and the form of their state in a solution with pH = 7-9 is the same. Therefore, the processes of their absorption by the bottom layer must also be identical. Moreover, it should be mentioned that the τ values for all the radioactive isotopes were larger in the second reservoir than in the smaller first reservoir.

The found τ values make it possible to place the isotopes in order with respect to the rate at which equilibrium is established in the reservoir: rare earths, yttrium > ruthenium > strontium.

Thus, on the basis of the experimental data, we obtained the constants necessary for calculating $q(t)$ and $p(t)$ for Sr^{90}, Ru^{106} and Ce^{144} in two reservoirs by means of the equations derived by approximating a stagnant reservoir by a two-component system. The calculation results are shown in Fig. 4, a and b.

The variation of the total concentration of Sr^{90}, Ru^{106} and Ce^{144} in water (curves 4 in Fig. 4a) is in fairly good agreement with the actual behavior of the concentration of radioactive isotopes obtained by measuring the over-all β-activity of samples (see Fig. 2).

The $p(t)$ curves (see Fig. 4b) have characteristic maximums, the existence of which can also be demonstrated analytically.

Thus, the results obtained in calculating the concentration of radioactive impurities in the water and the bottom layers of stagnant reservoirs are in fairly good agreement with the factual data available to us. The use of the equations derived also made it possible to determine some other characteristics of the behavior of Sr^{90}, Ru^{106} and Ce^{144} in stagnant reservoirs.

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