RADIOACTIVE WASTE OF RIVER TOM

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Satellite Photo of Tom River, showing the Siberian Chemical Complex, (Seversk), near the City of Tomsk (Courtesy Federation of American Scientists)

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EXECUTIVE SUMMARY

Short-lived phosphorus-32 (P32) and long-lived strontium-90 (Sr90) at 1,000,000 Bq/Kg(dry) radioactivity have been discovered in aquatic vegetation where River Romashka enters River Tom, downstream of the huge Seversk nuclear complex in Siberia.

This discovered pollution is probably the largest present-day discharge of radioactivity to the open aquatic environment, anywhere in the world.

This radioactive contamination of River Tom is even relatively greater than the historic contamination of the Columbia River, when the United States turned the mighty Columbia into *the most radioactive river in the world* for plutonium production, at the 1960s height of Cold War nuclear weapons production at Hanford Site.

The radioactive pollution now reported on River Tom is an order of magnitude greater than in the River Techa, near Chelyabinsk, which the Mayak nuclear facility has turned into an open, radioactive sewer.

The radioactive pollution of River Tom from Seversk even exceeds the radioactive discharge from 10,000 commercial nuclear reactors -- more than would provide for all the world's electrical power demand.

The Seversk nuclear complex is located 25 Km north of Tomsk, a city of 500,000. Seversk is situated on north-flowing River Tom, a tributary to River Ob in Siberia. Seversk is described as "the world's largest and greatest" nuclear complex. Seversk is also remembered historically for some of the world's largest discharges of radioactive wastes into the environment.

There were originally 5 nuclear reactors of the Siberian Chemical Combine (SCC) at Seversk. SCC still reportedly operates two closed-loop-cooled nuclear reactors (AD-4 and AD-5), uranium scrap processing services, contracted civilian nuclear fuel reprocessing (with conflicting reports whether this reprocessing is occurring), and nuclear fuel element fabrication services. The only one-through-coolant reactor at Seversk (Ivan-1) was closed in 1990.

No previously identified, present-day operations at Seversk account for the short-lived fraction of the radioactivity reported here. Based on descriptions of Seversk operational history, little or no short-lived radioactivity can plausibly be released now into open surface waters from historic operations or from stored or recently imported materials.

Because P32 is produced by neutron bombardment of naturally occurring P31, some unidentified, intense source of neutrons must be operating at Seversk, unannounced and out of rational control. This unidentified neutron source is presumably an unusual military reactor or, conceivably, an immense, particle accelerator.

The radioactive contamination of the open riverine environment reported here is accessible to fisherfolk, to local inhabitants, and to farm animals; and it persists downstream in River Tom, with only a factor of 4 - 6 reduction after 3.5 Km. This radioactivity discovered in River Tom presents a clear and present danger to human health and ecological integrity. Immediate counter-measures are required to mitigate regional radiological ruination.

This discovery comes from co-operation of Russian and American non-governmental organizations in Siberia in July - August 2000. This report of radiological contamination exemplifies the need for internationalized inspection of the environs surrounding nuclear facilities and the need for facility operators to be made accountable to publicly accepted standards, if global radiological degradation is to be averted.

INTRODUCTION

In July and August 2000, the American public-interest organization Government Accountability Project (GAP) undertook technology exchange with Russian non-governmental organizations, including Siberian Scientists for Global Responsibility (SSGR), based in Novosibirsk, and Tomsk Ecological Students' Inspection (TESI), based in Tomsk. The technology exchange included field measurements of radioactivity around the accessible perimeters of Siberian nuclear facilities, and collection of small samples for laboratory analyses. Samples were submitted to Russian laboratories, with 13, gram-size samples returned to the United States for check analysis.

Russian-American cooperation focused on identification of important radiological pathways. The Russian-American team checked the Mayak facility near Chelyabinsk, the NCCP facility at Novosibirsk, Krasnoyarsk-26, and Seversk near Tomsk. The main part of the investigation close by Seversk is reported here.

The Seversk nuclear facility is located 25 Km north of Tomsk, a city of 500,000. Tomsk is situated on north-flowing River Tom, a tributary to River Ob in Siberia; see map. (Image courtesy of Federation of American Scientists)

An official described Seversk as "the world's largest and greatest" nuclear complex [2]. Seversk is also remembered historically for the world's largest discharges of radioactive wastes into the environment [3].

There were originally 5 nuclear reactors of the Siberian Chemical Combine (SCC) at Seversk [4]. SCC still reportedly operates two closed-loop-coolant nuclear reactors (AD-4 and AD-5) and has contracted civilian nuclear fuel reprocessing (although there are conflicting reports on this occurrence), uranium scrap processing, and nuclear fuel element fabrication services. The only one-through-coolant reactor at Seversk (Ivan-1) was closed in 1990.

Based on descriptions of Seversk operational history, little or no short-lived radioactivity can plausibly be released now from the identified facilities into Seversk's River Romashka which contributes to River Tom.

On 10 August, the team boated to the shore of River Tom, 3.5 km downstream of the River Romashka discharge from the Seversk complex. Shoreline radioactivity measured 4 times background, with nearshore vegetation measuring much higher.

