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Ecological Research Series

^{129}I IN ANIMAL THYROIDS FROM NEVADA AND OTHER WESTERN STATES

Environmental Monitoring and Support Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Las Vegas, Nevada 89114

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^{129}I IN ANIMAL THYROIDS FROM NEVADA AND OTHER WESTERN STATES

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FOREWORD

Protection of the environment requires effective regulatory actions which are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach which transcends the media of air, water, and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound integrated monitoring data base through multidisciplinary, multimedia program designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment

- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs.

This report discusses the levels of iodine-129 found in the thyroids collected from domestic and wild animals from the Nevada Test Site and other western states. The results of this biological monitoring may be used to estimate the significance of iodine-129 contamination resulting from the nuclear testing program. This report should be of value to other researchers and to such agencies as the Office of Radiation Programs and the Nuclear Regulatory Commission. Further information on this subject may be obtained by contacting the Farm and Animal Investigation Branch of the Monitoring Systems Research and Development Division, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

George B. Morgan
Director
Environmental Monitoring and Support Laboratory
Las Vegas

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INTRODUCTION

For years, the nuclear tests conducted at the Nevada Test Site resulted in the formation of iodine-129. It was presumed that the iodine-129 would result in some degree of dosage to the thyroid of the local animals. However, prior to this study, the thyroid iodine-129 burdens had not been determined for either wild or domestic animals that live on and near the Nevada Test Site.

This study was conducted to measure the concentrations of iodine-129 in the thyroids of animals that reside on and around the Nevada Test Site, and to correlate these data with those from similar studies made around other nuclear facilities. The animals sampled included various species of wild animals and cattle from herds maintained on the Nevada Test Site since 1957 as biological monitors as well as cattle and goats used for special research projects.

CONCLUSIONS

Although levels in thyroids from Nevada Test Site cattle are statistically higher than levels in a northern Nevada background population, they are similar to those considered to be background by other investigators. The iodine-129/iodine-127 atom ratios reported are several orders of magnitude lower than those reported for animal thyroids collected near nuclear separation facilities. These findings indicate that the Nevada Test Site is not a significant source of iodine-129.

RECOMMENDATIONS

Because of the possible higher levels of iodine-129 in the thyroids of Nevada Test Site animals, it is recommended that periodic surveillance of iodine-129 levels be continued by collecting thyroids from free-ranging deer and cattle, and analyzing them by neutron activation analysis.

MATERIALS AND PROCEDURES

To attain the objectives stated in the introduction, thyroids were collected from animals sampled during the routine Animal Investigation Program surveillance activities with Nevada Test Site wildlife and the beef herd as described by Smith et al. (1976a). In addition, thyroids were collected from animals dying of natural causes at the Area 15 farm, from those sacrificed for other studies (e.g., salt feedlot studies, Shuyler et al., 1975), for the Area 13 grazing studies (Smith et al., 1976), and special investigations (Smith and Black 1975). During the annual hunting season, thyroids were collected from deer and elk in northern Nevada, Utah, and Wyoming. In addition, thyroids were collected from cattle slaughtered in certain abattoirs of northern Nevada to provide baseline values.

After collection, each thyroid was trimmed, weighed, and frozen. Thyroids of foxes and rabbits from the same area were pooled in order to have at least 1 gram of tissue. Each thyroid sample was placed in a plastic envelope with powdered paraformaldehyde prior to shipment to the analytical laboratory in lots of 20.

Preliminary investigations were made to determine the method of choice for the analysis for iodine-129 in the thyroids. Methods considered were the Phoswich detector, liquid scintillation, and neutron activation. Although iodine-129 is a radioactive nuclide, its extremely long half-life (1.7×10^7 years) results in a specific radioactivity of only 163 microcuries per gram. Furthermore, the low energy of its radiations (150 kiloelectronvolt beta and 38 kiloelectronvolt gamma) also makes detection by ordinary counting techniques very difficult. A reasonably large cross section (27 barns) for thermal neutron capture, leading to the formation of the activation product iodine-130 with a 12.6-hour half-life, makes the detection of iodine-129 by neutron-activation analysis highly practical. This method of analysis was chosen and a request for a proposal was prepared in November 1973. On May 10, 1974, a suitable contractor was selected and thyroids samples were submitted for analysis during May, August, and December 1974, and May 1975. Unfortunately, several of these samples (among them composite rabbit thyroid samples and thyroids collected from deer in northern Nevada and Utah) were lost during the analytical procedures. A total of 40 samples was successfully analyzed by the contractor.

While the original contract negotiations were in process, five bovine thyroids were analyzed by the successful bidder and another five were analyzed by a second applicant. In April 1975, a contract was awarded to a third applicant to provide neutron activation and iodine-129 analysis of 60 thyroid samples. These samples were sent to the second contractor in May and September 1975, and February 1976.

