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# Uptake of Strontium by Chamisa (*Chrysothamnus nauseosus*) Shrub Plants Growing Over a Former Liquid Waste Disposal Site at Los Alamos National Laboratory

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## Abstract

A major concern of managers at low-level waste burial site facilities is that plant roots may translocate contaminants up to the soil surface. This study investigates the uptake of strontium ($^{90}$Sr), a biologically mobile element, by chamisa (*Chrysothamnus nauseosus*), a deep-rooted shrub plant, growing in a former liquid waste disposal site (Solid Waste Management Unit [SWMU] 10-003[c]) at Los Alamos National Laboratory (LANL), Los Alamos, New Mexico. Surface soil samples were also collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing over SWMU 10-003(c) contained significantly higher concentrations of $^{90}$Sr than a control plant—one plant, in particular, contained 3.35 x $10^6$ Bq kg$^{-1}$ ash (9.05 x $10^4$ pCi g$^{-1}$ ash) in top-growth material. Similarly, soil surface samples collected underneath and between plants contained $^{90}$Sr concentrations above background and LANL screening action levels (>218 Bq kg$^{-1}$ dry [5.90 pCi g$^{-1}$ dry]); this probably occurred as a result of chamisa plant leaf fall contaminating the soil understory area followed by water and/or winds moving $^{90}$Sr to the soil interspace areas. Although some soil surface migration of $^{90}$Sr from SWMU 10-003(c) has occurred, the level of $^{90}$Sr in sediments collected downstream of SWMU 10-003(c) at the LANL boundary was still within regional (background) concentrations.

**Keywords: radionuclides, radioecology, $^{90}$Sr, Chamisa, *Chrysothamnus nauseosus***

## Introduction

Several studies have shown that vegetation growing over buried low-level radioactive waste sites at Los Alamos National Laboratory (LANL) may translocate radionuclides from the roots to aboveground plant compartments [1,2,3]. Deep-rooted perennial plant species like trees and shrubs were cited to be the major offenders [4,5], and may act as conduits to other biotic [6,7,8] and abiotic [9,10,11,12,] components that may eventually result in a radiation dose to humans [13,14,15,16].

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During a recent Environmental Restoration predrilling radiological surface survey in Bayo Canyon at LANL, some Chamisa (*Chrysothamnus nauseosus*) shrub plants exhibited elevated beta radioactivity (Derek Faulk, ERM/Golder, personal communication, July 1994) (Figure I). These late-successional plants, which may root as deep as 4.5 m (13.5 ft) [17], were growing over a former liquid waste disposal structure (#TA-10-43) (Solid Waste Management Unit [SWMU] 10-003[c]) [18]. Liquid waste disposal structure TA-10-43 held lanthanum ($^{140}$La) and strontium ($^{90}$Sr) contaminated wastes generated by the radiochemistry laboratory (TA-10-1) and was decommissioned and decontaminated in 1963—the structure was removed, excavated to a depth of 6 m (18 ft), and backfilled with soil and building debris from other parts of the TA-10 operation [19]. In 1974, a soil subsurface investigation detected elevated levels of gross beta radioactivity near SWMU 10-003(c) [20].

Strontium-90, a beta emitting isotope with a relatively long half-life (28 years) and high degree of food chain mobility, constitutes a potential long-term hazard [21]. The objective of this study was to determine the amount of $^{90}$Sr uptake in deep-rooting chamisa plants from a former liquid waste disposal area and determine the extent of soil-surface contamination.

