TRITIUM UPTAKE BY FISH IN A SMALL STREAM (U)

by

WSRC-TR--92-193-Rev.1

DE93 001899

D. Eaton and C. E. Murphy, Jr.
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

A technical deliverable being deposited at OSTI

OCT 26 1992

This article was prepared in connection with work done under Contract No. DE-AC09-89SR18035 with the U. S. Department of Energy. By acceptance of this article, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty free license in and to any copyright covering this article, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted article.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Tritium Uptake by Fish in a Small Stream (U)

D. Eaton and C. E. Murphy, Jr.

Publication Date: September 17, 1992

**Approved By: D.B. Moore-Shedrow, Manager
Environmental Sciences Section
Savannah River Technology Center**

**Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808**

SAVANNAH RIVER SITE

**THIS DOCUMENT WAS PREPARED IN CONNECTION WITH WORK UNDER
CONTRACT DE-AC09-89SR18035 WITH THE U.S. DEPARTMENT OF ENERGY.**

MASTER

012

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CONTENTS

ABSTRACT	1
INTRODUCTION.....	1
DISCUSSION	2
RESULTS	5
REFERENCES	8
ACKNOWLEDGEMENTS	8
APPENDIX A: DATA	9

LIST OF TABLES

- 1. Water and Organic Tritium Activities in Macrophytes,
Tree Leaves, and Fish from Four Mile Branch 10**

LIST OF FIGURES

- 1. Location of Vegetation and Fish Sampling Locations
on Four Mile Branch. 3**
- 2. The Results of Tritium Activity in Water from
Four Mile Branch 4**
- 3. The Tritium Activity in Water of Freeze-Drying in
Vegetation and Fish from Five Sampling locations
along Four Mile Branch 5**
- 4. Tritium Activity of Water of Combustion of Vegetation
and Fish Organic Matter 6**
- 5. The Relationship between the Tritium Activity in the Organic
Fraction of Leaves from Trees Adjacent to the Stream,
the Organic Fraction of Herbaceous Vegetation Growing
in the Stream, the Fish Organic and Water Fractions, and
Stream Water at Site 3..... 7**

TRITIUM UPTAKE BY FISH IN A SMALL STREAM

David Eaton* and C. E. Murphy, Jr.
Westinghouse Savannah River Company
Savannah River Technology Center
Aiken, S. C. 29808

ABSTRACT

The tritium concentration in the water from freeze drying and the water from combustion of the dry tissue was measured in fish (largemouth bass), stream macrophytes, and streamside vegetation at five sampling locations in Four Mile Branch on the Savannah River Site (SRS). Four Mile Branch has elevated tritium concentration, largely from migration of water through the soil from adjacent seepage basins that received industrial wastewater containing tritium. The stream water and the vegetation, through the food chain, are thought to be the two sources of tritium reaching the fish. Comparison of the tritium activity of the freeze-dried water from fish flesh and of the sources of tritium, indicates that the fish flesh approaches a steady-state concentration with the stream water. The freeze-dry water from the vegetation is at a lower specific activity than the stream water. The water of combustion from the vegetation is also at a lower specific activity than stream water. The water of combustion from the fish flesh is somewhat higher in specific activity than the stream water or the water in the fish. The distribution of tritium among the components of this system can be explained in terms of the turnover of water and organic hydrogen in the components.

INTRODUCTION

The objective of this paper is to determine the concentration of tritium in fish flesh as it is related to the sources of tritium in the stream. The primary sources of tritium in the fish flesh are tritiated water exchanged with mobile chemical sites in the flesh, and tritium on less exchangeable sites that is synthesized from organic matter moving up the food chain leading to the fish. Exchange of tritium with mobile sites is comparatively rapid. Exchange times are usually on the order of hours.¹ Metabolically incorporated tritium is less rapidly absorbed from food. Retention of tritium in the food chain depends on the level of catabolism as

food is digested and synthesized to new tissue. Carbohydrates are more completely catabolized, leading to loss of tritium. Lipids are less completely catabolized, with proteins intermediate to carbohydrates and lipids.² Once incorporated, turnover of carbon-associated tritium depends on the turnover of the compounds making up fish flesh. The metabolic turnover times are of the order of months to years. These differences in tritium incorporation rates can lead to differences in tritium concentration in the fish and its environment. The steady state tritium concentration is approached only after the ecosystem has been ex-

* Present address: Fort Valley State College, Department of Chemistry, P. O. Box 4345, Fort Valley, Georgia 31030

posed to the tritium sources for several times longer than the turnover times of the components of the system.