The neutron-activation and analytical procedures utilized by the two contractors are described in appendices A and B. Basically, both companies used the neutron-activation technique outlined by Magno et al. (1972).

RESULTS AND DISCUSSION

After the data were received from the analytical laboratories, they were tabulated according to the geographic location and date of collection. Tables 1 through 4 present analytical data about the thyroids collected from cattle maintained in Areas 18, 15, and 13 of the Nevada Test Site. In addition, analytical data on the thyroids collected from several goats, foxes, and coyotes from these same areas are given in these tables. Table 5 presents data on the thyroids of mule deer collected in the mountainous areas of the Nevada Test Site. Tables 6 and 7 present thyroid data from cattle that grazed areas that were 650 kilometers (northern Nevada) and 1,600 kilometers (Rocky Flats, Colorado) from the Nevada Test Site. Table 8 presents data from two elk collected in Wyoming. These tables also include information about the animals sampled, collection dates, micrograms of iodine per gram of tissue, picocuries of iodine-129 per gram of tissue, and picocuries of iodine-129 per gram of iodine. In order to assess whether the iodine-129 levels were elevated and to facilitate the comparison of these data with the data of other investigators in other parts of the country, the iodine-129 to iodine-127 atom ratios were also calculated.

Brauer et al. (1974) list typical values of the iodine-129 to iodine-127 atom ratios for cattle thyroids near nuclear separation facilities as 4×10^{-6}. They found a typical ratio of 8×10^{-9} in States such as Wisconsin, Kansas, and Texas, which are considered as background values in this report. Magno et al. (1972) reported atom ratios from bovine thyroids collected in the vicinity of the Nuclear Fuel Services Plant in New York ranging from 1.6×10^{-3} about 1.6 kilometers from the stack to 2.2×10^{-6} about 16 kilometers from the stack. In the same report, atom ratios are given for bovine thyroids from the Boston area (background) varying from 1×10^{-7} to 4×10^{-7}. In a personal communication, R. C. McFarland of Applied Physical Technology, Smyrna, Georgia, (July 9, 1975) stated that small animal thyroids from the South Carolina areas have atom ratios on the order of 2×10^{-4}. Examination of the data contained in tables 1 through 8 show that the iodine-129 to iodine-127 ratios reported fall between the two background ranges cited by Brauer and Magno.

The atom ratios in thyroids collected from beef cattle of northern Nevada (table 6) approach the background levels cited by Brauer and are generally one or two orders of magnitude lower than those observed for the Nevada Test Site and Rocky Flats, Colorado, beef cattle. The median iodine-129 to iodine-127 atom ratios in thyroids from the Nevada Test Site Area 18 beef cattle were 1.5×10^{-7} in 1973, 1.6×10^{-7} in 1974, and 1.4×10^{-8} in 1975. The apparent decrease in iodine-129 in 1975 may not be real, but rather may result from differences in analytical reporting by the two laboratories involved, as most of the thyroids in 1973 and 1974 were processed by the second contractor.

As shown in table 2, the median iodine-129 to iodine-127 atom ratios of 5.3×10^{-9} found in the thyroids of nine Hereford heifers maintained on a fattening ration in a feedlot at Area 15 was the lowest reported for adult Nevada Test Site cattle. Also, it was noted that the ratio of stable iodine to tissue was higher in those animals than for all other cattle sampled from desert environments. Probably the fattening ration fed to these heifers contained more stable iodine than the ration of the other range cattle sampled.

The free-ranging cattle from the Nevada Test Site and Rocky Flats beef cattle subsisted on the native vegetation of their respective ranges with little or no supplemental feeding. Therefore, the source of iodine-129 for these populations was assumed to be local in nature. The Area 15 cattle were corralled and fed hay and concentrates that originated from commercial sources away from the Nevada Test Site. The stable iodine content of these feeds probably had a diluting effect on the iodine-129 intake of these animals.

The median iodine-129 to iodine-127 atom ratios found in Nevada Test Site deer thyroids was 8.8×10^{-8} in 1973 and 1974 (six deer) and 2.2×10^{-8} in 1975 (seven deer). It was noted by Ballad et al. (1976) that deer generally acquire higher levels of iodine-129 than cattle. This relationship is noted on the Nevada Test Site when the heifers maintained in the Area 15 feedlot are compared to Nevada Test Site deer. It is though that the near saturation levels of mineral iodine in commercial feeds and salt licks may account for differences in the iodine-129 levels of cows and deer.

A report by Brauer et al. (1974) listed an average atom ratio of 1.8×10^{-7} for four elk thyroids collected in Wyoming during 1963. This value is very similar to the values listed in tables 8 (2.8×10^{-7} and 1.82×10^{-7}).