## Procedures

Soil samples were collected underneath (understory) and between (interspace) two chamisa plant shrub canopies—those that measured the highest in beta radioactivity with field survey instrumentation—growing in Bayo Canyon with a stainless steel scoop at the 0- to 5 cm (0 to 2 in.) depth in August of 1994. Background soil samples were collected east and upwind of the site approximately 0.82 km (0.5 mi) away. At least three subsamples were collected from each zone, mixed thoroughly in a stainless steel bowl, poured into 500-mL poly bottles, and double bagged in Ziploc containers. Similarly, plant top growth and root growth from each of the two chamisa plants were sampled by cutting the desired plant parts into 2.5- to 5.0-cm (1- to 2-in.) pieces, placing into 1-L glass beakers, covering with tin foil, and double bagging into Ziploc containers. A background plant was also collected. All samples were transported to the Laboratory (LANL) under full chain-of-custody protocols in a locked ice chest. At the Laboratory, plant samples were ashed to 500°C, transferred to labeled 500-mL poly bottles, sealed with chain-of-custody tape, and submitted along with the soil samples to an environmental chemistry group (CST-9) at LANL for the analysis of $^{90}$Sr using a gas-proportional counter technique [22] and total uranium by the kinetic phosphorescence method [3].

## Results and Discussion

The analysis of $^{90}$Sr and total uranium in chamisa plants and soils collected over SWMU 10-003 (c) in Bayo Canyon at LANL and from a background area can be found in Table I and Table II, respectively.

Both chamisa plants, and especially in top-growth material, contained significantly higher concentrations of $^{90}$Sr than top-growth material collected from a background