Four Mile Branch presents an opportunity to determine the tritium concentration of the components of an aquatic system that has been exposed to tritium for a long period, relative to the turnover times of the organisms in the stream. The origin of Four Mile Branch is near the center of the Savannah River Site. The creek follows a generally southwesterly path for about 24 km through the SRS until it reaches the Savannah River. The total watershed is on the SRS and drains about 57 km². The watershed includes several facilities, including the Isotope Separations Areas, C-Reactor, and the Low Level Waste Burial Ground.

The natural flow of the creek is about 0.14 m³/s, which is increased to 0.57 m³/s by the process effluents of the Separations Areas. Prior to 1986, the flow increased to 11.3 m³/s below the confluence with the C-Reactor cooling water. Approximately half the tritium released to Four Mile Branch is from direct sources, and half is from migration through the groundwater to the creek from the Separations Areas Seepage Basins. In addition there has been a small amount of tritium migration from the Low Level Waste Burial Ground.

Migration of tritium from the seepage basins occurs along the creek from springs or seeps that occur at locations where the creek is near the basins (Figure 1). The annual average tritium concentration at several locations is shown in Figure 2. The

concentration is low above the seep area, increasing as it passes the seeps from F-Area and H-Area, and decreasing as it passes the C-Reactor effluent, which has a lower tritium concentration than the creek. The increase in tritium content in the most downstream sampling location after 1986 is the result of C-Reactor being placed on stand-by at that time. The steady decrease in the tritium content of the stream at location 3 and below location 5 reflects the decreased use and finally the closure of the F-Area Seepage Basins.

In its upper reaches, Four Mile Branch is an acid, soft water stream. It is deeply shaded by a canopy of riparian vegetation dominated by broad-leaf trees. Because of the lack of light, the primary productivity of the stream is low, except in those areas where clearing of timber has allowed light to enter. The chemistry of the stream is altered by the input of the Separations Area seeps, but the stream is still largely shaded except in a few locations where the trees have been removed for road or power right-of-ways or by beaver activity. In this region, the productivity of the stream is dependent on the input of detritus from the surrounding forest. Below the C-Reactor effluent entrance the stream has been greatly modified by the increased flow and the high temperature of the effluent water. The stream is more open to light from this point until its entrance into the Savannah River Swamp. Prior to 1986, the heated water prevented fish from living in the stream below the reactor effluent entrance, although it is known that fish did migrate from the swamp into the stream during periods of reactor outage. Since 1986, fish have become re-established in this section of creek.

DISCUSSION

Sampling stations were established at five locations along Four Mile Branch (Figure 1). The locations were selected for ease of access. In addition,

where possible, the locations had deep enough water to support larger fish. The bass were collected with a rod and reel at the three most down-

Figure 1. Location of Vegetation and Fish Sampling Locations on Four Mile Branch. The Environmental Monitoring Group's Water Sampling Stations are Located at Sites 2, 3, and below Site 5, After the Confluence of the Stream Carrying Effluent from C Reactor.

Figure 2. The Results of Tritium Activity in Water from Four Mile Branch. Data is from Measurements Made by SRS Environmental Monitoring Group.

stream of the locations. Water samples, in-stream vegetation, and streamside tree leaves were collected from the stream at the same time that bass were collected. Two samplings were completed at each of the five stations during the summer of 1991. At the time the fish were collected they were immediately placed in a plastic bag containing water from the stream in which they were caught. The fish were transported, alive, to the laboratory where they were processed. The vegetation samples were collected and stored in glass containers.