Nonparametric statistical tests (the Mann-Whitney U-test, and the Kruskal-Wallis Analysis of Variance) indicate that the iodine-129 to iodine-127 ratios in the cattle thyroid data fall into three groups. There are no significant differences (probability = 0.5727) between the animals from Area 18 of the Nevada Test Site, Area 13 of the Nevada Test Site, and Rocky Flats; thus animals from these three geographical areas may be considered as one group. The cattle from northern Nevada constitute a second group. The cattle from Area 15 of the Nevada Test Site are a third group with ratios of intermediate magnitude, but significantly different from the Nevada Test Site, Rocky Flats group and the group of northern Nevada cattle. On the basis of these tests, the probability that the paired groups of cattle have the same average isotope ratios are summarized as follows:

a. The probability that the Area 15 thyroids would be the same as those from northern Nevada is 0.0097.

b. The probability that the Nevada Test Site and Rocky Flats thyroids would be the same as those from northern Nevada is 0.00001.

c. The probability that the Nevada Test Site and Rocky Flats thyroids would be the same as those from Area 15 is 0.004.

The Bonferonni principle states that in order for all these probabilities to be simultaneously true at the 5 percent level (95 percent confidence) each one must have a probability of 0.01 or less; this was found to be the case for this data set.

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TABLE 1. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE - AREA 18, NTS

Sample Identification	Collection Date	μg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
BOV-1-NTS-73*	05/16/73	137	0.0090	66	3.7×10^{-7}	Hereford cow, 2 yrs.
BOV-3-NTS-73*	05/16/73	45	0.0023	51	2.9×10^{-7}	Hereford cow, 5 yrs.
BOV-4F-NTS-73*	05/16/73	354	0.0126	36	2.0×10^{-7}	Fetus of dam cow no. 4, 8.5 mos.
BOV-6-NTS-73*	05/16/73	77	0.0029	37	2.1×10^{-7}	Hereford steer, 1 yr.
BOV-7-NTS-73*	10/18/73	698	0.0096	14	7.9×10^{-8}	Hereford female, 6 mos.
BOV-8-NTS-73*	10/18/73	221	0.0060	27	1.5×10^{-7}	Hereford steer, 1.5 yrs.
BOV-10-NTS-73*	11/16/73	1,230	0.0075	6.1	3.5×10^{-8}	Hereford cow, 4.5 yrs.
BOV-11-NTS-73*	10/18/73	1,210	0.0109	9	5.1×10^{-8}	Hereford cow, 2.5 yrs.
BOV-12-NTS-73†	10/18/73		0.00096	4.7	2.7×10^{-8}	Hereford steer, 1.5 yrs.
BOV-1-NTS-74*	05/15/74	150	0.0052	34	1.9×10^{-7}	Hereford steer, 1 yr.
BOV-2-NTS-74*	05/15/74	415	0.0088	21	1.2×10^{-7}	Hereford cow, 6 yrs.
BOV-3-NTS-74*	05/15/74	510	0.0050	9.9	5.6×10^{-8}	Hereford steer, 3 yrs.
BOV-4-NTS-74*	05/15/74	200	0.0080	40	2.3×10^{-7}	Hereford cow, 15 yrs.
BOV-5-NTS-74*	05/15/74	173	0.0178	103	5.8×10^{-7}	Hereford cow, 3 yrs.
BOV-6-NTS-74*	05/15/74	321	0.0156	49	$2.8 \times 10\ ^{7}$	Hereford female calf, 2 wks.
BOV-8-NTS-74*	10/24/74	760	0.009	12	6.8×10^{-8}	Hereford steer, 1.5 yrs.
BOV-9-NTS-74*	10/24/74	770	0.008	10	5.7×10^{-8}	Hereford cow, 9 yrs, squamous cell carcinoma of eye
BOV-1-NTS-75†	05/22/75	555	0.0012	2.21	1.26×10^{-8}	Hereford cow, 4 yrs.
BOV-2-NTS-75†	05/22/75	762	0.0019	2.52	1.44×10^{-8}	Hereford cow, 13 yrs.
BOV-3-NTS-75†	05/22/75	789	0.0016	1.99	1.13×10^{-8}	Hereford steer, 1 yr.
BOV-4-NTS-75†	05/22/75	669	0.0017	2.58	1.47×10^{-8}	Hereford steer, 2 yrs.
BOV-5-NTS-75†	05/22/75	487	0.00089	1.84	1.05×10^{-8}	Hereford steer, 1 yr.