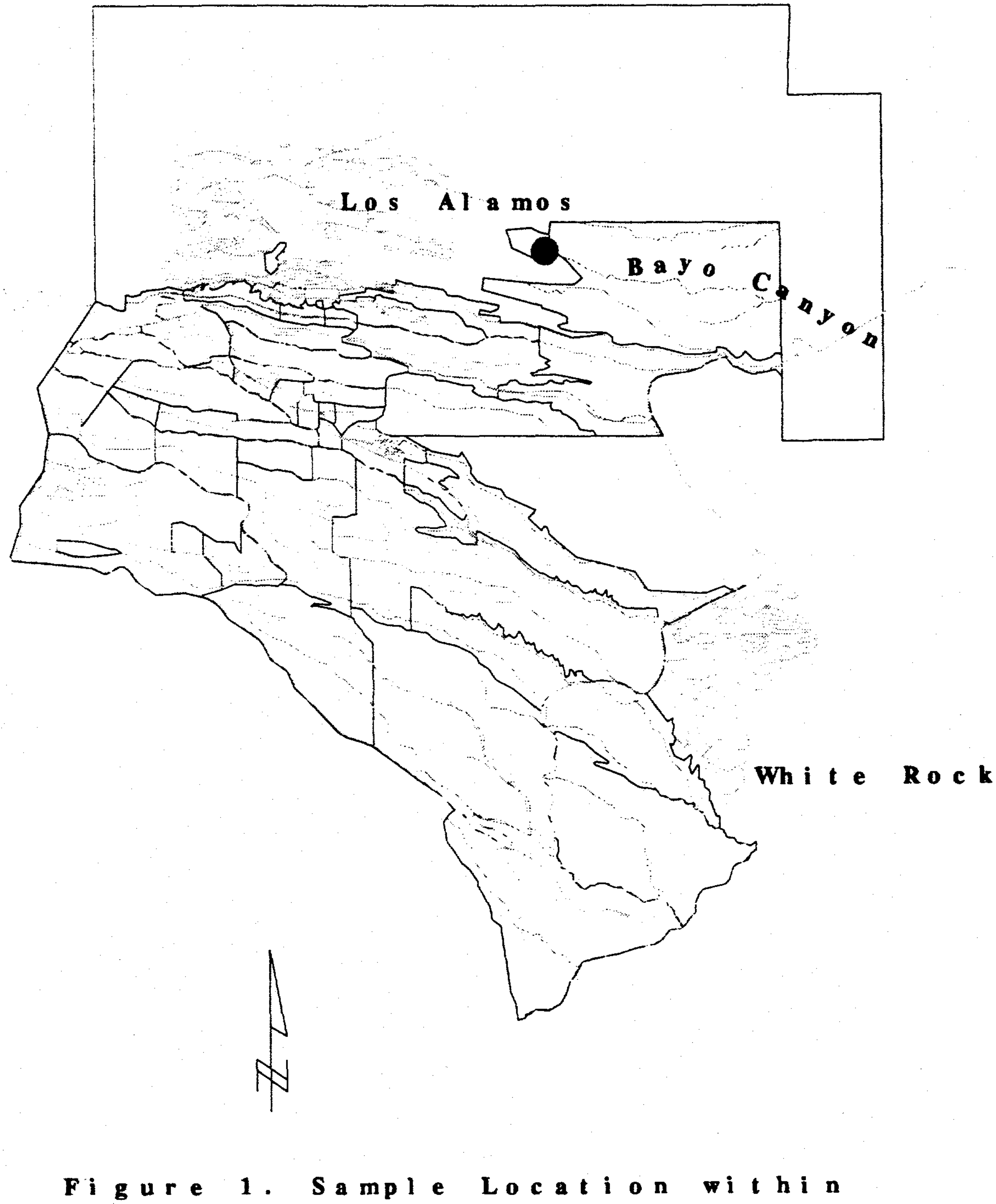


Figure 1. Sample Location within Bayo Canyon at Los Alamos National Laboratory

chamisa plant. One chamisa plant, in fact, contained $3.35 \times 10^6$ Bq $kg^{-1}$ ash ($9.05 \times 10^4$ pCi $g^{-1}$ ash) of $^{90}Sr$—over 300,000 times higher than the control plant. Although the amount of $^{90}Sr$ contamination at depth (source) is not completely known, a recent Environmental Restoration borehole investigation conducted approximately 0.6 to 0.9 m (2 to 3 ft) away from where the plants where collected showed $1.55 \times 10^5$ Bq $kg^{-1}$ dry (4201 pCi $g^{-1}$ dry) of $^{90}Sr$ at the 5- (15-ft) to 5.3-m (16-ft) depth [23]. Strontium-90, a high biological mobile isotope because of its chemical similarity to calcium, is readily taken up by plants [24] and chamisa plant roots have been shown to grow as deep as 4.5 m (13.5 ft) or more [17]. All uranium levels in top-growth and root-growth materials from chamisa plants growing over SWMU 10-003(c) were equal to uranium levels in top-growth and root-growth samples from chamisa plants collected from a background location. The higher concentrations of uranium in the roots of the chamisa plants as compared to the top-growth materials were probably due to the fact that the root samples contain more soil on the surface than does the top-growth material which biased the analytical results.

Both understory and interspace soil samples contained $^{90}Sr$ at above-background concentrations; this probably occurred as a result of chamisa plant leaf fall contaminating the soil understory area followed by water and/or wind dispersal contaminating the soil interspace areas. Soil collected from underneath chamisa plant #1, in fact, contained 1914 times more $^{90}Sr$ than background soil samples which correlates very well with the chamisa plant uptake data. Interspace soil areas also contained $^{90}Sr$ at elevated levels ranging in concentration from 481 to 592 Bq $kg^{-1}$ dry (13 to 16 pCi $g^{-1}$ dry); the highest level was over 11 times higher than background. Moreover, both understory and interspace soil areas contained $^{90}Sr$ levels above the LANL screening action level (SAL) of 218 Bq $kg^{-1}$ dry (5.9 pCi $g^{-1}$ dry) [25]. Radionuclide concentrations in soils above SAL's, which are based on radiation dose levels using a risk assessment pathway computer code called RESRAD [26], initiate and require the Laboratory to further evaluate the area (i.e., site-specific baseline risk assessment, additional sampling, etc.) [27]. Although the soils data show that some migration of $^{90}Sr$ from the contaminated source has occurred, the levels of $^{90}Sr$ in sediments (3.7 Bq $kg^{-1}$ dry [0.10 pCi $g^{-1}$ dry]) collected downstream of SWMU 10-003(c) at the Bayo Canyon/State Road 4 intersection (LANL boundary) in 1994 [28] were still within regional (background) concentrations (32 Bq $kg^{-1}$ dry [0.87 pCi $g^{-1}$ dry]) [22], however. Also, all uranium concentrations in soils collected from underneath and between chamisa plants growing over SWMU 10-003(c) were within background soil concentrations. These data correlated very well with other soil uranium background studies conducted within LANL [29] and regional off-site areas [30].