The fish fillets, grass, and leaves were either processed immediately or stored in a freezer in the glass containers. This prevented the exchange of tritiated water with laboratory air. The water was removed from the samples by freeze drying.³ The

water from the freeze drying was collected in cold traps. About 200 grams of sample were freeze-dried.

After freeze-drying, the dry organic matter was combusted in a furnace which could burn up to 100 grams of sample.⁴ A cold trap was used to collect the water during the approximately two hours it took to combust the dried samples. The water of combustion was then run through the freeze-dry apparatus to remove dissolved material. The creek water, the freeze-dry water, and the water of combustion were counted using liquid scintillation counting. Each sample was individually spiked with a standard tritium spike to measure the counting efficiency.

Figure 3. The Tritium Activity in the Water of Freeze-Drying in Vegetation and Fish from Five Sampling Locations Along Four Mile Branch. The Sites are Numbered from Most Upstream to Most Downstream Location.

RESULTS

The concentration of tritium in freeze-dry water is shown in figure 3. Fish could not be collected from locations 1 and 2 because of the small size of the stream at these locations. Analysis of the vegetation suggests that there was little tritium upstream of location 2. The tritium concentration of the water from the fish did not vary greatly between locations 3, 4, and 5. This can be explained by the fact that tritiated water exchanges rapidly with the fish, and the freeze-dry water reflects the concentration to which the fish have been exposed in the past day or less.

Tritium concentration in the vegetation is lower

and shows more variability than for the fish. The lower concentration in the vegetation is to be expected because tritium concentrations in the leaves of vegetation will lie between the concentration of the sources of water in the leaves. In this case the water is from the stream, from rainwater in the soil, and from atmospheric water vapor. The rainfall and atmospheric water vapor concentration can be expected to be lower than the concentration in the stream water.⁵ The variability is probably related to the relationship between location and root extension of the vegetation. Some vegetation may get more water from the stream than other vegetation.

Figure 4. Tritium Activity in Water of Combustion of Vegetation and Fish Organic Matter.

Tritium in water of combustion is shown in Figure 4. The highest levels of organic tritium in the fish are found at location 3. At this site the herbaceous vegetation was partially submerged and much more abundant than at the other locations due to greater sunlight. Fish living at location 3 cannot easily migrate between this location and areas below location 4, because of an obstruction in the stream caused by the Road A-7 bridge, and probably spend their entire life in this section of stream.

The fact that fish found at locations 4 and 5 have

lower flesh tritium activity may be related to their mobility. Fish at or below location 4 can migrate all the way to the Savannah River Swamp and even the Savannah River, itself.

The isolation of the fish at site 3 suggests that this location may be an ideal site to study tritium in an aquatic ecosystem. The distribution of organic tritium at site 3 is shown in Figure 5. The tree leaves and herbaceous macrophytes at this location have lower organic tritium specific activity than the stream water. This is consistent with the vege-

Figure 5. The Relationship Between the Tritium Activity in the Organic Fraction of Leaves from Trees Adjacent to the Stream, the Organic Fraction of Herbaceous Vegetation Growing in the Stream, the Fish Organic and Water Fractions, and Stream Water at Site 3.

tation freeze-dry water from the vegetation. The water in the leaf, which is sampled in freeze-drying is the source of hydrogen for photosynthesis and production of organic matter. The fish organic tritium specific activity is higher than the the vegetation, the stream water, or the water in the fish flesh.

The relatively high specific activity of the fish organic matter can be explained by the history of tritium activity in the stream system and the difference in turnover time of hydrogen between the vegetation and the fish flesh. Both the herbaceous vegetation and the tree leaves are produced during

the year of the measurements and the majority of the tritium is from the water of the current year. The fish have grown in the stream for several years and their organic tritium specific activity has been affected by the tritium activity of the stream system over a longer period of time than the specific activity of the vegetation. The tritium activity of the organic matter of the fish is approximately equal to the activity of the water measured in the previous year.