TABLE 1. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE - AREA 18, NTS (continued)

Sample Identification	Collection Date	μg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
BOV-7-NTS-75†	07/29/75	500	0.0010	1.99	1.14×10^{-8}	Hereford female calf, 1 yr., accident victim.
BOV-8-NTS-75†	10/16/75	620	0.0010	1.62	9.25×10^{-9}	Hereford bull, 4 mos.
BOV-9-NTS-75†	10/16/75	310	0.0012	3.86	2.20×10^{-8}	Hereford bull, 4 mos.
BOV-10-NTS-75†	10/16/75	990	0.0099	0.995	5.68×10^{-9}	Hereford cow, 4 mos.
BOV-11-NTS-75†	10/16/75	570	0.0018	3.12	1.78×10^{-8}	Hereford cow, 7 yrs.
BOV-12-NTS-75†	10/16/75	980	0.0036	3.69	2.11×10^{-8}	Hereford cow, 9.5 yrs.
BOV-13-NTS-75†	10/16/75	650	0.0017	2.56	1.46×10^{-8}	Hereford cow, 5 yrs.
1973 Range		45–1,230	0.00096–0.0126	4.7–66	2.7×10^{-8}–3.7×10^{-7}	
1973 Median		179	0.0075	27	1.5×10^{-7}	
1974 Range		150–770	0.005–0.0178	9.9–103	5.6×10^{-8}–5.8×10^{-7}	
1974 Median		368	0.0084	27.5	1.6×10^{-7}	
1975 Range		310–990	0.00089–0.0099	0.995–3.86	5.68×10^{-9}–2.2×10^{-8}	
1975 Median		635	0.00165	2.4	1.4×10^{-8}	

*Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.
†Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

TABLE 2. SUMMARY OF ^{129}I THYROID SAMPLES FROM AREA 18 CATTLE - AREA 15 FEEDLOT FOR 4.5 MONTHS

Sample Identification	Collection Date	μg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
820-NTS-74*	11/13/74	920	0.0088	0.960	5.48×10^{-9}	Hereford heifer, 1.5 yrs.
821-NTS-74*	11/13/74	1,180	0.0093	0.785	4.48×10^{-9}	Hereford heifer, 1.5 yrs.
841-NTS-74*	11/13/74	1,150	0.0038	0.328	1.87×10^{-9}	Hereford heifer, 1.5 yrs.
838-NTS-74†	11/13/74	960	0.0050	5	2.8×10^{-8}	Hereford heifer, 1.5 yrs.
856-NTS-74†	11/13/74	500	0.0050	11	6.3×10^{-8}	Hereford heifer, 1.5 yrs.
824-NTS-74*	11/13/74	1,440	0.0010	0.717	4.8×10^{-9}	Hereford heifer, 1.5 yrs.
825-NTS-74†	11/13/74	1,100	0.0030	3	1.7×10^{-8}	Hereford heifer, 1.5 yrs.
829-NTS-74*	11/13/74	1,260	0.0051	0.406	2.32×10^{-9}	Hereford heifer, 1.5 yrs.
842-NTS-74*	11/13/74	696	0.0064	0.926	5.27×10^{-9}	Hereford heifer, 1.5 yrs.
Range		500- 1,440	0.001- 0.0093	0.328- 11	1.87×10^{-9}- 6.3×10^{-8}	
Median		1,100	0.0050	0.926	5.27×10^{-9}	

*Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

†Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.

TABLE 3. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE AND A COYOTE - AREA 15, NTS

Sample Identification	Collection Date	μg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
COW-16-NTS-73*	05/23/73	748	0.0041	5.5	3.1×10^{8}	Holstein cow, 15 yrs., Area 15 since 1963.
BULL-216-NTS-74*	03/13/74	160	0.0018	11	6.2×10^{8}	Holstein bull, 4.5 yrs.
COW-139-NTS-74*	03/13/74	99	0.0018	18	1.0×10^{7}	Holstein cow, 5.5 yrs.
BIG SAM*	05/09/74	113	0.0049	44	2.5×10^{7}	Hereford steer, 9 yrs. fistulated.
BULL-516-NTS-74†	05/09/74	951	0.001	1.33	7.61×10^{9}	Hereford bull, 3 yrs.
CALF-1-321†	05/22/75	1,010	0.0004	0.424	2.42×10^{9}	Holstein-Cross female, 2 mos.
CALF-5-2693†	05/22/75	1,060	0.0001	0.106	6.05×10^{10}	Holstein male, 1 mo.
CALF-4-323†	05/22/75	826	0.0004	0.535	3.05×10^{9}	Holstein male, 2 mos.
CALF-2-319†	05/22/75	373	0.00008	0.205	1.17×10^{9}	Holstein male, 3 mos.
CALF-3-317†	05/22/75	722	0.0002	0.291	1.66×10^{9}	Holstein-Cross female, 3 mos.
CALF-6-320†	05/22/75	558	0.0002	0.302	1.73×10^{9}	Holstein-Cross female, 3 mos.
CALF-7-326†	09/03/75	620	0.0002	0.307	1.75×10^{9}	Holstein male, 1 day.
HEREFORD BULL†	09/30/75	200	<0.0002	<1.21	6.91×10^{9}	Polled Hereford bull, Area 15 for 3 mos., originated CA.
Range		99-1,060	0.00008-0.0049	0.106-44	6.65×10^{-10}-2.5×10^{-7}	
Median		589	0.0004	<0.873	1.75×10^{-9}	
COYOTE-1-NTS-75†	07/23/75	220	0.002	8.29	4.73×10^{-8}	Female, 3 mos.

*Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.
†Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

TABLE 4. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE, GOATS, AND FOXES - AREA 13, NTS

Sample Identification	Collection Date	$\frac{\mu g\ Iodine}{g\ Tissue}$	$\frac{pCi\ ^{129}I}{g\ Tissue}$	$\frac{pCi\ ^{129}I}{g\ Iodine}$	$^{129}I/^{127}I$ Atom Ratio	Remarks
COW-2-A13-73*	10/25/73	112	0.00139	12	6.8×10^{-8}	Hereford cow, 10 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
COW-3-A13-73†	10/25/73	---	0.00021	2.7	1.5×10^{-8}	Hereford-Cross cow, 11 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
CALF-12-A13-73*	10/25/73	496	0.0074	15	8.5×10^{-8}	Born Area 13 in May 1973. Dam cow no. 8.
COW-1-A13-74*	07/09/74	560	0.0081	14	7.9×10^{-8}	Angus cow, 12 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
COW-4-A13-74*	07/09/74	610	0.0071	1.6	9×10^{-9}	Hereford cow, 11 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
COW-6-A13-74*	07/09/74	860	0.0066	7.7	4.4×10^{-8}	Angus cow, 12 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
COW-5-A13-75‡	07/29/75	1,020	0.004	3.90	2.21×10^{-8}	Hereford-Angus cow, 9 yrs., Area 13 since May 1973. Originally Kingman, Arizona.
CALF-15-A13-75‡	01/29/75	1,290	0.005	3.55	2.02×10^{-8}	Angus-Cross bull, 1 yr.
CALF-18-A13-NTS‡	01/29/75	629	0.002	3.93	2.24×10^{-8}	Newborn female calf. Dam cow no. 5.
CALF-13-A13-75‡	01/29/75	1,090	0.004	3.85	2.20×10^{-8}	Angus-Cross bull, 1 yr.
COW-30-A13-76‡	01/16/76	690	0.004	5.36	3.06×10^{-8}	Hereford-Cross female, 1 yr.
BOV-14-A13-76‡	01/28/76	380	0.001	3.62	2.07×10^{-8}	Angus cow, 2.25 yrs.
BOV-19-A13-76‡	01/28/76	720	0.003	3.78	2.16×10^{-8}	Angus bull, 0.5 yr.

TABLE 4. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE, GOATS, AND FOXES - AREA 13, NTS (continued)

Sample Identification	Collection Date	μg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
Range		112- 1,290	0.00021- 0.0081	2.7- 15	1.5×10^{-8}- 8.5×10^{-8}	
Median		660	0.004	3.93	2.24×10^{-8}	
GOAT-1-A13-73*	08/07/73	1,500	0.0074	4.8	2.7×10^{-8}	Female goat, 1 yr., Area 13 since May 1973. Originally Tuba City, Arizona.
GOAT-2-A13-73*	10/25/73	126	<0.0026	<21	$<1.2 \times 10^{-7}$	Female goat, 3 yrs., Area 13 since May 1973. Originally Tuba City, Arizona.
FOXES-A13-74*	05/20/74	1,000	0.0260	<26	1.5×10^{-7}	Composite of three foxes.

*Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.
†Analytical Laboratory was Georgia Tech Research, Atlanta, Georgia.
‡Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