The Tom River, 3.5 km downstream of the Romashka River, Sample Site 2.

Russian team members who had permitted access to the mouth of River Romashka collected vegetation sample media similar to those observed and collected from the aforementioned boat landing, downstream. The radioactive, vegetation samples obtained from the mouth of River Romashka were divided and submitted to laboratory analysis in Russia and checked in the United States. Primary results are reported here.

RESULTS

Vegetation samples were collected from the mouth of River Romashka at its discharge into River Tom at [North 56.64492 degrees, East 84.76057 degrees] on 10 August 2000, and on the same shore of River Tom, 3.5 Km downstream at [North 56.67508 degrees, East 84.71398 degrees].

Samples were tested in the field for radioactivity by Geiger counter (Radalert Inspector). Discovery of high radiation levels at the mouth of River Romashka was by representatives of TESI and SSGR. American involvement was by Government Accountability Project (GAP), with technical support by Nuclear-Weapons-Free America (NwfA). *[Photos by Tom Carpenter.*]

Sergey Paschenko confers with Norm Buske.

Alexei Osochenko and Alexey Toropov.

Small samples were returned to the United States to check with Russian results. These check samples were dried up to 100 degrees C before analysis. All reported results are dry weight.

The check samples were analyzed in a photon detector, sodium-iodide well type, with precision temperature control, two-point spectral stabilization, and constant photo-peak-width digital transform, having a *window* from 20 KeV to 2500 KeV [5]. Sample geometry is adjusted to specific gravity 0.25 in filled, 125 mL PET plastic containers.

This detector is custom designed for precision spectral subtractions. One mode involves subtractions of long-count blank (dummy in copper-lined lead shield) and reference spectra such as potassium-40, strontium-90, and cesium-137 radionuclide standard materials.

Another mode involves subtraction of a sample spectrum, recounted after several days, from a corresponding, previous sample spectrum, to obtain a spectrum of *decayed* radioactivity in the sample, in the interval between counts. With halflives of 29 and 30 years respectively, Sr90 and Cs137 decay rate is practically constant over intervals of a few weeks. Such long-lived radionuclide activity is thus subtracted out of a difference spectrum. A difference spectrum is the energy spectrum of only short-lived, photon-emitting radioactivity in the analyzed sample.

Of particular interest is Sr90 analysis with this detector. Sr90 analysis is based on photo-peak counting at 29.5 KeV and presence of broad lobes corresponding to compton scattering and also to bremsstrahlung up to yttrium-90 decay product beta escape energy of 2280 KeV [6]. (The linear, spectral zero-intercept of this bremsstrahlung is 1670 KeV.) The photo-peak count for Sr90 is confirmed by presence of the two, higher energy spectral lobes.

Sr90 counting at 29.5 KeV depends on absence of interfering photo-peaks, such as K40 and Cs137 x-rays. With the spectra of K40 and Cs137 subtracted, by matching their respective gamma peaks in sample and reference spectra, most equilibrated environmental samples are quiet in the 22 - 40 KeV region, except for Sr90. Hence, reliable Sr90 counts are feasible.

In the case of the samples from Rivers Romashka and Tom, a spate of short- and long-lived radionuclides contaminate vegetation samples. So special compensations are necessary to sort Sr90 out by means of the sodium-iodide spectrometer. This sorting consisted of repeated counts of one sample to identify and sort out short-lived radionuclides. All samples are reported consistently here, as a set, with remaining complicating radionuclides listed -- as determined from that sample recounting and sorting.

The Siberian Chemical Complex (Seversk)
(Photo courtesy of Federation of American Scientists.)

The one sample counted repeatedly to sort out radionuclide constituents was a bluegreen algal mat from the Romashka River mouth. This sample was counted on 20 and 28 August and on 08 and 17 September 2000.

A short-lived, broadband (beta) emitter with total beta energy (extrapolated from linear spectral die-off region) 1650 +/- 100 KeV and halflife 13.6 +/- 3.6 days was analyzed in the difference spectra of this sample. This beta emitter exhibited a photo-peak at 32 KeV and thus contributed to Sr90 counts by the usual Sr90 analysis.

By reference to a chart of the nuclides, this short-lived beta emitter was identified as phosphorus-32. P32 is pure beta emitter with a beta energy of 1710 KeV and a halflife of 14.3 days. By means of the difference spectra obtained by repeatedly counting the bluegreen algal sample from the mouth of River Romashka, the contributions of P32 and Sr90 were separated. For this separation, the efficiency of P32 detection was conservatively estimated to equal the efficiency of Sr90 detection.

These difference counts revealed an unidentified radionuclide in the bluegreen algal sample, having a *single* photo-peak near 98 KeV and a halflife between 1.0 and 2.5 days. No radionuclide having these properties has been identified in NwfA's reference library.

