RADIONUCLIDE CONTAMINANT ANALYSIS OF RODENTS AT A WASTE BURIAL SITE, LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT Small mammals were sampled at two waste burial sites (Sites 1 and 2) at Area G, TA-54, and a control site outside Area G (Site 3) to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for americium (^{241}Am), strontium (^{90}Sr), plutonium (^{238}Pu and ^{239}Pu), total uranium (U), and examined by gamma spectroscopy (including cesium [^{137}Cs]). Significantly higher (parametric t-test at p = 0.05) levels of total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and potassium (^{40}K) were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Our results show higher concentrations in pelts compared to carcasses which is similar to what has been found at waste burial/contaminated sites outside of Los Alamos National Laboratory. Site 1 had significantly higher (alpha = 0.05, P = 0.0095) total U concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher (alpha = 0.05, P = 0.0195) ^{239}Pu concentrations in carcasses than either Site 1 or Site 3.

KEYWORDS: radionuclides, waste sites, small mammals

INTRODUCTION

A solid, low-level radioactive disposal facility has been operating at Area G, TA-54, since 1957 and has been used to dispose of various wastes including tritium waste, transuranic waste, volatile organic compounds, and mixed waste. Environmental monitoring of air, soil, water runoff, and vegetation has been in place to examine potential migration of contaminants. Recently, there has been no sampling to determine contaminant concentration of small mammals within the boundaries of Area G. Consequently, the collection and analysis of small mammals at TA-54, Area G, was initiated as part of the Enhanced Environmental Annual Surveillance program at Area G by the Environmental, Safety, and Health Division in collaboration with the Solid Waste Management Group. The program is intended to provide data to aid in meeting requirements of DOE Order 5400.1, which specifies monitoring of existing operations at radioactive waste burial sites.

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Rodents can affect the distribution of radionuclides at radioactive waste burial sites through their burrowing activities [1]. Burrowing activity and mound building can expose contaminated soils which can then be dispersed by wind and water erosion [2]. Predators of small mammals can also disperse radioactive material in their feces, urine, or regurgitated pellets [3]. Burrowing animals can also alter the soil profile and change the physical and chemical processes in the soil profile resulting in movements of buried contaminants [4]. In addition, small mammals utilizing waste burial sites can be contaminated through direct contact of contaminated soil or by ingestion of soil (i.e., soil consumption during pelt grooming) or from foraging on plant resources [5] and could subsequently become a form of contaminant transport off site via predation from predator species [6].

The collection and analysis of burrowing small mammals at two waste burial sites (Sites 1 and 2) within Area G, TA-54, Los Alamos National Laboratory (LANL), was used to (1) identify radionuclides potentially present within surface and subsurface soils at waste burial sites within Area G by sampling the tissues of nocturnal small mammals that burrow, (2) quantitatively estimate the amount of radionuclide uptake at specific waste burial sites within Area G and compare with a control site (Site 3) by sampling carcasses of burrowing nocturnal small mammals, (3) determine the primary mode of contamination to small mammals, either by surface contact or through ingestion/inhalation, and (4) estimate small mammal densities at each waste burial site and the control site for use in estimating potential contaminant loads within the rodent population. Data collected from the waste burial sites were compared to a control site. A general description of Area G and the various wastes buried within its boundaries is given in Eklund (1995) [7].

METHODOLOGY

Three sites were selected for sampling (trapping) within Area G (Figure 1) with respect to ongoing disposal operations. These sites were defined as follows:

1. *A recently disturbed/contaminated site.* This site is a shallow earth-covered storage site for transuranic uranium drums, built on top of old previously filled disposal pits. Vegetation is not well established and consists of plant species associated with disturbed ground.
2. *A partially disturbed/contaminated waste burial site.* This site has established vegetation with a mixture of native plants and plant species associated with disturbed ground.
3. *An undisturbed/uncontaminated control site.* There are no waste operations occurring at this site which consists of well-established native plant species associated with a piñon pine/juniper woodland.

Site 1 is located on a recent waste storage earthen mound with a lack of well established vegetation, Site 2 is located on a waste burial site where vegetation has become well established, and Site 3 is located west of the check-in facility for Area G. Site 3, located within a piñon-juniper woodland and adjacent to the operating disposal site, was selected as the control site. Vegetation samples were also collected at various locations within and near Area G waste burial sites [8], including two locations at Site 1 of this study. When applicable, results of vegetation sampling are presented in the text of this report.