## Conclusions

Deep-rooted plants like chamisa are able translocate $^{90}Sr$, a highly mobile element, from shallow low-level waste sites to the soil surface. Although there was some migration of $^{90}Sr$ from the contaminated source, the levels of $^{90}Sr$ in sediments collected near the LANL boundary were within background concentrations. Post revegetation management of deep-rooted plants growing in low-level wastes sites may be needed and/or biotic

**Table I. Radionuclide concentrations in chamisa (Chrysothamnus nauseosus) growing in a former liquid waste disposal unit # TA-10-43 (SWMU 10-003c) at Los Alamos National Laboratory.**

| Sample | $^{90}Sr$ (Bq kg$^{-1}$ ash) | Total Uranium (ug g$^{-1}$ ash) |
|---|---|---|
| Chamisa SWMU plant 1 | | |
| top growth | $3.35 \times 10^6$ ($4.12 \times 10^4$)[a] | 0.67 (0.02) |
| root growth | $1.50 \times 10^6$ ($1.85 \times 10^5$) | 3.12 (0.62) |
| Chamisa SWMU plant 2 | | |
| topgrowth | $2.19 \times 10^5$ ($2.74 \times 10^4$) | 0.73 (0.02) |
| rootgrowth | $1.71 \times 10^5$ ($2.15 \times 10^4$) | 3.19 (0.64) |
| Chamisa background plant[b] | | |
| topgrowth | 11.10 (14.8) | 0.78 (0.16) |
| rootgrowth | 0.00 (7.4) | 3.15 (0.64) |

[a] (+/- 2 counting uncertainty); values are the uncertainty in the analytical result at the 95% confidence level.

[b] Collected 0.82 km east and upwind of SWMU plants 1 and 2.

**Table II. Radionuclide concentrations in soil surface samples collected over a former liquid waste disposal unit # TA-10-43 (SWMU 10-003c) at Los Alamos National Laboratory.**

| Sample | $^{90}Sr$ (Bq kg$^{-1}$ dry) | Total Uranium (ug g$^{-1}$ dry) |
|---|---|---|
| Soil SWMU plant 1 | | |
| understory | 7081.8 (910.0)[a] | 2.52 (0.56) |
| interspace | 466.2 (59.2) | 2.85 (1.42) |
| Soil SWMU plant 2 | | |
| understory | 1387.5 (177.6) | 2.60 (1.24) |
| interspace | 592.0 (74.0) | 2.54 (1.32) |
| Soil background plant[b] | | |
| understory | 3.7 (14.8) | 4.83 (1.06) |
| interspace | 51.8 (14.8) | 4.98 (1.00) |
| RSRL[c] | 30.3 | 4.05 |
| SAL[d] | 162.8 | 29 |

[a] (+/- 2 counting uncertainty); values are the uncertainty in the analytical result at the 95% confidence level.

[b] Collected 0.82 km east and upwind of soil SWMU plants 1 and 2.

[c] Regional Statistical Reference Level from Fresquez et al. [33].

[d] Los Alamos National Laboratory Screening Action Level from Fresquez et al. [33].

barriers may be required to deter plant roots from penetrating into contaminated waste materials.