More than a dozen short-lived gamma peaks with halflives from 4 to 80 days were detected in the bluegreen algal sample. With subsequent recounts, the calculated halflives of some of these peaks increased and the peak energy shifted slightly, suggesting the existence of unresolved double or even more compounded photo-peaks. Linear extrapolation of the highest energy bremsstrahlung indicated a highest beta decay energy of about 3500 KeV in the short-lived difference spectra.

The short-lived radioactivity identified in this sample of bluegreen algae is thus: one unidentified photo-emitter with an energy of about 98 KeV and a halflife in the range of 1 - 2.5 days; pure beta emitter P32 with a 14.3-day halflife; more than a dozen gamma photo-peak emissions with halflives between 4 days and 80 days.

This array of short-lived radioactivity in the sample evidences diverse discharge of inherently short-lived radioactivity in liquid discharges from some source at Seversk [7].

Two dozen, long-lived photo-peaks were also observed in this bluegreen algal spectrum.

For most of the photo-peaks observed in the spectra, there were several radionuclides as candidate sources. Chromium-51 and silver-110m were specifically identified from the analyses.

The Cs137 counting peak at 662 KeV was compounded with the 658 KeV peak of Ag110m as well as shorter-lived radioactivity (about 80 days). This was inadequately resolved in the analysis and is thus reported hereunder as “Cs137+?”.

Gamma-emitting radionuclides having halflives greater than a week were measured in jointly-collected samples, by the Tomsk Environmental Committee Radiation Control Laboratory and by the Novosibirsk official laboratory [8]. The gamma emitters were dominated by Cr51. The sums of those gamma emitters reported by those two laboratories were 5520 and 1940 Bq/Kg, respectively, with the mean of those two value listed as “Total gamma”, below:

River Romashka Bluegreen Algae. With decay analysis.

P32	110,000.	Bq/kg(dry)
Sr90	16,000.	“
Total gamma	3,700.	“ [8]
Cs137+?	380.	“ [9]

Before the decay analysis of this sample spectrum, the P32 and Sr90 had not been separated, and so the P32 was not corrected for decay but instead was initially reported for the time of counting as “Without decay analysis”:

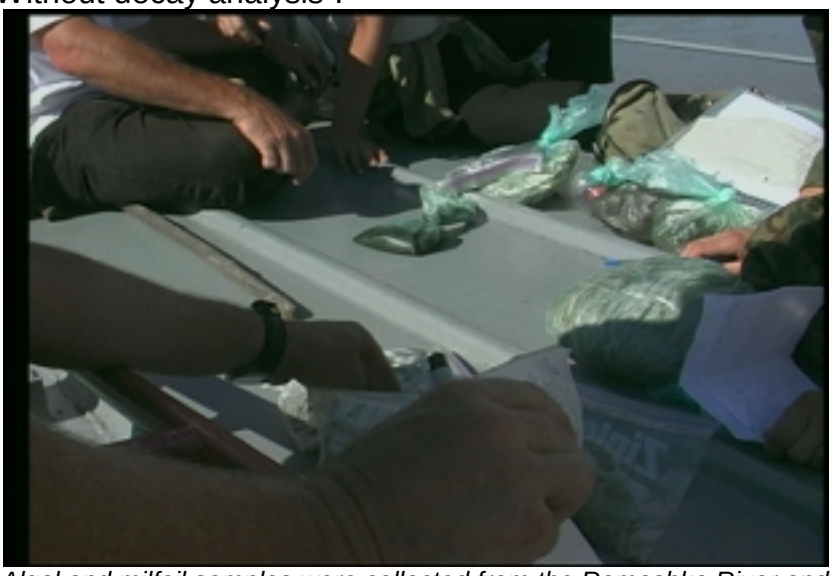
River Romashka Bluegreen Algae. Without decay analysis.

P32+Sr90	62,000.	Bq/Kg(dry)
Total gamma	3,700.	“ [8]
Cs137+?	440.	“

That is, about a quarter the “P32+Sr90” *without decay analysis*, corresponded to “Sr90” *with decay analysis*, and almost twice the “P32+Sr90” *without decay analysis*, corresponded to “P32” *with decay analysis*, in the one recounted bluegreen algal sample.

The check samples retained by the American team are now being analyzed independently in Canada for Sr90 by mass spectrometry to obtain an independently confirming distinction between Sr90 and P32 contents [8].

Decay analysis was not performed by NwfA on any other sample before sample analyses were undertaken in Canada. Thus, no other separation of Sr90 and P32 is reported here, and all other P32 and Sr90 results are combined as “P32+Sr90” “Without decay analysis”.



Algal and milfoil samples were collected from the Romashka River and analyzed by the Russian/American Team. Photo courtesy Moon Callison, CDI.

Two other vegetation samples were collected next to this bluegreen algal sample: A pondweed (milfoil) sample and a grass sample from 3 m on shore [10]. Results are without decay analysis:

River Romashka Milfoil. Without decay analysis.

P32+Sr90	1,000,000.	Bq/Kg(dry)
Cs137+?	830.	“

River Romashka Grass. Without decay analysis.

P32+Sr90	8,500.	Bq/Kg(dry)
Total gamma	190.	“ [11]
Cs137+?	40.	“

A bluegreen algal mat sample, collected 3.5 km downstream (north), on River Romashka (east) side of River Tom, yielded the following results:

River Tom Bluegreen Algae. Without decay analysis.