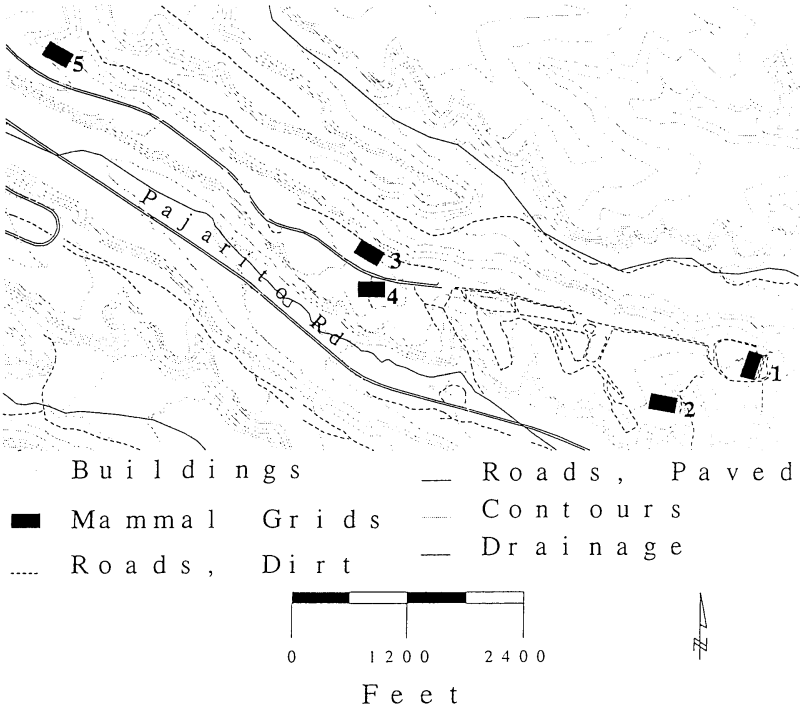

FIGURE 1. LOCATIONS OF SITES OF SMALL MAMMAL GRIDS AT AREA G. (SITES 4 AND 5 WERE LATER ADDED BECAUSE OF LOW CAPTURE RATES AT SITE 3.)

A grid design consisting of 100 snap traps placed approximately 10 m apart in a 10 x 10 design was used to collect animals at each of the three sites. Snap trapping took place over three to four nights (until at least 15 animals were captured at each site). Procedures for handling and field processing of small mammals with respect to potential infection of hantavirus are given in Mills, *et al.* [9], and Biggs and Bennett [10]. These same safety procedures were followed for collecting tissue samples from snap-trapped animals. At least 15 rodents were captured at Sites 1 and 2. However, low capture rates at Site 3 necessitated additional sampling in the vicinity of that location (identified as Sites 4 and 5 on Figure 1). Additional snap traps were placed in similar habitat adjacent to Site 3 and west of the Area G controlled-access gate to ensure that a sufficient sample size was obtained for analysis. Snap traps were baited and set in late afternoon and checked in early morning. Traps with animals were taken to a central processing station where pelts were removed. Precautions during handling were taken to minimize cross contamination from carcass to pelt while removing pelts. All external hair was removed from appendages.

Three composite samples were collected at each site with each sample consisting of a minimum of five animals. The pelt was separated from the carcass of each animal, and analysis for each radionuclide was run on the pelt and carcass separately. Due to total ashed weight, the three composite samples of pelts were combined for each site for a total of one sample per site only. The samples were placed into 1 liter glass beakers. The beaker contents were covered with tin foil and ashed at 500°C for 120 hr. The sample ash was pulverized and homogenized before it was submitted to a

LANL analytical laboratory for the analysis for americium (^{241}Am), strontium (^{90}Sr), plutonium (^{238}Pu and ^{239}Pu), total uranium (U), and for gamma spectroscopy (including cesium [^{137}Cs]). All methods of radiochemical analysis have been described previously [11]. Results are reported on a per ash weight basis (g/ash). There were insufficient amounts of pelts to analyze the composite samples separately due to the lack of a minimum amount of ash required to conduct the analysis. In these cases, the composite samples were combined for each site. Separate analysis of pelts and carcasses allowed for a more accurate determination of radionuclide concentration (ingestion/inhalation or external body surface).

The Statistical Analysis System (SAS) was used to analyze all data sets [12]. A univariate test was used to determine if carcass radionuclide means were normally distributed within each site. Most means were normally distributed, and so a parametric t-test was used to determine if the means of each radionuclide were equal between carcasses and pelts. This was not conducted by site since only one pelt sample per site existed. An Analysis of Variance (ANOVA) was used to determine if any significant differences in the amount of radionuclide in carcass samples existed between sites (the ANOVA generates an alpha [probability] at the 0.05 level), and Duncan's multiple range test was used to identify where the significant differences occurred between the sites.

Rodent densities were estimated using Leslie's regression method [13] applied to each grid where the daily total number of captures was plotted against the cumulative daily captures. Confidence intervals were calculated at 90% using the general method [13].

RESULTS

Density estimates

The deer mouse (*Peromyscus maniculatus*) was the only small mammal species captured at Sites 1 and 2. Deer mice and pinyon mice (*P. trueii*) were captured at the control site. The highest densities of animals occurred on Sites 1 and 2 with very low capture rates at the control site. Because of the low capture rates at Site 3, additional locations were trapped adjacent to it. Density estimates of rodents occurring at Sites 1 and 2 were calculated by regressing the number of daily captures onto the cumulative number of captures for each day. Rodent density of Site 3 is based on total number of animals captured due to no new captures being recorded on the last day of trapping. The density of the trapping area is based on a 100 m by 100 m grid with an additional 5 m boundary strip to help account for animals being drawn into the grid due to the bait. Therefore the total effective trapping area is approximately 1.21 ha. Table 1 gives the estimated density (# animals/ha) of each site sampled after adjustment for the total effective trapping area.