TABLE 5. SUMMARY OF ^{129}I THYROID SAMPLES FROM MULE DEER - NTS

Sample Identification	Collection Date	$\frac{\mu g\ Iodine}{g\ Tissue}$	$\frac{pCi\ ^{129}I}{g\ Tissue}$	$\frac{pCi\ ^{129}I}{g\ Iodine}$	$^{129}I/^{127}I$ Atom Ratio	Remarks
MD-4-NTS-73*	11/10/73	1,500	0.0240	16	9.09×10^{-8}	Mule deer male, 2.5 yrs., accident vicitm, Area 19.
MD-1-NTS-74*	01/30/74	3,600	0.2079	58	3.3×10^{-7}	Mule deer pregnant doe, adult, Area 30.
MD-2-NTS-74*	05/02/74	1,300	0.0270	23	1.3×10^{-7}	Mule deer male, adult, hunter kill, Area 12.
MD-3-NTS-74*	07/18/74	760	<0.0100	<14	$<7.9 \times 10^{-8}$	Mule deer, adult, road kill, Area 12.
MD-4-NTS-74*	10/18/74	1,060	0.0038	3.54	2.02×10^{-8}	Mule deer male, 2.5 yrs., hunter kill, Area 19.
MD-5-NTS-74*	11/25/74	2,600	0.037	15	8.5×10^{-8}	Mule deer male, 8 to 9 yrs., road kill, Pahute Mesa Road, Area 19.
MD-1-NTS-75†	01/21/75	1,350	0.0165	12.2	6.97×10^{-8}	Mule deer female, 3.5 yrs., accident victim, Area 12.
MD-2-NTS-75†	05/22/75	517	0.0016	3.15	1.80×10^{-8}	Mule deer male, 3.5 yrs., accident vicitim, Area 17.
MD-3-NTS-75†	06/16/75	947	0.0169	17.9	1.02×10^{-7}	Mule deer male, 5.5 yrs., road kill, Area 17.
MD-4-NTS-75†	08/03/75	710	0.0038	5.27	3.01×10^{-8}	Mule deer male, 5.5 yrs., road kill, Area 12.
MD-5-NTS-75†	08/21/75	680	0.00026	3.83	2.19×10^{-8}	Mule deer male, mature, road kill, Area 12.
MD-6-NTS-75†	09/10/75	420	<0.00031	<0.744	$<4.25 \times 10^{-9}$	Mule deer female, 3 yrs., road kill, Area 20.
MD-7-NTS-75†	09/11/75	1,350	0.0043	3.14	1.79×10^{-8}	Mule deer female, 4 yrs., hunter kill, Area 20.
Range		420–3,600	0.00026–0.2079	<0.744–58	$<4.25 \times 10^{-9}$ – 3.3×10^{-7}	
Median		1,060	<0.01	12.2	6.97×10^{-8}	

***Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.**
†Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

TABLE 6. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE - NORTHERN NEVADA

Sample Identification	Collection Date	$\frac{\mu g \text{ Iodine}}{g \text{ Tissue}}$	$\frac{pCi\ ^{129}I}{g \text{ Tissue}}$	$\frac{pCi\ ^{129}I}{g \text{ Iodine}}$	$^{129}I/^{127}I$ Atom Ratio	Remarks
COW-1*	03/05/75	644	0.0008	1.27	7.25×10^{-9}	Cow from Reno.
STEER-2*	03/05/75	1,720	0.0001	0.0742	4.23×10^{-10}	Steer from Elko.
STEER-A*	07/22/75	492	<0.0001	<0.262	$<1.50 \times 10^{-9}$	Hereford-Cross steer, Reno.
STEER-B*	08/05/75	526	0.0005	1.04	5.93×10^{-9}	Hereford-Cross steer, Fallon.
STEER-C	07/22/75	330	0.0002	0.687	3.92×10^{-9}	Polled Hereford-Cross steer, 18 mos., Fallon.
STEER-D*	08/13/75	1,510	0.00002	0.0120	6.85×10^{-11}	Hereford steer, Smith Valley.
STEER-E*	07/22/75	491	0.0004	0.849	4.84×10^{-9}	Polled Hereford-Cross steer, Fallon.
STEER-F*	08/13/75	876	0.00005	0.0566	3.23×10^{-10}	Angus-Cross steer, Smith Valley.
STEER-G*	09/03/75	1,150	0.00006	0.543	3.10×10^{-10}	Hereford-Angus steer, 15 mos., Humbolt County.
STEER-H*	08/05/75	1,000	0.001	1.08	6.16×10^{-9}	Hereford-Cross steer, Fallon.
STEER-I*	08/13/75	2,170	0.0006	0.278	1.59×10^{-9}	Hereford-Cross steer, Smith Valley.
COW-J*	08/08/75	239	0.0003	1.07	6.11×10^{-9}	Holstein cow, 8 yrs., University of Nevada, Reno.
STEER-K*	08/05/75	717	0.0009	1.27	7.25×10^{-9}	Angus-Cross steer, Fallon.
STEER-L*	09/03/75	1,180	0.0001	0.0960	5.48×10^{-10}	Shorthorn-Cross steer, Humbolt County.
UNK-M*	08/13/75	1,520	<0.00001	<0.0102	$<5.82 \times 10^{-11}$	Hereford steer, Smith Valley.
COW-N*	08/08/75	252	0.0003	1.10	6.28×10^{-9}	Holstein cow, 6 yrs., University of Nevada, Reno.
Range		239-2,170	<0.00001-0.001	<0.0102-1.27	$<5.82 \times 10^{-11}$-7.25×10^{-9}	
Median		797	0.00025	0.483	2.76×10^{-9}	

*Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

TABLE 7. SUMMARY OF ^{129}I THYROID SAMPLES FROM CATTLE - ROCKY FLATS, COLORADO

Sample Identification	Collection Date	µg Iodine / g Tissue	pCi ^{129}I / g Iodine	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
BOV-2-RF*	11/16/73	1,140	0.0690	60	3.4×10^{-7}	Angus cow, 18+ yrs.
BOV-4-RF*	11/16/73	610	0.0076	12.4	7.04×10^{-8}	Shorthorn female, 6 mos.
BOV-5-RF†	11/16/73	400	0.0013	3.3	1.9×10^{-8}	Hereford cow, 18 yrs.
BOV-6-RF*	11/16/73	1,910	0.0120	6.3	3.6×10^{-8}	Hereford female, 6 mos.
BOV-7-RF†	11/16/73	147	0.0006	4.1	2.3×10^{-8}	Shorthorn female, 5 mos.
BOV-9-RF*	11/16/73	2,000	0.0200	10.1	5.7×10^{-8}	Hereford female, 6 mos.
Range		610-2,000	0.0006-0.0690	3.3-12.4	1.9×10^{-8}-3.4×10^{-7}	
Median		1,525	0.0098	8.2	4.7×10^{-8}	

*Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.
†Analytical Laboratory was Georgia Tech Research, Atlanta, Georgia.

TABLE 8. SUMMARY OF ^{129}I THYROID SAMPLES FROM ELK - WYOMING

Sample Identification	Collection Date	µg Iodine / g Tissue	pCi ^{129}I / g Tissue	pCi ^{129}I / g Iodine	$^{129}I/^{127}I$ Atom Ratio	Remarks
ELK-1-74*	10/21/74	760	0.038	50	2.8×10^{-7}	Hunter kill, Rawlings.
ELK-2-RAWLINGS†	10/21/74	554	0.018	31.9	1.82×10^{-7}	Hunter kill, Rawlings.

*Analytical Laboratory was General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.
†Analytical Laboratory was Applied Physical Technology, Smyrna, Georgia.

APPENDIX A. TECHNICAL APPROACH: NEUTRON ACTIVATION OF THYROID SAMPLES AND IODINE-129 ANALYSIS BY GENERAL ELECTRIC COMPANY, VALLECITOS NUCLEAR CENTER, PLEASANTON, CALIFORNIA

It is proposed to analyze thyroids received in sets of 20 by the neutron activation technique as outlined in the U.S. Environmental Protection Agency report "Iodine-129 in the Environment Around a Nuclear Reprocessing Plant" by Paul J. Magno, Thomas C. Reavey, and John C. Apidianakis (October 1972), available from U.S. Environmental Protection Agency, Office of Radiation Programs, Field Operations Division, Washington, DC 20460. Five to 10 grams of thyroid are cut in small pieces together with 10,000 dpm of freshly manufactured iodine-131 separated from freshly fissioned uranium so as to be low in iodine-129, and solubilized in alcohol and sodium hydroxide. The mass is slowly heated over several hours to a final temperature of 600^{0} C to complete the fusion. Great care must be taken to avoid foaming or rapid reaction. The sample is cooled, dissolved in water, oxidized with chlorine to exchange iodine-131 with iodine-129, -127, acidified with nitric acid, and extracted twice with carbon tetrachloride and hydroxylamine hydrochloride. The iodine is back extracted into a sodium sulfite solution.

A second extraction is performed into toluene from nitric acid and sodium nitrite and back extracted into sodium sulfite solution. The toluene extraction is repeated once again and extracted into amonium sulfite to separate the iodine from bromine. The ammonium sulfite solution is gently evaporated to dryness in a quartz ampoule, sealed, and irradiated in the General Electric Test Reactor for 1 to 4 hours at 8×10^{13} neutron flux in the shuttle tube. One hour is required for samples greater than 4 grams. A 1-gram sample requires 4 hours of irradiation. Known samples containing 10 milligrams of iodine-127 and National Bureau of Standards iodine-129 standard will be included for calibration purposes and cobalt-aluminum flux wires will monitor total exposures for each irradiation. Each irradiation capsule will hold five quartz vials. A period of 12 hours is allowed for decay after irradiation. The ampoules are opened, water and 10 milligrams of iodine carrier are added; the solution is acidified and sodium nitrite added to release iodine which is extracted into toluene. The organic phase is scrubbed with 0.01<u>M</u> nitric acid to remove activated bromine, sodium, and other impurities. The iodine is stripped into an ammonium sulfite solution. The iodide is precipitated as palladium iodide and filtered onto a paper disk for counting on a germanium (lithium) detector. The iodine-127 is calulated from the number of microcuries of iodine-126 present and the iodine-129 is calculated from the iodine-130 present after correction for in-pile and out-of-pile decay. Chemical recovery is calculated from iodine-131 recovery. Calibration is by known iodine-127 and iodine-129 samples. Blanks on the iodine-131 are run to establish that iodine-131 is fresh and the iodine-129 blank is low. One day is required to solubilize samples and

1 day is required to purify them. Irradiation and cooling is performed at night. The third day is spent purifying the irradiated samples and counting them. A maximum of 2 runs of five samples can be made in a 5-day week.