P32+Sr90	16,000.	Bq/Kg(dry)

Cs137+? 90. " [12]

The million Bq/Kg of P32+Sr90 beta radioactivity discovered in pondweed from the mouth of River Romashka demands attention.

With these results, Seversk now regains its prior fame as the world's largest radiological polluter.

Equally surprising is discovery, already mentioned but worth repeating here, of radioactive waste of halflife even less than 2.5 days entering River Tom from Seversk.

DISCUSSION

Radioactivity counted 10 days after sampling in aquatic vegetation from River Romashka was dominated by P32 having a 14-day halflife. P32 is produced by neutron bombardment of naturally occurring phosphorus-31. Gamma-emitting Cr51, having a 28-day halflife, is produced by neutron activation of naturally occurring chromium-50.

The abundance of short-lived radioactivity --with P32 dominating-- implies at least one source of radioactive pollution from Seversk must be a direct discharge from a nuclear facility having a high neutron flux, without benefit of waste retention after neutron activation to allow radioactive die-out of short-lived activation products.

Within months after the once-through-coolant plutonium production reactor at Seversk was shut down in August 1990, there could not possibly have been any remaining discharges of very undecayed, short-lived radioactive waste into the River Tom from that plant [13]. Even that once-through-coolant reactor reportedly had not released such short-lived radioactivity into River Romashka, as that would have been unacceptable practice even during the Cold War [14].

The long-lived Sr90 and Cs137 radioactivity reported here might be ascribed to leaching from old liquid retentions from the pre-1990, once-through-coolant, plutonium production reactor. But the overwhelming short-lived radioactivity identified in the bluegreen algal sample makes clear there must be a present-day discharge of newly produced radioactivity into River Romashka and thence River Tom. Difficulty in identifying several gamma photo-peaks suggests the character of this radioactivity does not resemble what would be expected from an ordinary nuclear reactor.

Following upon this concern, the investigators have been advised informally that the P32 and sodium-24 (having a 15-hour halflife, too short for measurement in this study) come from irradiation of additives to the cooling water of *a military reactor* now operating at Seversk. The Sr90 radioactivity discovered in the aquatic biota has likewise been informally attributed to spent ("whacked") reactor fuel elements at Seversk. -- But neither start-up of an unidentified military reactor at Seversk nor breach of spent fuel elements can readily explain the peculiar and overwhelming short-lived radioactivity detected in River Tom.

This lack of radiological clarity invites concern for possible liquid toxic releases attending the newly discovered radioactive pollution.

In addition to the laboratory analyses reported in the Results, many measurements of general radioactivity were made at the scene with a scintillation detector and Geiger counters on 10 August and subsequently.

On a split of the bluegreen algal sample from the mouth of River Romashka, SSGR performed replicate Geiger counts with thin sheets of aluminum added between the sample and the counter. Using published data for radiation absorption by intervening materials, SSGR concluded after two months of repeated measurements that 97 - 99% of the radiation in the bluegreen algal sample from River Romashka was from a beta emitter of about 1800 KeV energy, having halflife of 15.2 +/- 1.5 days [15].

This turned out to be a remarkably good determination for the P32 content. However, without laboratory analysis for gamma emitting constituents, several candidate radionuclides, such as europium-156, could not be ruled out by SSGR as the primary radionuclide, nor could the P32 content be confirmed.

This repeated measurement demonstrated the potential for detailed, quantitative monitoring by simple dosimeters, merely by inserting thin barriers between a sample and a dosimeter, and then repeating measurements. But the need for additional spectrometric and other laboratory analyses of some samples is also apparent from this work.

Regarding laboratory analysis, now the results of several counting passes of one bluegreen algal sample through a single sodium-iodide detector -- with no sample preparation except drying -- have been presented in the Results. The main components of artificial radioactivity, both beta and gamma, have been conveniently and economically obtained. Thus, modern dosimeters and laboratory spectrometers in trained public-interest hands are seen to allow quantitative discovery of major radiological releases to public lands and waters.

Gamma activity was profiled in the water column of River Tom at the downstream boat landing location by SSGR, on 10 August. Gamma activity in the cloudy surface water, 1 - 2 meters below the surface, measured 0.020 - 0.025 mR/hr. In deeper clear water, gamma was halved (0.013 - 0.016 mR/hr).

While these measurements of River Tom were being logged, a 1-Kg fish was purchased from a fisherman in a nearby boat. His fresh-caught fish were destined for market in Tomsk that evening. The fish that was purchased measured 5 times usual background radioactivity (measured in Tomsk). The fish head was twice as radioactive as the intestine. This suggested the excessive fish radioactivity might be concentrated in bone.