Radionuclide analysis

Results of data analysis presented in this paper are primarily for the radionuclides total U, ^{241}Am, ^{238}Pu and ^{239}Pu, ^{90}Sr, ^{137}Cs, bismuth (^{214}Bi), cobalt (^{60}Co), europium (^{152}Eu), potassium (^{40}K), and thallium (^{208}Tl) (Table 2). A total of 27 radionuclides were analyzed using gamma spectroscopy. However, results are presented only for those that showed detectable activity based on the gamma spectroscopy. These included ^{137}Cs, ^{214}Bi, ^{60}Co, ^{152}Eu, ^{40}K, and ^{208}Tl.

All carcass means were normally distributed (Table 3) with the exception of ^{137}Cs in Site

1, total U in Site 2, and ^{60}Co and ^{152}Eu in Site 3.

The mean concentration of each radionuclide found in carcasses and pelts by site is given in Tables 4 and 5, respectively, and shown in Figure 2. For most sites, the mean concentration of radionuclides in carcasses were lower than the concentrations found in pelts (only one composite pelt sample was analyzed per site due to low total ashed weight of combined samples) for total U, ^{241}Am, ^{238}Pu, and ^{239}Pu. For the remaining radionuclides, concentrations in carcasses were usually nearly equal to or exceeded the mean concentrations in the pelts. An ANOVA test was used to determine if the mean radionuclide concentrations in carcasses were different between sites, and Duncan's multiple range test was used to show where the differences occurred. The results are discussed below.

Total U

There were no significant differences in total U in carcasses between Sites 2 and 3. However, Site 1 had significantly higher

TABLE 1. RODENT DENSITY ESTIMATE OF AREA G (SITES 1 AND 2) AND CONTROL (SITE 3).

SITE 1	DAY	NO. OF CAPTURES	NO. OF TRAPS
	1	13	100
	2	6	100
	3	5	100
DENSITY ESTIMATE (# animals/ha)	23.84		
VAR(N) ESTIMATE	13.24		
90% CONFIDENCE INTERVAL	Lower 90% Limit 4.08		Upper 90% Limit 61.85
SITE 2	**DAY**	**NO. OF CAPTURES**	**NO. OF TRAPS**
	1	17	100
	2	6	100
	3	1	100
DENSITY ESTIMATE (# animals/ha	20.67		
VAR(N) ESTIMATE	0.60		
90% CONFIDENCE INTERVAL	Lower 90% Limit 17.09		Upper 90% Limit 27.04
SITE 3	**DAY**	**NO. OF CAPTURES**	**NO. OF TRAPS**
	1	4	100
	2	0	100
	3	—	—
DENSITY ESTIMATE (# animals/ha)	3.31*		

*no new captures were recorded after the first night of trapping, therefore, a third night of trapping was not conducted; this estimate is treated as a "complete census" of rodents at the site.

(alpha = 0.05, P = 0.0095) total U concentrations in carcasses than Sites 2 and 3 and was over two times higher than the control, Site 3.

^{90}Sr, ^{40}K, ^{241}Am, ^{238}Pu, ^{137}Cs, ^{214}Bi, ^{152}Eu, ^{60}Co, ^{208} Tl

There were no significant differences (alpha = 0.05) in concentrations of ^{241}Am (P = 0.1267), ^{238}Pu (P = 0.0846), ^{137}Cs (P = 0.4607), ^{214}Bi (P = 0.2697), ^{152}Eu (P = 0.1539), ^{60}Co (P = 0.9612), or ^{208} Tl (P = 0.2076) in rodent carcasses between sites.

TABLE 2. (CONTINUED ON NEXT PAGES) SUMMARY OF ANALYTICAL RESULTS FOR RADIONUCLIDES SHOWING DETECTABLE ACTIVITY.

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (µg/g or pCi/g)[a,b]	ANALYTICAL UNCERTAINTY
1	1	^{241}Am	Carcass	0.01	0.03
1	2	^{241}Am	Carcass	0.009	0.03
1	3	^{241}Am	Carcass	0.012	0.03
1	1	^{241}Am	Pelt	0.052	0.03
1	1	^{238}Pu	Carcass	0.137	0.031
1	2	^{238}Pu	Carcass	0.173	0.037
1	3	^{238}Pu	Carcass	0.012	0.03
1	1	^{238}Pu	Pelt	0.506	0.035
1	1	^{239}Pu	Carcass	0.034	0.02
1	2	^{239}Pu	Carcass	0.023	0.015
1	3	^{239}Pu	Carcass	0.02	0.02
1	1	^{239}Pu	Pelt	0.089	0.02
1	1	^{90}Sr	Carcass	1.7	0.2
1	2	^{90}Sr	Carcass	3.4	0.2
1	3	^{90}Sr	Carcass	2.8	0.3
1	1	^{90}Sr	Pelt	0.9	0.5
1	1	^{137}Cs	Carcass	0.04	0.06
1	2	^{137}Cs	Carcass	0.04	0.06
1	3	^{137}Cs	Carcass	0.04	0.06
1	1	^{137}Cs	Pelt	0.02	0.03
1	1	^{214}Bi	Carcass	0.41	0.13
1	2	^{214}Bi	Carcass	0.72	0.16
1	3	^{214}Bi	Carcass	0.58	0.15
1	1	^{214}Bi	Pelt	0.42	0.14
1	1	^{60}Co	Carcass	0.94	0.17
1	2	^{60}Co	Carcass	1.01	0.15
1	3	^{60}Co	Carcass	1.12	0.16
1	1	^{60}Co	Pelt	0.99	0.15

