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ASSAY OF TRITIUM IN WHITE OAK CREEK, OAK RIDGE, TENNESSEE

IRVING T. GLOVER AND GARY W. CUSHING*

Roane State Community College
Harriman, Tennessee 37748

ABSTRACT

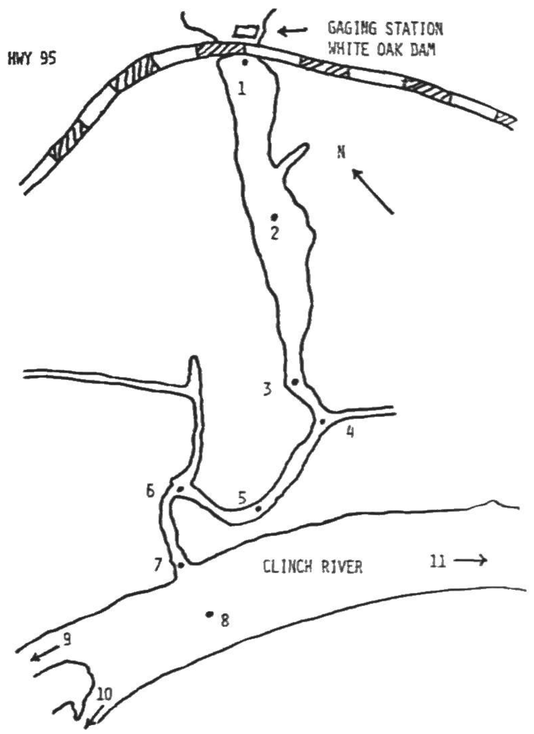
Grab samples of the water in white Oak Creek were taken in 1975 on May 29 and June 17, and in White Oak Lake on July 24. Tritium activities were assayed by liquid scintillation counting. The highest concentration of radioactivity observed was 0.685 nCi/ml at White Oak Dam on May 29. An approximate tenfold dilution of tritium activity was found on traversing the 0.6 mile stretch of White Oak Creek from the dam to the confluence with the Clinch River on June 17.

**Energy Research and Development Administration undergraduate Summer research participant, Oak Ridge Associated Universities, Oak Ridge, Tennessee 37830.*

INTRODUCTION

White Oak Lake, located within the controlled area of the Oak Ridge Reservation, was formed in 1943 to serve as a final control in the water stream from Oak Ridge National Laboratory to the Clinch River. Low-level radioactive wastes from the Laboratory are discharged to White Oak Creek upstream from White Oak Lake. Drainage from the lake is into the final stretch of White Oak Creek which discharges into the Clinch River 0.6 miles below White Oak Dam (Fig. 1). The lake serves as a final settling basin for wastes from the Laboratory and provides dilution and temporary holdup for decay of short-lived radionuclides before release to the

FIG. 1: *Sketch of White Oak Creek from White Oak Dam to confluence with the Clinch River. Numbers correspond to samples in Tables 1 and 2.*



Clinch River (Lomenick and Gardner, 1965).

Large quantities of radioisotopes, notably ^{137}Cs, ^{60}Co, and ^{90}Sr, have accumulated in sediments in the lake bed, and waste water also enters the lake from nearby intermediate-level chemical waste pits and trenches. Intermediate-level liquid waste has been discharged into these pits and trenches which by 1967 had received about 35×10^6 gallons containing over 10^6 Ci of mixed fission products, more than half of which was ^{90}Sr and ^{137}Cs (Lomenick *et al*, 1967). Tritium was released to these waste seepage pits during the period 1952 to March 1966. Tracer studies with tritium indicate a median groundwater velocity in the area of about 0.5 ft/day (Jacobs, 1968, p. 66). Drainage from the pits and trenches is into White Oak Creek and White Oak Lake where it is continuously monitored at the dam before it overflows into the lower part of White Oak Creek 0.6 miles above its confluence with the Clinch River.

The discharge to the stretch of White Oak Creek below White Oak Dam is regulated at the dam. Some dilution is afforded in this stretch by drainage from noncontaminated areas and by small tributaries. At the confluence with White Oak Creek, the Clinch River has an average flow of 4500 ft^3/sec (Jacobs, 1968, p. 79), a flow velocity of 0.2 - 2.3 ft/sec, and full vertical and transverse mixing within 4-6 miles downstream from the mouth of White Oak Creek (Jacobs, 1968, p. 62). The Clinch River, with a mean discharge of 4600 ft^3/sec above White Oak Creek, could accomodate 1.1×10^4 Ci/day of tritium without exceeding 1 nCi/ml (Jacobs, 1968, p. 63).

This study is concerned with the concentration of tritium in White Oak Lake in the summer of 1975, its dilution on traversing the 0.6 miles from the dam to the Clinch River, and the effect of mixing with the large flow in the Clinch River at its confluence with White Oak Creek.

MATERIALS AND METHODS

Samples were taken directly below White Oak Dam (May 29), at intervals of approximately 150 yards going downstream from the dam to the mouth of White Oak Creek and in the Clinch River at the confluence and about 1 mile above and below (June 17), and in White Oak Lake (July 24). The sample taken on May 29 (1-*I*) was for preliminary investigation. Three samples (1 liter each) were taken at the lake on July 24 by participants in a summer institute, "Applied Ecology," held at Oak Ridge Associated Universities from July 14 to August 1, 1975. The samples on the 0.6 mile stretch of White Oak Creek from the dam to the Clinch River and in the river were taken by the authors. In this case, three 20 ml samples were taken at each of 11 locations for a total of 33 samples (Fig. 1).