The US Environmental Protection Agency (EPA) drinking water standard for Sr90 is 0.3 Bq/L. With assumed human consumption of 2 L/day of drinking water,

0.6 Bq/day of Sr90 is a limiting dose of Sr90 for daily public ingestion. Vegetation near the shoreline of the Rivers Romashka and Tom is thus seen to represent a radioactive hazard with wet-weight-basis Sr90 radioactivity in the range of thousands of times the EPA drinking water standard. There is probably greater biological concentration along some pathways to human food consumption, given the evidence presented here of contamination having entered aquatic vegetation and the anecdote of one radioactive fish destined for market.

Strontium mimics calcium in humans, with half retained in the whole body for 35 years. Strontium accumulates in bone, where half is retained for 50 years.

In modern popular culture, calcium's function in the human body is usually depicted as structural: providing sound bones and teeth. But the human body is highly evolved, and *multi-tasking* is routine. From a scientific perspective, calcium ions play an essential role in controlling a multitude of physiological processes at all bodily scales. Inasmuch as these control functions are pivotal to human survival, the body accumulates huge reservoirs of calcium, which is the most abundant inorganic element in the human body. The calcium needed for human metabolic control is mostly stored in the bones, in the form of the phosphate mineral apatite [16]. Thus, Sr90 in drinking water and in foodstuffs replaces calcium with energetic beta emitting particles that destroy bodily control mechanisms by radioactive decay, particularly those control processes located on bone surfaces.

Phosphorus is retained in the body for 0.7 years generally and for 3 years in bones [17]. The phosphate in the apatite mineral of human bones is phosphorus oxide, as has just been described in regard to calcium and strontium.

"Phosphorus plays an indispensable role in the [multitude of] biochemical processes that govern life itself... [16]." Hence, the exact ecological and public health consequences of intensive P32 contamination of River Tom biota are difficult to comprehend without detailed studies of P32 pathways, accumulation sites, and biological concentration factors.

P32 and Sr90 are thus seen to be a pair of radionuclides that concentrate in human bone reservoirs of essential metabolites, and thus destroy human metabolic stasis by beta irradiation of the locales of the P32 and Sr90 decay sites in the bones.

In continental regions like Tomsk which lack ancient seabed deposits of calcium carbonate, provision of adequate calcium in the human diet is a nutritional concern.

One method of adding calcium to the human diet involves making stew of animals, such as poultry and fish. Stewing a fish extracts the calcium from the bones and makes the extracted calcium available for human digestion. Strontium and phosphorus are carried along with the extracted calcium.

There is thus an obvious fish-to-stew pathway for human impact from the intensive P32 and Sr90 radioactivity reported here in River Tom. The fish purchased

locally, revealing gross radioactivity even to survey dosimeters, indicates the magnitude of concern for public health.

The shorelands and surface waters between River Romashka and the boat landing 3.5 Km downstream were readily accessible and being used by fisherfolk, by the public, and by farm animals. Warning signs were present but few and deteriorated, and ineffectual.

The present investigators were repeatedly assured by officials that the described radioactivities in River Romashka and River Tom have been tested regularly since 1990 by the Russian Hydro-Meteorological Service and the results published. But no documentation of the high beta radioactivity has yet been found.

The magnitude of the reported Seversk release of beta radioactivity to River Tom is staggering. Comparison is here made to the present-day (1994) River Techa at Muslyumovo, Siberia; to the Columbia River, Washington State, during the height of the Cold War (1965); to the present-day (1999) Columbia River; and to the River Danube (1969) downstream of the civilian nuclear power station at Grundremmingen, Germany.

River Techa is so contaminated with Sr90, it is essentially an open, radioactive liquid waste disposal sewer. Towns downstream of the Mayak facility -- the source of this radioactive pollution-- are being evacuated because of public health threat. The main radioactivity in River Techa water is Sr90.

The Columbia River received the once-through-cooling water from 8 of the United States' plutonium production reactors during the Cold War, turning the mighty Columbia into "the most radioactive river in the world." The main radioactivity in the Columbia River in 1965 was short-lived gamma emitters, particularly chromium-51, sodium-24, copper-64, and neptunium-239. The total gamma radioactivity was 9,000 times the Sr90 activity [18]. The ratio of P32/Sr90 was 172. Thus, Sr90 radioactivity in the Columbia River in 1965 was but a minute fraction of the total radioactive contamination of the river. This fact must be remembered in valuating the comparison presented here.

After Cold War production of plutonium at Hanford Site ended, the short-lived gamma radioactivity disappeared, and the main radionuclides entering the Columbia River are now residual Sr90 from "N-Springs" and tritium (H3) from central Hanford. Thus, Sr90 is a good indicator of present-day contamination of the Columbia River. No measurable, short-lived radioactivity is presently discharged to the Columbia River from Hanford.

The radiological impact on River Danube of the nuclear power station at Gundremmingen is included here for reference to what might be expected from the AD-4 and AD-5 reactors still operating at Seversk. Except for tritium, the Gundremmingen discharge into the Danube is dominated by beta-emitting strontium-89 (with a 51-day halflife), at 20 times the Sr90 activity [19]. Short-lived (8-day halflife) iodine-131 dominates the gamma emitting radionuclides in the Gundremmingen discharge, at 8 times the Sr90 activity. No P32 is reportedly

discharged from Gundremmingen; inasmuch as the nuclear plant --like those operating at Seversk-- has a closed primary cooling loop, and so the short-lived, neutron activation product P32 would not be discharged into River Danube.