[a]Total U in measurements of µg/g; all other contaminant measurements are in pCi/g.
[b]To convert pCi/g to Bq/kg, multiply all values by 37.

TABLE 2. (CONTINUED FROM PREVIOUS AND ONTO NEXT PAGES) SUMMARY OF ANALYTICAL RESULTS FOR RADIONUCLIDES SHOWING DETECTABLE ACTIVITY.

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (μg/g or pCi/g)[a,b]	ANALYTICAL UNCERTAINTY
1	1	^{152}Eu	Carcass	2.24	0.55
1	2	^{152}Eu	Carcass	2.36	0.56
1	3	^{152}Eu	Carcass	2.66	0.63
1	1	^{152}Eu	Pelt	1.97	0.52
1	1	^{40}K	Carcass	50.15	5.78
1	2	^{40}K	Carcass	49.47	5.73
1	3	^{40}K	Carcass	47.19	5.5
1	1	^{40}K	Pelt	43.45	5.14
1	1	^{208}Tl	Carcass	0.22	0.07
1	2	^{208}Tl	Carcass	0.25	0.06
1	3	^{208}Tl	Carcass	0.26	0.07
1	1	^{208}Tl	Pelt	0.26	0.07
2	1	total U	Carcass	0.318	0.032
2	2	total U	Carcass	0.397	0.040
2	3	total U	Carcass	0.316	0.038
2	1	total U	Pelt	1.362	0.136
2	1	^{241}Am	Carcass	0.099	0.030
2	2	^{241}Am	Carcass	0.034	0.030
2	3	^{241}Am	Carcass	0.019	0.030
2	1	^{241}Am	Pelt	1.14	0.071
2	1	^{238}Pu	Carcass	0.033	0.010
2	2	^{238}Pu	Carcass	0.001	0.004
2	3	^{238}Pu	Carcass	0.006	0.002
2	1	^{238}Pu	Pelt	0.237	0.030
2	1	^{239}Pu	Carcass	0.121	0.017
2	2	^{239}Pu	Carcass	0.072	0.010
2	3	^{239}Pu	Carcass	0.042	0.006
2	1	^{239}Pu	Pelt	1.269	0.079
2	1	^{90}Sr	Carcass	1.7	0.2
2	2	^{90}Sr	Carcass	0.6	0.2
2	3	^{90}Sr	Carcass	1.3	0.2
2	1	^{90}Sr	Carcass	1.3	0.8
2	1	^{137}Cs	Carcass	0.01	0.02
2	2	^{137}Cs	Carcass	0.03	0.05
2	3	^{137}Cs	Carcass	0.06	0.09
2	1	^{137}Cs	Pelt	0.03	0.05
2	1	^{214}Bi	Carcass	0.49	0.12
2	2	^{214}Bi	Carcass	0.41	0.11
2	3	^{214}Bi	Carcass	0.50	0.14
2	1	^{214}Bi	Pelt	0.44	0.13
2	1	^{60}Co	Carcass	0.94	0.12

[a]Total U in measurements of μg/g; all other contaminant measurements are in pCi/g.
[b]To convert pCi/g to Bq/kg, multiply all values by 37.

TABLE 2. (CONTINUED FROM PREVIOUS AND ONTO NEXT PAGES) SUMMARY OF ANALYTICAL RESULTS FOR RADIONUCLIDES SHOWING DETECTABLE ACTIVITY.