APPENDIX B. TECHNICAL APPROACH: NEUTRON ACTIVATION OF THYROID SAMPLES AND IODINE-129 ANALYSIS BY APPLIED PHYSICAL TECHNOLOGY (APT), SMYRNA, GEORGIA

The basic task will be to provide iodine-127 and iodine-129 analyses on 40 to 60 samples of thyroid tissue supplied by the U.S. Environmental Protection Agency. Samples should be in the range of 1 to 30 grams (wet) and shipped in paraformaldehyde. Analyses will be reported as: micrograms iodine-127 per gram tissue, picocuries iodine-129 per gram tissue, micrograms iodine-129 per gram iodine-127, and picocuries iodine-129 per gram iodine-127.

Neutron activation analysis of thyroid tissue for iodine-129 requires chemical separation of the iodine prior to irradiation to reduce interference from other reactions. The iodine-129 is determined by the neutron gamma reaction iodine-129 (n,γ) iodine-130; the iodine-130 decays by beta emission with a 12.4-hour half-life. The iodine-127 is determined by the neutron gamma reaction iodine-127 (n,γ) iodine-128, where the iodine-128 decays by beta emission with a 25-minute half-life. Primary interfering reactions are:

(1) I-127 (n,γ) I-128 (n,γ) I-129 (n,γ) I-130
(2) U-235 (n,f) I-131
(3) Cl-37 (n,γ) Cl-38
(4) I-127 (n,2n) I-126
(5) Br-81 (n,γ) Br-82

Pre-irradiation chemical separation greatly reduces the interference from reactions (2), (3), and (5). Interferences from reaction (4) can be eliminated by using a well moderated neutron flux for irradiation such as a heavy water reactor where the thermal neutron flux is high and the ratio of thermal neutrons to fast reactions is also high. The irradiation of chemical blanks is used to assess the interference of reagent contamination and interference from reaction (1).

The analytical method used by APT is an adaptation of a method developed by P. Magno, T. Reavey, and J. Apidianakis of the U.S. Environmental Protection Agency. The sample of thyroid tissue is fused with sodium hydroxide and iodine-131 tracer for chemical yield determination. A series of solvent extractions is used to chemically separate the iodine from other interfering elements present in the original sample. The product of the solvent extractions is an ammonium sulfite solution containing the iodine for neutron activation analysis. Iodine solutions in ammonium sulfite can be irradiated in polyethylene containers without significant adsorption on the container walls. The iodine solution is irradiated in a thermal neutron flux of about 10^{13} neutrons per square centimeter per second for about 14 hours. Following irradiation more solvent extractions further decontaminate the iodine. Finally, the iodine is precipitated as palladium iodide for counting. The samples are first counted as soon as possible after irradiation for the 25-minute half-life iodine-128. After several hours decay, the samples are counted again for iodine-130 and iodine-131. Comparison with a National Bureau of Standards iodine-129 standard and a known quantity of iodine-127 and iodine-131 carrier irradiated simultaneously with the samples permits a determination of the iodine-129 and iodine-127 content of the original thyroid sample.

The sensitivity of this procedure has been determined as 2×10^{-9} microcuries iodine-129. For samples of 1 to 30 grams, the sensitivity is 2×10^{-9} microcuries iodine-129 per gram of tissue and 7×10^{-11} microcuries iodine-129 per gram of tissue, respectively. These limits are in compliance with the requested sensitivity of 1×10^{-8} microcuries iodine-129 per gram of tissue.

Due to the lengthy pre-irradiation and post-irradiation chemical procedures, the relatively short half-life of the iodine-130 (12.4 hours), and the long counting time required, the maximum number of samples that can be effectively analyzed with the required sensitivity is limited. Samples submitted in groups of 20 will require 45 days for analysis and the report can be forwarded in 60 days from receipt of samples. Data for any given sample can be provided on request within approximately 2 weeks after the sample arrives at APT.

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16. ABSTRACT

The data from over 80 thyroids collected during 1973, 1974, and 1975 from animals residing on the Nevada Test Site indicate that iodine-129 levels in these thyroids are near background levels. However, the median levels in the thyroids of animals living on the Nevada Test Site are slightly elevated from those found in northern Nevada, but are similar to those found near Denver, Colorado, and Rawlins, Wyoming. Statistical analyses of the iodine-129/iodine-127 ratios in cattle thyroids suggest that three populations were sampled. These populations are: (1) northern Nevada cattle which were considered as a baseline population, (2) corralled Nevada Test Site cattle with intermediate ratios, and (3) free-grazing cattle from Nevada Test Site and Rocky Flats, Colorado, which had the highest ratios reported.

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