The main channel of River Tom follows the west side of an island that begins just upstream of the mouth of River Romashka and extends downstream 5 Km. Flow estimates and calculations were made for the Seversk (east of island) passage of the River Tom, called “Tom Side” in the comparison below. “Transport” is the total Sr90 radioactivity carried downstream annually. (The references and notes in brackets provide the basis for the calculations. Notice the basis for estimating the flow rate of the side channel in River Tom, given under the table.)

Table. COMPARISON OF Sr90 CONTAMINATION IN RIVERS

River	Year	Flow Rate*	Concentration Sr90**	Annual Sr90 Transport 10^{12} Bq	(Ci)
Columbia	1965	100.	0.07	6.6	(179.)[18]
“	1999	100.	0.000027	0.0027	(0.073)[20]
Techa	1994	0.22	7.0[21]	1.5	(42.)
Tom Side* **	**2000**	**2.**	**14.**[22]	**28.**	**(760.)**
Danube	1969	4.5	0.00074	0.0033	(0.09)[19]

* River flow rate unit: 10^{12} L/year.

** Concentration unit: Bq/L. The U.S. Environmental Protection Agency drinking water limit for Sr90 is O.3 Bq/L = 8 pCi/L. (One Becquerel {Bq} is the disintegration of one atomic nucleus per second. To convert Bq to picocuries {pCi}, multiply by 27. One picocurie is 10^{-12} curies.)

*** Seversk (east) side of island at River Tom downstream sample location. Order of magnitude, effective flow estimate: 200 m channel width; 1.5 m deep contamination at center, based on *in situ* dosimetry; 0.2 m/sec current speed estimated visually: 60 m^3/sec = $2x10^{12}$ L/year.

The values in the Table above show the discovered discharge of radioactivity from Seversk into River Tom to be greater (in relevant terms of Sr90) than any previously reported river contamination, even at the height of the Cold War, before the human and ecological consequences of artificial radioactivity in the environment were fully appreciated. In the post-Cold War era, this pollution of River Tom is in a league by itself, dwarfing even the open sewer status of River Techa.

During the 1960s and 1970s, when nuclear weapons were regularly detonated in the Earth’s atmosphere and before human and ecological consequences of exposure to artificial radioactivity were well known, there were several massive dumpings of waste into the ocean. The notion was that the ocean is so huge it should be able to dilute any conceivable pollution to safe levels.

Perhaps the largest and most consequential of those old ocean discharges was from British Nuclear Fuels Limited's reprocessing plant at Sellafield (formerly Windscale, in West Cumbria) on the Irish Sea. Discharges were predominantly gamma-emitters, chiefly Cs137 (with 30-year halflife). The main beta emitter was Sr90, with releases in the range of 10^{15} Bq/year, before the plant was closed because of its unacceptable discharges [23]. But no short-lived radioactivity, such as P32, was reportedly discharged. Spent nuclear fuel is stored long enough before reprocessing to allow the short-lived radioactivity to decay, so workers are not exposed and the environment is not needlessly polluted. Thus, the radioactive pollution discovered in River Tom is surely not from any nuclear fuel reprocessing operation.

Satellite Image of Seversk.
Photo courtesy of Federation of American Scientists.

From these comparisons, the source of the radioactive pollution discovered in River Tom vegetation can be seen to resemble what might be expected if liquids that had been neutron-activated in the core of a very large nuclear reactor were minimally processed and then dumped directly into River Romashka. Such a reactor has not been identified, although a *military* reactor has been informally reported at Seversk, as already noted.

Thus, the world's largest discharge of short-lived radioactive pollution of the aquatic environment --reported here-- seems to come from an unidentified source at Seversk.

Seversk is now reported to have begun massive new discharges of short- and long-lived, liquid radioactivity into River Tom without control, without notice, without monitoring, and without regard for public health or ecological integrity.

This present concern is multiplied by the prospect that Russia will begin to import and reprocess or store nuclear wastes and fuels from abroad. This would multiply transportation, handling, processing, and storage of deadly materials in Russia. Yet the discovery reported here shows Russian government authorities at "the world's largest and greatest" nuclear facility --Seversk-- not to be held accountable for nuclear management practices that are already effectively out of rational control.

Unfortunately, the United States is actively pushing the Russian atomic agency MINATOM to take foreign radioactive materials that are too dangerous for the United States and other Western countries to deal with. The United States is thus providing an economic incentive for Russia to further deteriorate its public health and environmental quality.

Just as the United States and former Soviet Union were partners in the nuclear arms race -- officially termed Mutually Assured Destruction (MAD) -- so America and Russia remain partners in killing their own populations and ruining their own lands and waters by continuing industrial and military nuclear processes on regional and even global scales, with little regard for safety, health, or environmental quality.

Furthermore, the discovery reported here shows a tendency to intentionally dispose of new wastes over the top of old waste disposals that were reportedly discontinued long ago. Thus, the public begins now to see how bad practices of the past are becoming a foundation for more of the same, or even worse.