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (µg/g or pCi/g)[a,b]	ANALYTICAL UNCERTAINTY
2	2	^{60}Co	Carcass	0.91	0.14
2	3	^{60}Co	Carcass	0.96	0.17
2	1	^{60}Co	Pelt	0.96	0.15
2	1	^{152}Eu	Carcass	2.89	0.64
2	2	^{152}Eu	Carcass	2.13	0.54
2	3	^{152}Eu	Carcass	2.39	0.56
2	1	^{152}Eu	Pelt	2.94	0.71
2	1	^{40}K	Carcass	43.87	5.22
2	2	^{40}K	Carcass	46.35	5.35
2	3	^{40}K	Carcass	45.39	5.32
2	1	^{40}K	Pelt	40.22	4.86
2	1	^{208}Tl	Carcass	0.20	0.06
2	2	^{208}Tl	Carcass	0.15	0.05
2	3	^{208}Tl	Carcass	0.21	0.07
2	1	^{208}Tl	Pelt	0.16	0.06
3	1	total U	Carcass	0.252	0.025
3	2	total U	Carcass	0.174	0.017
3	3	total U	Carcass	0.267	0.027
3	1	total U	Pelt	0.979	0.196
3	1	^{241}Am	Carcass	0.009	0.030
3	2	^{241}Am	Carcass	0.003	0.030
3	3	^{241}Am	Carcass	0.007	0.030
3	1	^{241}Am	Pelt	0.014	0.030
3	1	^{238}Pu	Carcass	0.012	0.030
3	2	^{238}Pu	Carcass	0.006	0.030
3	3	^{238}Pu	Carcass	0.001	0.030
3	1	^{238}Pu	Pelt	0.003	0.030
3	1	^{239}Pu	Carcass	0.003	0.020
3	2	^{239}Pu	Carcass	0.001	0.020
3	3	^{239}Pu	Carcass	0.005	0.020
3	1	^{239}Pu	Pelt	0.037	0.020
3	1	^{90}Sr	Carcass	2.0	0.3
3	2	^{90}Sr	Carcass	1.8	0.3
3	3	^{90}Sr	Carcass	1.9	0.2
3	1	^{90}Sr	Pelt	1.8	0.6
3	1	^{137}Cs	Carcass	0.12	0.05
3	2	^{137}Cs	Carcass	0.02	0.03
3	3	^{137}Cs	Carcass	0.06	0.09
3	1	^{137}Cs	Pelt	0.02	0.03
3	1	^{214}Bi	Carcass	0.30	0.14
3	2	^{214}Bi	Carcass	0.52	0.14

[a]Total U in measurements of µg/g; all other contaminant measurements are in pCi/g.
[b]To convert pCi/g to Bq/kg, multiply all values by 37.

^{239}Pu

No significant differences in concentrations of ^{239}Pu in carcasses occurred between Sites 1 and 3 but Site 2 had significantly higher (alpha = 0.05, P = 0.0195) ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. Mean concentrations in carcasses at Site 2 (0.078 pCi/g) were three and 26 times higher than Sites 1 and 3, respectively.

Analysis was conducted on overall mean concentrations of radionuclides to determine if differences existed between pelts and carcasses (Figure 3). The analysis was not conducted by site due to only one pelt sample per site being analyzed. For all sites combined, no significant differences were found between pelt and carcass concentrations for the contaminants analyzed. However, much higher concentrations in pelts were observed for total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K.

CONCLUSION

This study was intended to establish baseline measurements of radionuclide concentrations in small mammals at Area G, TA-54, during the summer of 1994. The data can then be used to modify future studies at Area G to better identify radionuclide transport and concentration loads in and around the site.

As shown in Table 1, higher densities of rodents were recorded for the two sites within Area G, both of which are located on predisturbed ground. Typically, at other predisturbed locations within Laboratory

TABLE 2. (CONTINUED FROM PREVIOUS PAGES) SUMMARY OF ANALYTICAL RESULTS FOR RADIONUCLIDES SHOWING DETECTABLE ACTIVITY.

SITE	SAMPLE NUMBER	RADIOISOTOPE	SAMPLE TYPE	ANALYTICAL RESULT (µg/g or pCi/g)[a,b]	ANALYTICAL UNCERTAINTY
3	3	^{214}Bi	Carcass	0.39	0.18
3	1	^{214}Bi	Pelt	0.56	0.24
3	1	^{60}Co	Carcass	0.43	0.12
3	2	^{60}Co	Carcass	2.42	0.28
3	3	^{60}Co	Carcass	0.42	0.09
3	1	^{60}Co	Pelt	1.28	0.28
3	1	^{152}Eu	Carcass	0.17	0.26
3	2	^{152}Eu	Carcass	2.72	0.65
3	3	^{152}Eu	Carcass	0.10	0.15
3	1	^{152}Eu	Pelt	0.03	0.05
3	1	^{40}K	Carcass	22.58	2.7
3	2	^{40}K	Carcass	46.52	5.48
3	3	^{40}K	Carcass	28.92	3.08
3	1	^{40}K	Pelt	529.19	40.64
3	1	^{208}Tl	Carcass	0.17	0.06
3	2	^{208}Tl	Carcass	0.22	0.06
3	3	^{208}Tl	Carcass	0.16	0.06
3	1	^{208}Tl	Pelt	0.33	0.11

[a]Total U in measurements of µg/g; all other contaminant measurements are in pCi/g.
[b]To convert pCi/g to Bq/kg, multiply all values by 37.

boundaries, small mammal densities have been higher than in undisturbed habitats. The low densities recorded for the control site is also typical of other studies conducted on mesa top habitats within Laboratory boundaries, especially within piñon pine/juniper woodlands. The primary species collected at Sites 1 and 2 was the deer mouse species. Deer mice are a more "opportunistic" species compared to other mice expected to occur in the vicinity of Area G and are, therefore, more likely to invade and populate the disturbed sites.