REFERENCES

1. Blaylock, B. G., and M. L. Frank. "Distribution of tritium in a chronically contaminated lake". *Behaviour of Tritium in the Environment*, IAEA-SM-232/74, Vienna, pp. 247-256 (1979.).
2. van den Hoek, J., M. H. J. ten Have, G. B. Gerber, and R. Kirchmann. "The Transfer of Tritium-Labeled Organic Material from Grass into Cow's Milk". *Radiation Research* 16: 105-113 (1985).
3. Hayes, D. W. "Design and Evaluation of a Freeze-Dry Apparatus for Removing Free Water for Tritium Analysis". DP-1634, E.I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, 20pp (1982).
4. Bogen, D.C., C.A. Henkel, C.G.C. White, and G.A. Welford. "A Method for the Determination of Tritium Distribution in Environmental and Biological Samples". *J. Radioanalytical Chemistry* 13: 335-341 (1973).
5. Murphy, C. E., Jr. "The Relationship Between Tritiated Water Activities in Air, Vegetation, and Soil under Steady-State Conditions". *Health Physics* 47(4): 635-639 (1984).

ACKNOWLEDGEMENT

The information contained in this article was developed during the course of work under Contract No. DE-AC09-89SR18035 with the U.S. Department of Energy.

APPENDIX A:
DATA

Table 1. Water and Organic Tritium Activities in Macrophytes, Tree Leaves, and Fish From Four Mile Branch

Sample Site	Type	Date	Water (pCi/mL)	Counting Error	Organic (pCi/mL)	Counting Error
1	Grass	30-Jul-91	3.2	1.64	25.3	4.92
1	Grass	15-Aug-91	4.0	1.66	30.3	5.38
1	Leaves	30-Jul-91	3.9	1.76	29.1	5.43
1	Leaves	18-Aug-91	5.0	1.84	26.3	4.87
2	Grass	03-Jul-91	8.9	2.37	55.2	8.38
2	Grass	09-Aug-91	27.3	5.00	55.4	8.53
2	Leaves	03-Jul-91	4.4	1.67	51.6	7.94
2	leaves	09-Aug-91	25.7	4.79	76.0	11.01
3	Bass	03-Jul-91	361.7	42.74	327.0	39.78
3	Bass	30-Jul-91	137.6	18.17	297.2	35.97
3	Grass	02-Jul-91	24.3	4.51		
3	Grass	30-Jul-91	50.7	7.96	121.7	16.36
3	Leaves	02-Jul-91	245.2	30.02	224.4	27.71
3	Leaves	30-Jul-91	50.5	7.94	137.9	18.21
4	Bass	09-Jul-91	174.1	22.11	51.8	7.96
4	Bass	09-Aug-91	289.3	35.10	139.0	18.33
4	Grass	03-Jul-91	63.3	9.36	116.2	15.55
4	Grass	09-Aug-91	78.9	11.36	90.1	12.68
4	Leaves	13-Jul-91	38.3	6.29		
4	Leaves	09-Aug-91	52.2	8.14	124.3	16.65
5	Bass	13-Jul-91	204.7	25.53	244.6	29.95
5	Bass	09-Aug-91	265.9	32.53	15.4	3.40
5	Grass	13-Jul-91	121.0	16.10	204.6	26.16
5	Grass	30-Jul-91	59.3	9.00	95.4	13.30
5	Leaves	13-Jul-91	38.3	6.27	46.0	7.26
5	Leaves	30-Jul-91	21.7	4.26	75.3	10.93

Blank

DISTRIBUTION

WSRC-TR-92-193, Rev 1

DOE

E.C. Goodson

773-41A

Mr. Gene Nardella, U.S. Department of Energy, Office of Energy Research, Office of Fusion Energy, ER 533, Germantown, MD 20545

WSRC

D.B. Moore-Shedrow

773A

J.B. Gladden

773-42A

M. Paller

773-42A

L. Wike

773-42A

D.M. Hamby

773A

D.W. Hayes

773A

R. Lorenz

735-11A

T.V. Crawford

773A

C.E. Murphy Jr.

773-42A

C.W. Tope

703-43A

Records Administration

773-52A

External

Dr. David Eaton, Department of Chemistry, Fort Valley State College, Fort Valley, GA 31030

**DATE
FILMED
01/08/93**