The discovery reported here demands true internationalization of monitoring national nuclear facilities and demands widespread publication of the results if regional or even global radiological ruination is to be averted.

CONCLUSIONS

(1) Radioactivities of short-lived P32 and long-lived Sr90 have been detected in aquatic vegetation at the mouth of River Romashka, entering the River Tom from the Seversk facility at levels up one million becquerel/Kg(dry). River Tom is intensely fished here, and this shoreline is accessed by local population and farm animals.

(2) A pair of samples of bluegreen aquatic algal mats, one collected from the mouth of River Romashka and the other 3.5 Km downstream on the shore of River Tom, showed only 4 - 6 fold reduction in radioactivity downstream. The

radiological impact from the Seversk facility is thus extensive as well is intensive.

(3) This radioactive contamination is unusual in character and is discharged from some unidentified neutron source, presumably at Seversk. This reported radioactivity is probably the world's largest discharge of radioactivity to the open aquatic environment.

(4) The radionuclide contamination reported here represents a clear and present danger to public health and ecological viability along River Tom, downstream of Seversk, and wherever fish from the affected stretch of River Tom are regularly eaten.

(5) Release of short-lived radioactivity to the open environment is an abandoned practice of the Cold War and is without merit. The source of liquid radioactive waste entering River Romashka and then River Tom must be shut down immediately to lessen public health threat and ecological impact. The affected river should be prominently posted to warn the public of grave danger; the highly impacted stretch of river should be closed to fishing; the shorelands should be cordoned off. International inspection is required immediately to characterize the radioactive contamination and to decimate it.

(6) Given this discovery of present Russian unwillingness or inability to control Russian radioactive materials, American enticements for Russia to take foreign nuclear materials the West cannot deal with are improper and dangerous. Russia needs help cleaning up its pollutions, not more pollutants. A change in American foreign policy is urgently required. Such a change in American policy will have to come from the public-interest sector or from direct public actions.

(7) The radiological degradation reported here demands true internationalization of the monitoring of national nuclear facilities and necessitates widespread publication of the radioactive facts if regional or even global radiological ruination is to be averted. This report is thus a case study for a new direction in international public-interest activism.

(8) The next step is policy making by appropriate public-interest representatives to bring this radiological ruination of River Tom under public control and to expeditiously diminish the human and ecological harms being done.

NOTES and REFERENCES

[1] Author affiliations: Buske: Nuclear-Weapons-Free America (NwfA). Pashenko: Siberian Scientists for Global Responsibility (SSGR). Toropov: Tomsk Ecological Students' Inspection (TESI). Program management for Government Accountability Project (GAP): Tom Carpenter. Thanks to Alice Hengesbach of Initiative for Social Action and Renewal in Eurasia (ISAR) for coordination and translation during the field study. This scientific report in the public interest has been translated into Russian by Colin McCullough.

[2] A.M. Adam, Head, State Committee for Environmental Protection of the Tomsk Region, taped interview (07 August 2000).

[3] D.J. Bradley, Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union, Battelle Press, Columbus OH (1997) Sec. 18.1.

[4] N. Boehmer and T. Nilsen, "Seversk", The Nuclear Chronicle from Russia, www.bellona.no : reprocessing in siberia : reprocessing plants in siberia (1995.09.19 12:00).

[5] "KeV" = kilo electron volt. An electron volt is the energy acquired by an electron dropping across a potential difference of one volt. One KeV is a thousand electron volts. 511 KeV is the energy of annihilation of an electron at rest. One becquerel (Bq) is one nuclear disintegration per second.

[6] A sodium-iodide crystal can serve as a photon detector in several ways. As a photon detector, the crystal displays a photo-peak at about 30 KeV energy due to compton from the K-shells of the crystal. This is one detectable effect within the detector crystal itself. Other physical processes within decaying source atoms and within a source medium are also detectable. The causative mechanisms for ant particular radionuclide spectrum are not here of particular concern; instead identification and quantification of the radionuclides in environmental samples is sought. Good results are obtained by maintaining constant counting conditions and subtracting entire, comparable constituent spectra digitally.

[7] Given the prevalence of the short-lived fraction of the radioactivity in this bluegreen algae sample, the measured P32 is almost certainly a neutron-activation product of naturally occurring phosphorus (P31), rather than a decay product of artificial silicon-32, which has a halflife of 100 years.

[8] Comparisons of gamma emitter results from Tomsk and Novosibirsk laboratory analyses for jointly collected bluegreen algal samples from River Romashka mouth follow [Bq/Kg(dry)]:

Nuclide:	Cr51	Sc46	Mn54	Co60	Zn65	Cs137	Total
Halflife:	28da	84da	312da	5.3yr	243da	30yr	
Tomsk:	4200.	140.	270.	370.	540.	--	5520.
Novosibirsk:	710.	350.	80.	260.	400.	150.	1940.
NwfA:	--	--	--	--	--	380.	--

Values are for time of sample collection. Gamma results for radioactivity less than one-week halflife is not reportable here. The check samples analyzed by NwfA and reported here have been submitted to a Canadian laboratory for Sr90 analysis by mass spectrometry. At the time of the present report, the Canadian laboratory has encountered severe or even unrecoverable problems with digestion of the samples in a nitric acid and hydrogen peroxide solution.