Our studies generally showed greater amounts of the radionuclides total U, ^{241}Am, ^{238}Pu, and ^{239}Pu in the pelts of animals compared to the carcasses. In studies conducted at waste burial sites or contaminated sites outside of the Laboratory, similar results were found. Markham, *et al.* [14] found higher concentrations of ^{238}Pu, ^{239}Pu, and ^{241}Am in the pelts and gastrointestinal tracts

TABLE 3. PROBABILITY VALUES FOR NORMALITY TEST ON MEAN CONCENTRATION OF RADIONUCLIDES BY CARCASS.

CONTAMINANT	P Value*		
	SITE 1	SITE 2	SITE 3
total U	0.5399	0.0413	0.2879
^{241}Am	0.6368	0.3386	0.6368
^{238}Pu	0.4099	0.2783	0.8995
^{239}Pu	0.2500	0.7364	0.9916
^{90}Sr	0.6786	0.7016	0.9916
^{137}Cs	0.0000	0.7803	0.7803
214Bi	0.8931	0.1939	0.8001
^{60}Co	0.7562	0.7803	0.0083
^{152}Eu	0.5367	0.6555	0.0447
^{40}K	0.4222	0.7523	0.4935
^{208}Tl	0.4632	0.2982	0.8774

* less than 0.05 indicates non-normal distribution

TABLE 4. MEAN RADIONUCLIDE CONCENTRATIONS FOR SMALL MAMMAL CARCASS SAMPLES.

	SITE 1			SITE 2			SITE 3		
RADIONUCLIDE	N	Mean	SE	N	Mean	SE	N	Mean	SE
^{214}Bi	3	0.57	0.089	3	0.467	0.029	3	0.403	0.064
^{241}Am	3	0.01	0.001	3	0.051	0.025	3	0.006	0.002
^{238}Pu	3	0.107	0.049	3	0.013	0.010	3	0.006	0.003
^{137}Cs	3	0.04	0.000	3	0.033	0.015	3	0.067	0.029
^{60}Co	3	1.023	0.052	3	0.937	1.090	3	1.09	0.665
^{152}Eu	3	2.42	0.125	3	2.470	0.223	3	0.997	0.862
^{208}Tl	3	0.243	0.012	3	0.187	0.019	3	0.217	0.026
^{239}Pu	3	0.026	0.004	3	0.078	0.023	3	0.003	0.001
U	3	0.487	0.054	3	0.344	0.027	3	0.231	0.029
^{90}Sr	3	2.6	0.498	3	1.2	0.321	3	1.9	0.058
^{40}K	3	48.94	0.895	3	45.2	0.722	3	32.67	7.161

Radionuclide concentrations for U are measured µg/g; all other contaminants are measured in pCi/g. To convert pCi/g to Bq/kg, multiply by 37.

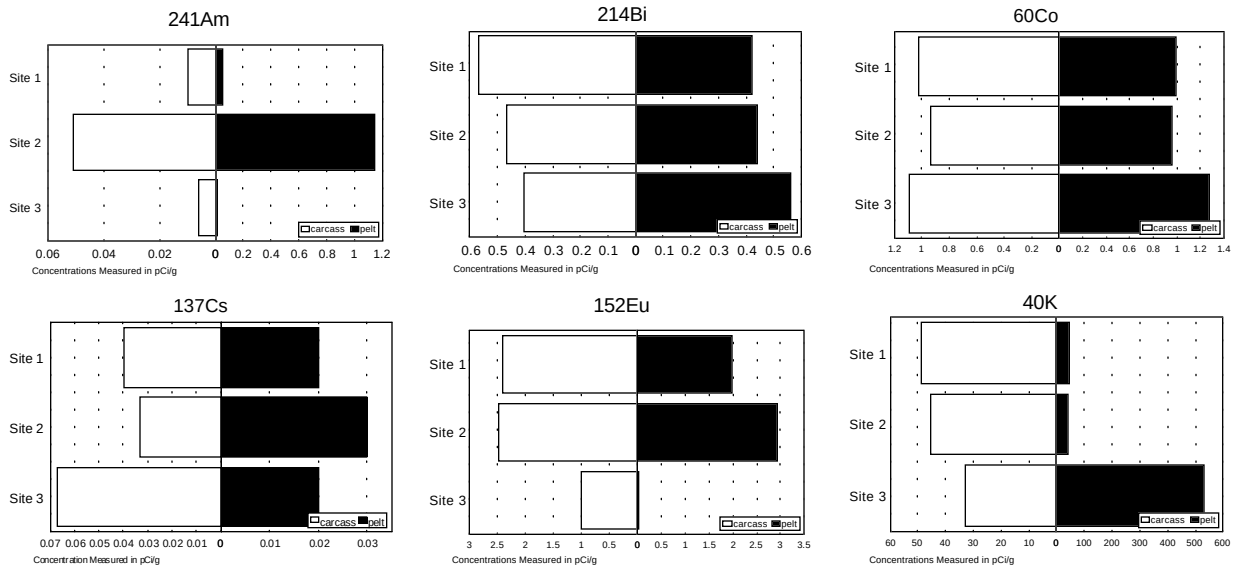

FIGURE 2. (CONTINUED ON NEXT PAGE) RADIONUCLIDE CONCENTRATIONS IN SMALL MAMMALS BY SITE, TA-54, AREA G (TO CONVERT pCi/g TO Bq/kg, MULTIPLY BY 37).

compared to the carcass and lungs. Studies conducted at the Idaho National Engineering Laboratory on waste disposal sites also showed the highest concentration of ^{238}Pu, $^{239+240}$Pu, ^{241}Am, ^{90}Sr, and ^{137}Cs in pelt samples [1].

