TRITIUM CONCENTRATIONS IN NORTHEAST GEORGIA RAINWATER

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Abstract. Rainwater has been measured for tritium content in Georgia near the Savannah River Site and the Vogtle Electric Generating Plant, which are located on the banks of the Savannah River in South Carolina and Georgia, respectively. The measurements are part of a routine long-term environmental monitoring program performed by the Georgia Department of Natural Resources. Results obtained over several years show a gradual decrease in tritium concentrations, associated with reduced tritium releases by reactors and tritium production facilities at the Savannah River Site. The information is used to indicate possible sources of tritium in groundwater and in surface waters other than the Savannah River, and to estimate radiation doses to persons in the environment.

INTRODUCTION

Measurements of tritium (H-3,T) are performed in rainwater collected near the Westinghouse Savannah River Site (SRS) and the Vogtle Electric Generating Plant (VEGP) of Southern Nuclear Co. on the Savannah River. The samples are collected as part of the radiological environmental monitoring program undertaken by the Environmental Protection Division of the Georgia Department of Natural Resources and are analyzed at the Environmental Resources Center. The program also monitors tritium in air, water, vegetation, food, and aquatic species, and measures other radionuclides in the environment (EPD 1995). The program was begun in 1978; rainwater tritium results for the last four years are presented here to indicate the current magnitudes of environmental tritium contamination and radiation dose to persons via this medium.

Tritium is discharged from several stacks at SRS, which produces tritium for nuclear weapons, and at VEGP, a nuclear power plant with two pressurized water reactors. The locations of the two sources are shown in Fig. 1, and the amounts of airborne tritium release in 1995 - 1998 are listed in Table 1 (Arnett and Mamatey 1998, SNC-VEGP 1998). Most of the airborne tritium is released at SRS, and most of that tritium is in the form of water (HTO) vapor; the remainder is gaseous forms such as HT and CH_3T. The measurements reported here are of HTO.

Radionuclides in the environment of the two facilities, including tritium in rainfall, are also measured by the facility operators and the South Carolina Department of Health and Environmental Control. A summary of the pattern of tritium levels in rainfall during earlier years has been presented on the basis of SRS measurements (Murphy et al. 1991).

The SRS would be expected to be a major contributor to tritium in rainwater at nearby monitoring locations. In addition, HTO is in rainwater from natural production of tritium in air. Remote man-made sources also contribute, mainly atmospheric fusion weapon tests during the early 1960s, tritium production facilities other than SRS, and fuel reprocessing in other countries. The specific activity of naturally produced tritium is reported to be between 3 and 16 picocurie per liter (pCi/L) of water. The concentration in rain and surface water of cosmogenic radionuclides such as tritium fluctuates

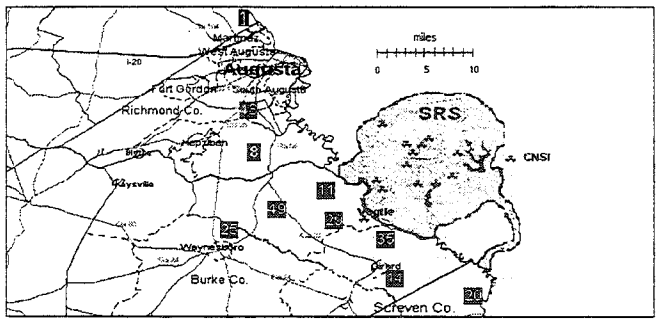

Figure 1. Map of rainwater collections sites

Table 1. Airborne tritium release near the Savannah River, Ci/y

Source	1995	1996	1997	1998
Savannah River Site	97,000	55,000	58,000	--[c]
Plant Vogtle[b]	287	173	105	--[c]

a. From SRS Environmental Reports.
b. From SNC-VEGP Annual Radioactive Effluent Release Reports.
c. Not yet available.

with time and increases with latitude. The tritium concentration due to man-made sources reached several thousand pCi/L in the U.S. during the early 1960s but has steadily decreased since then (NCRP 1979).

PROCEDURE

Rainwater is collected in a 20-L plastic bottle with a funnel that has a 940-cm^2 collection area. The collectors are placed at the 10 locations on the Georgia side of the Savannah River indicated in Fig. 1. A control collector was in Savannah and now is in Atlanta. At the end of each monthly collection period, the sample is decanted from the collector bottle and transported to the laboratory.

A portion of the sample is distilled and a 10-ml aliquot of distillate is mixed with 10-ml scintillation cocktail and counted for two 50-min. periods with a scintillation detector. The count rate in the tritium channel is corrected for detector background (5 count/min.), adjusted for detector efficiency (25%), checked for interference shown by other channels, and calculated in terms of pCi/L. The detection limit by this method is 200 pCi/L. The uncertainty of measurement in terms of 2 standard deviations is approximately 200 pCi/L for values below 2,000 pCi/L. The detector efficiency is determined by periodically counting standards traceable to NIST, and the detector background is checked frequently with blank samples.

For more sensitive detection, a 100-ml sample is made basic with 0.8 g sodium peroxide and electrolytically distilled in a cell placed in an ice bath until the volume is reduced to 13-ml. This concentrates HTO relative to H_2O by a factor of 6.5. The sample is distilled and a 10-ml aliquot is mixed with the cocktail and counted in the scintillation counter for two 500-min. periods. The detection limit is 10 pCi/L and the uncertainty of measurement is about 10 pCi/L in these low-level samples.