[9] Wet / dry weight ratio of this sample is 1.9. A jointly-collected sample was measured by Novosibirsk official laboratory as 147 Bq/Kg(dry) Cs137.

[10] Wet / dry weight ratios and counting times are respectively: Milfoil is 11.0 and counted 16th August; Grass is 4.7 and counted 19th August.

[11] The aquatic bluegreen algal results of [8] compare to co-sampled grass on the River Romashka shore and three sediment samples from the location of algal mat collection. The following results are from the Tomsk laboratory, with one comparison value by NwfA lab [Bq/Kg(dry)]:

Nuclide:	Cr51	Sc46	Mn54	Co60	Zn65	Cs137	Total
Halflife:	28da	84da	312da	5.3yr	243da	30yr	
grass:	80.	6.6	13.	6.5	76.	10.4	190.
(NwfA lab comparison value:)						(40.)	
sediments:	500. ±440.	76. ±45.	18. ±3.	160. ±32.	190. ±100.	280. ±230.	1200.

[12] Wet / dry weight ratio of this sample is 2.8.

[13] D.J. Bradley, Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union, Battelle Press, Columbus OH (1997) 452.

[14] D.J. Bradley, Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union, Battelle Press, Columbus OH (1997) Table 18.1. Zinc-65, with a halflife of 244 days is the shortest reported.

[15] S.E. Pashenko, personal communication (16 October 2000).

[16] C.A. Hampel, ed, The Encyclopedia of the Chemical Elements, Reinhold Book Corp., New York NY (1968) 102-3, 532.

[17] Y. Wang [ed.], Handbook of Radioactive Nuclides, Chemical Rubber Co., Cleveland OH (1969) Table 16.

[18] _____, Effects of Ionizing Radiation on Aquatic Organisms and Ecosystems, IAEA Technical Reports Series No. 172, Vienna (1976) Table IX. Concentration of Sr90 is calculated from this referenced transport datum and the mean Columbia River flow rate.

[19] _____, Effects of Ionizing Radiation on Aquatic Organisms and Ecosystems, IAEA Technical Reports Series No. 172, Vienna (1976) Tables X and XIV. The flow rate of River Danube is tabulated as the ratio of reported discharge Sr90 activity (tabulated as “Transport”) divided by the Sr90 concentration 1.5 Km downstream.

[20] T.M. Poston, et al, eds., Hanford Site Environmental Report for Calendar Year 1999, PNNL-13230, Pacific Northwest National Laboratory, Richland WA (2000) Table 3.1.4. Concentration of Sr90 is calculated from this referenced transport and the mean Columbia River flow rate.

[21] _____, Sources Contributing to Radioactive Contamination of the Techa River and Areas Surrounding the "Mayak" Production Association, Urals, Russia, Joint Norwegian-Russian Expert Group for Investigation of Radioactive Contamination of the Northern Areas, Østerås (1997) Table 8.1.4. This Sr90 activity of 7.0 Bq/L in River Techa water is at Muslyumovo in 1994. Table 5.2.1 gives the River Techa flow rate at 2.1×10^{11} L/year entering, with about 0.1×10^{11} L/year in addition at Muslyumovo. The calculated transport of 1.5×10^{12} Bq/year of Sr90 compares to 1.4 and 1.7×10^{12} Bq/year listed in Table 5.2.9 for 1991 and 1992, respectively. This checks the River Techa accounting for Sr90.

[22] The listed concentration of Sr90 depends on a Biological concentration Factor (BF), calculated as follows: A sample of green aquatic algae collected from River Techa at Muslyumovo on 29 July 2000 was split and analyzed by the Chelyabinsk regional laboratory and by Nuclear-Weapons-Free America (NwfA). Sr90 results were 1800 and 2600 Bq/Kg(dry), respectively, with a mean value of 2200 Bq/Kg(dry). Dividing this by the river water value of 7.0 Bq/L, as in [21], BF = 310 L/Kg(dry) is calculated for green algae in River Techa. This BF is assumed to apply also to the bluegreen algae sample collected from River Tom. Next, from the River Romashka bluegreen algae data in the results of this report, Sr90/(P32+Sr90) dry content is estimated to be 16,000/62,000 = 0.26. The River Tom bluegreen algae (P32+Sr90) activity of 16,000 Bq/Kg(dry) thus yields an estimate of Sr90 in the Seversk Side of River Tom as 16,000 Bq/Kg(dry) x 0.26 / 310 L/Kg(dry) = 14 Bq/L. This is the concentration tabulated.

[23] M. Eisenbud, Environmental Radioactivity (3rd ed.), Academic Press, inc., San Diego (1987) Fig. 11-1. _____, Effects of Ionizing Radiation on Aquatic Organisms and Ecosystems, IAEA Technical Reports Series No. 172, Vienna (1976) Table XI.