Total U was shown to occur in significantly higher concentrations (in carcasses) at Site 1 compared to Sites 2 and 3. Also, Site 2 had higher concentrations of ^{239}Pu compared to Sites 1 or 3. Total U concentrations in vegetation collected at Site 1 indicate a range of 1.23 to 1.72 pCi/g ash [8] whereas concentrations in small mammal carcasses were less than 0.5 pCi/g ash. Vegetation collected at Site 1 had ^{90}Sr concentrations ranging from 2.0 to 3.3 pCi/g ash [8]. The

TABLE 5. RADIONUCLIDE CONCENTRATIONS[a] FOR SMALL MAMMAL PELT SAMPLES.

	SITE 1		SITE 2		SITE 3	
RADIONUCLIDE	N	CONCENTRATION	N	CONCENTRATION	N	CONCENTRATION
^{214}Bi	1	0.42	1	0.44	1	0.56
^{241}Am	1	0.052	1	1.14	1	0.014
^{238}Pu	1	0.506	1	0.237	1	0.003
^{137}Cs	1	0.02	1	0.03	1	0.02
^{60}Co	1	0.99	1	0.96	1	1.28
^{152}Eu	1	1.97	1	2.94	1	0.03
^{208}Tl	1	0.26	1	0.16	1	0.33
^{239}Pu	1	0.089	1	1.269	1	0.037
U	1	1.931	1	1.362	1	0.979
^{90}Sr	1	0.9	1	1.3	1	1.8
^{40}K	1	43.45	1	40.22	1	529.19

[a]Radionuclide concentrations for U are measured µg/g; all other contaminants are measured in pCi/g.

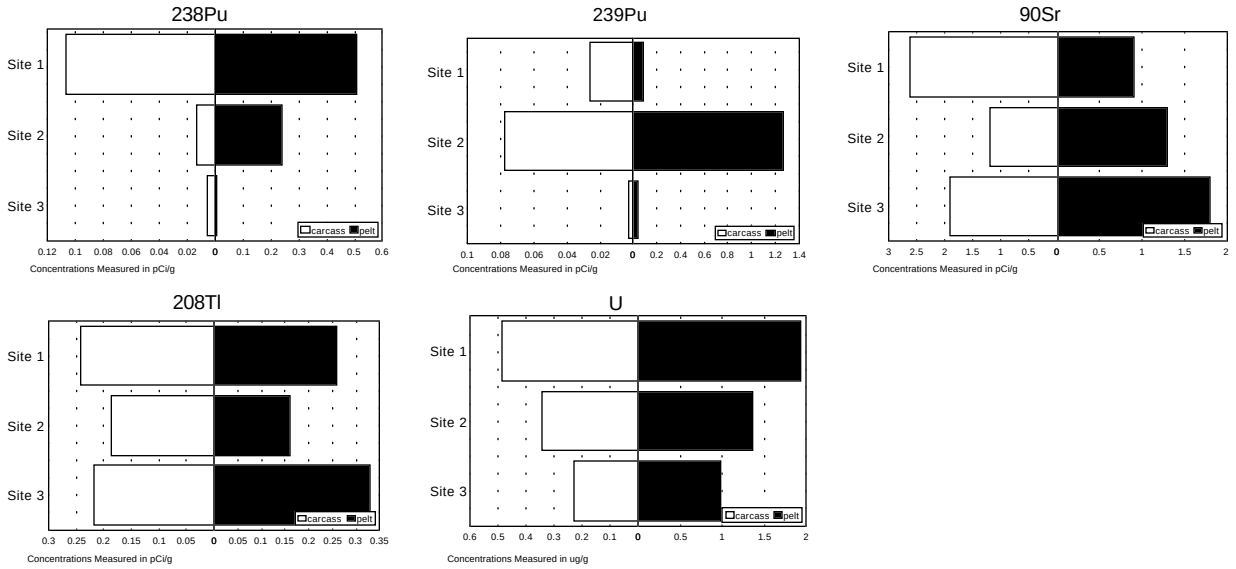

FIGURE 2. (CONTINUED FROM PREVIOUS PAGE) RADIONUCLIDE CONCENTRATIONS IN SMALL MAMMALS BY SITE, TA-54, AREA G (TO CONVERT pCi/g TO Bq/kg, MULTIPLY BY 37).