RESULTS AND DISCUSSION

Annual average tritium concentrations in rainwater at the five locations nearest SRS and VEGP were between 410 and <200 pCi/L while all of the more distant samples averaged <200 pCi/L between 1995 and 1998, as listed in Table 2. The nearest locations are 18-26 km distant from the center of SRS; the other ones are 26-48 km distant. The pattern of monthly concentrations in Fig. 2 shows a gradual decrease in activity except for six or seven occasions of elevated tritium concentrations. Each value is believed to depend on airborne tritium release rates and wind directions just before and during rainfall, and the extent of tritiated moisture scavenges from air by each rain, summed over all rainfall during the month. The highest monthly concentration was 3,700 pCi/L at location #35 in September 1995. The elevated values are attributed to SRS releases.

Tritium concentrations had decreased from earlier years when SRS was in full operation, compared to the present shutdown of all five reactors at SRS. The highest concentration was 32,000 pCi/L in Nov. 1982 at #25; all other elevated levels were below 14,000 pCi/L between 1978 and 1994. Some even higher tritium concentrations were measured in rainwater at on-site locations by SRS staff during this earlier

Table 2. Average tritium concentration in rainwater, pCi/L

Sampler	1995	1996	1997	1998
# 11	330	250	360	<200
35	420	200	<200	<200
29	300	310	260	260
49	240	<200	310	<200
8	<200	<200	220	<200

Note: Tritium concentrations were <200 pCi/L at samplers # 14, 1, 20, 25, and 48.

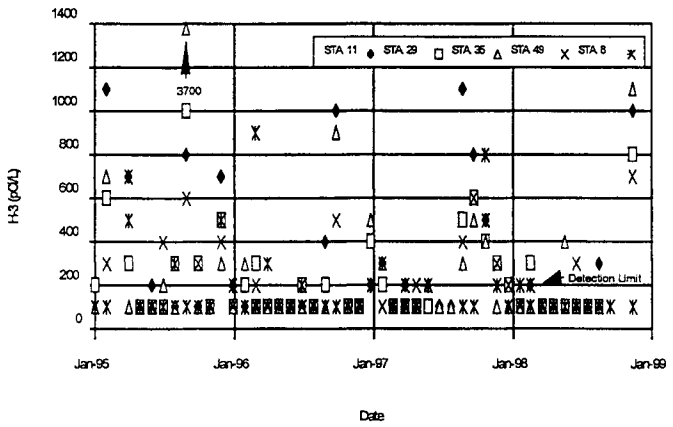

Figure 2. Monthly tritium concentration in rainwater

period, but levels decreased rapidly with distance from SRS (Murphy et al. 1991).

More sensitive measurements of tritium in 1998 samples, listed in Table 3, show values of 63 to 190 pCi/L at some samplers near SRS and VEGP, while four other nearby samplers had concentrations between 700 and 1,100 pCi/L in December 1998 (see Fig. 2). The concentration was 17 pCi/L at the remote Atlanta location (#133). Values of 6 - 10 pCi/L are reported for tritium in rain water at Miami FL at this time (Grall 1999). This suggests that most of the tritium measured near the SRS and VEGP sites in those 1998 samples is due to local releases. A curve of tritium concentration as a function of distance from SRS by Murphy et al. (1990), extended to 265 km, suggests that the rainwater in Atlanta may have a tritium concentration due to SRS of approximately 10% of the values near SRS.

Tritium intake by humans can be due to consuming rainwater collected in cisterns or reaching wells, or by consuming foods exposed to the water. Tritium that had been found in water from a few wells and a pond near the Savannah River before the period of this study (Summerour et al. 1993) is attributed to rainwater. Tritium routinely measured in the Savannah River downstream from SRS and VEGP is mostly due to liquid discharges at these facilities.

The measured values in rainwater can be compared to the EPA Safe Drinking Water maximum contaminant level for tritium of 20,000 pCi/L (EPA 1976). This level corresponds to a radiation dose rate of 4 mrem/y to the whole body of an adult who consumes 2 L of water per day. Hence, the annual

Table 3. More sensitive measurements of tritium in monthly samples

Sampler #	Distance from SRS center[b], km	Collection date	Tritium conc., pCi/L
29[a]	21	4-9/98	104
8	26	12/98	63
48	40	12/98	190
25	38	12/98	130
133	265	12/98	17

a. Six-month composite
b. Subtract approx. 10 km for distance to SRS boundary

consumption of tritiated water at a concentration of 300 pCi/L would result in a dose of only 0.06 mrem/y. Intake of milk and other foods that would contain tritium from rainfall would not double this value.

CONCLUSION

Tritium in rainwater on the Georgia side of the Savannah River in 1995 - 1998 near SRS and VEGP had a maximum monthly concentration of 3,700 pCi/L at one location on one occasion. During the 4 year period, concentrations averaged between 200 and 300 pCi/L at all nearby locations, and <200 pCi/L at locations more distant by about 15 km. By 1998, tritium concentrations in rainwater at these locations had decreased to about 100 pCi/L attributable to SRS releases. The concentrations are much lower than the maximum contaminant level for tritium in drinking water of 20,000 pCi/L. The radiation dose of persons drinking water and eating foods exposed to tritium transferred by this pathway in 1995-1998 is well below 0.1 mrem/y.

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