Two liquid scintillation vials were prepared from each sample. The vials contained 10 ml of "Instagel" cocktail solution (Packard Instrument Company) and 1 ml of the sample to be counted. Background samples were prepared from 1 ml of tap water in 10 ml of Instagel. The samples were counted to 10,000 counts, giving one standard deviation of 1% of the gross count rate. The counting efficiency of each sample was determined by the "external standard channels ratio technique" using quenched tritium standards (Packard Instrument Company).

Background was substracted from sample gross count rate to yield net count rate. The standard deviation of the net count rate (SD) was calculated from the equation (Chase, 1959):

$$SD = \left(\frac{R_g}{t_g} + \frac{R_b}{t_b} \right)^{1/2}$$

where: R_g = sample gross count rate, R_b = background count rate, t_g = sample counting time, t_b = background counting time.

The 2 SD value as a percent of the net count rate was calculated:

$$2\ SD(\%) = \frac{2\ SD}{R_g - R_b} \times 100$$

The 2 SD range provides the 95% confidence level.

No radioactivity was observed above 18 kev, indicating that tritium was the isotope being counted.

RESULTS

The mean radioactivity (nCi/ml) and the 2 SD value as a percent of the mean radioactivity for each of the samples is given in Table 1.

TABLE 1: *Tritium Assay by Authors of Samples Collected May 29 and June 17.*

Date	Sample	Location*	Activity (nCi/ml)	2SD (%)
May 29	A	1	0.685	2.4
June 17	1	1	0.513	2.5
	2	2	0.500	2.5
	3	3	0.426	2.5
	4	4	0.309	2.7
	5	5	0.244	2.9
	6	6	0.157	3.4
	7	7	0.057	5.8
	8	8	0.048	6.6

* See Figure 1.

Table 2 gives the results on the same samples and on samples from White Oak Lake taken on July 24. These data were obtained by participants in a summer institute, "Trace Analysis for Environmental Pollutants," held at Oak Ridge Associated Universities, August 4-22. It should be pointed out that the 2 SD values are quite large in Table 2 for samples with low radioactivities because the counting time available to participants was limited by other scheduled activities in the program.

TABLE 2: *Tritium Assay by Students of Samples Collected May 29, June 17, and July 24.*

Date	Sample	Location*	Activity (nCi/ml)	2SD (%)
May 29	A	1	0.645	2.5
June 17	1	1	0.522	2.9
	2	2	0.518	2.9
	3	3	0.422	3.4
	4	4	0.297	4.3
	5	5	0.239	5.1
	6	6	0.158	7.3
	7	7	0.058	17.
	8	8	0.056	20.
July 24	B	White Oak Lake	0.352	3.8

* See Figure 1.

The count rate of samples 9, 10, and 11, collected about 1 mile above and below the confluence, were not sufficiently above background count rate to warrant counting the long time required to obtain significant data. The mean count rate from 18 counting vials for these samples was 52.1 cpm/ml, while the mean background from 6 counting vials containing 1 ml of tap water each was 51.1 cpm/ml. These samples are not included in Tables 1 and 2.

DISCUSSION

Rainfall in the Oak Ridge area was 8.77 inches between May 29 and July 24. Dilution by this rainwater may account for the 23.4% reduction in concentration of tritium at White Oak Dam between May 29 (0.685 nCi/ml) and June 17 (0.513 nCi/ml) and the low concentration (0.352 nCi/ml) found in the lake on July 24. Drainage from non-contaminated areas and small tributaries along the 0.6 mile stretch from the dam (0.513 nCi/ml) to the confluence with the Clinch River (0.057 nCi/ml) provide a dilution factor of about 10 (88.9% decrease in tritium activity).

Title 10, Atomic Energy, Part 20, Appendix B, Tables I and II, United States Code of Federal Regulations, 1974 lists the maximum permissible concentration (MPC) of tritium in drinking water for restricted areas as 100 nCi/ml and for unrestricted areas as 3 nCi/ml, respectively. The maximum concentration of tritium observed in this study was 0.685 nCi/ml, 0.685% MPC for restricted areas and 22.8% MPC for unrestricted areas. This concentration could be increased 100-fold without exceeding MPC for restricted areas and 4-fold without exceeding MPC for unrestricted areas. The concentration found at the confluence of White Oak Creek with the Clinch River was 0.057 nCi/ml (1.9% MPC for unrestricted areas) and could be increased 50-fold without exceeding MPC for unrestricted areas.

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LITERATURE CITED

Chase, G. D. and J. L. Rabinowitz. 1959. *Radioisotope Methodology*. Burgess Publishing Co., Minneapolis. p. 83.

Jacobs, D. G. 1968. *Sources of Tritium and Its Behavior Upon Release to the Environment*. 87 pp. USAEC Division of Technical Information, Oak Ridge.

Lomenick, T. F., and D. A. Gardner. 1965. The occurrence and retention of radionuclides in the sediments of White Oak Lake. Health Physics *11*:567-577.

Lomenick, T. F.; D. G. Jacobs; and E. G. Struxness. 1967. The behavior of strontium-90 and cesium-137 in seepage pits at ORNL. Health Physics *13*:897-905.