mean concentration of ^{90}Sr in small mammal carcasses at Site 1 was 2.6 pCi/g ash, well within the range of concentrations found in vegetation at that location. Additional studies and further monitoring of these sites will more accurately assess if correlations exist between radionuclide concentrations in vegetation and rodents. This information, coupled with determining the mode (surface contact, inhalation/ingestion) of contamination to the animal, can help to identify potential pathways of contaminants in a particular plant/animal community by examining if radionuclides are ingested, inhaled, or picked up via surface contact. Additional studies that are currently being conducted elsewhere at the Laboratory, coupled with past data collected at the Laboratory, will be used to more closely examine the relationship between food habits of small mammals and radionuclide uptake via vegetation. Knowledge of densities, food habits, and population dynamics will also help to estimate contaminant loads within the biota at a waste site as well as potential transport off the site. The information can also be used to gain a better understanding about the distribution of radionuclides within the biotic community of Area G and its impact, if any, on biotic communities surrounding Area G.

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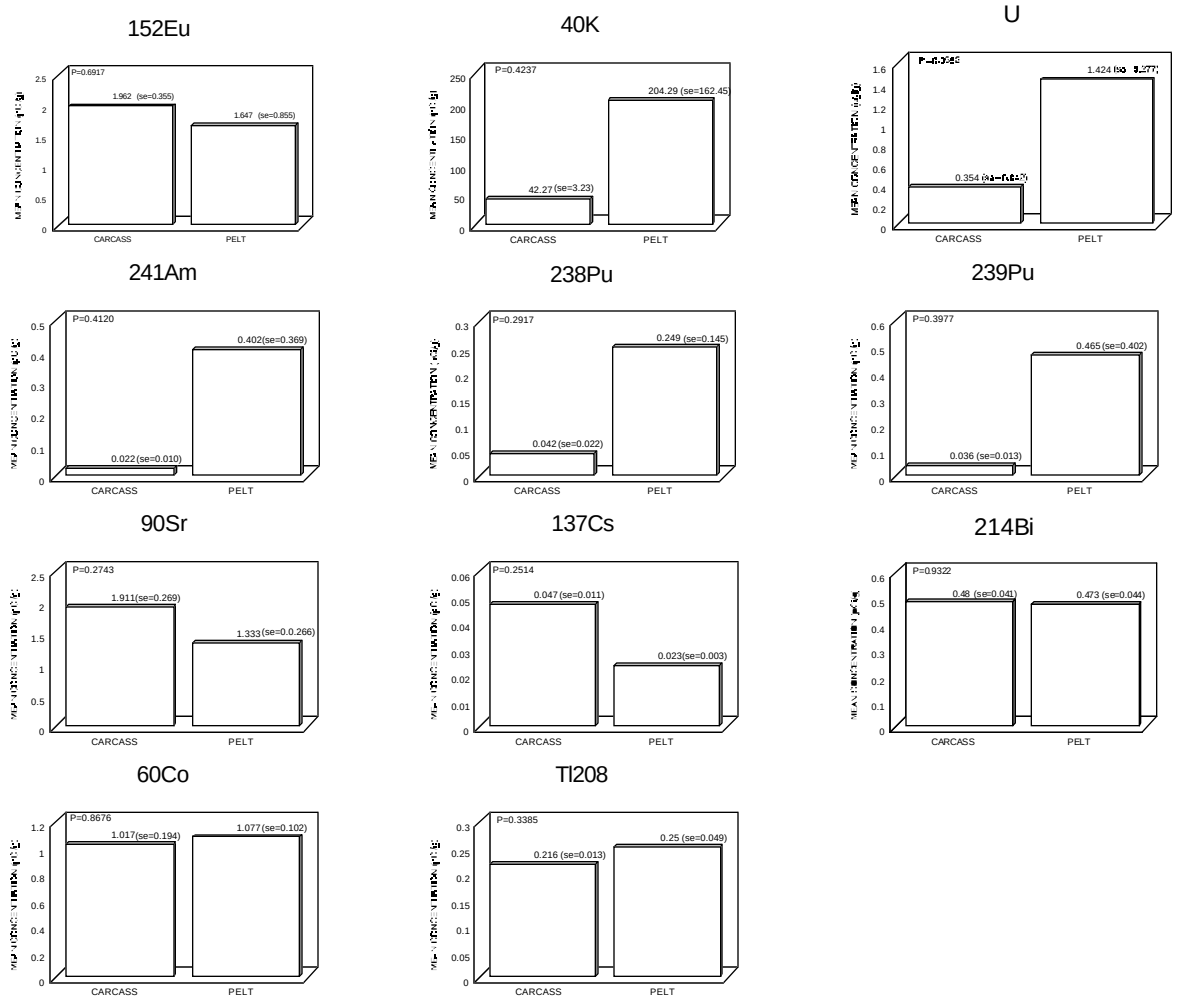

FIGURE 3. OVERALL MEAN CONTAMINANT CONCENTRATIONS IN PELTS AND CARCASSES (TO CONVERT pCi/g TO Bq/kg, MULTIPLY BY 37).

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