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**References**

1. D.R Dreesen, and M.L. Marple, Uptake of Trace Elements and Radionuclides From Uranium Mill Tailings by Fourwing Saltbush (*Atriplex canescens*) and Alkali Sacaton (*Sporobolus airoides*), Los Alamos Scientific Laboratory report LA-UR-79-3045, 1980.
2. W.J. Wenzel, T.S. Foxx, A.F. Gallegos, G. Tierney, and J.C. Rogers, Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area G, Los Alamos National Laboratory report LA-11126-MS, 1987.
3. P.R. Fresquez, J.B. Biggs, and K.D. Bennett, Radionuclide Concentrations in Vegetation at Radioactive-Waste Disposal Area G during the 1994 Growing Season, Los Alamos National Laboratory report LA-12954-MS, 1995.
4. T.S. Foxx, G.D. Tierney, and J.M. Williams, Rooting Depths of Plants on Low-Level Waste Disposal Sites, Los Alamos National Laboratory report LA-10253-MS, 1984.
5. T.S. Foxx, G.D., Tierney, and J.M. Williams, Rooting Depths of Plants to Biological and Environmental Factors, Los Alamos National Laboratory report LA-10254-MS, 1984.
6. T.E. Hakonson, and K.V. Bostick, The Availability of Environmental Radioactivity to Honeybee Colonies at Los Alamos, J. Environ. Qual., 5 (1976) 307-310.
7. R.O. Gilbert, J.H. Shinn, E.H. Essington, T. Tamura, E.M. Romney, K.S. Moor, and T.P. O'Farrel, Radionuclide Transport from Soil to Air, Native Vegetation, Kangaroo Rats and Grazing Cattle on the Nevada Test Site, Health Phys., 55 (1988) 869-887.
8. J.E. Pinder, K.W. McLeod, R.F. Lide, and K.C. Sherrod, Mass Loading of Soil Particles on a Pasture Grass, J. Environ. Radioactivity, 13 (1991) 341-354.
9. J.W. Healy, An Examination of the Pathways from Soil to Man for Plutonium, Los Alamos Scientific Laboratory report LA-6741-MS, (1977).
10. S.Y. Lee, T. Tamura, and E.H. Essington, Characteristics of Radioactivity Contamination of Soil at the Nevada Test Site, Nucl. Chem. Waste Manage., 7 (1985) 179-190.
11. N.M. Becker, Quantification of Uranium Transport Away From Firing Sites at Los Alamos National Laboratory--A Mass Balance Approach, In: R.G. Post, (Ed.), Proceedings of the Symposium on Waste Management: Technology and Programs for

Radioactive Waste Management and Environmental Restoration, Tucson, Arizona, 1992, pp. 657-659.

12. K. Bunzl, H. Forster, W. Kracke, and W. Schimmack, Residence Times of Fallout $^{239+240}Pu$, $^{238}Pu$, $^{241}Am$ and $^{137}Cs$ in the Upper Horizons of an Undisturbed Grassland Soil, J. Environ. Radioactivity, 22 (1994)11-27.
13. P.R. Fresquez, D.R. Armstrong, and J.G. Salazar, Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory: 1981 to 1993, Los Alamos National Laboratory report LA-12818-MS, 1994.
14. P.R. Fresquez, D.R. Armstrong, and J.G. Salazar, Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory, Los Alamos National Laboratory report LA-12872-MS, 1995.
15. P.R. Fresquez, D.R. Armstrong, and J.G. Salazar, Radionuclide Concentrations in Elk That Winter on Los Alamos National Laboratory Lands, Los Alamos National Laboratory report LA-12795-MS, 1995.
16. P.R. Fresquez, D.R. Armstrong, and J.G. Salazar, Radionuclide Concentrations in Soils and Produce from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens, Los Alamos National Laboratory report LA-12932-MS, 1995.
17. G.D. Tierney, and T.S. Foxx, Root Lengths of Plants on Los Alamos National Laboratory Lands," Los Alamos National Laboratory report LA-10865-MS, 1987.
18. Los Alamos National Laboratory, Remedial Facility Investigation Workplan for Operable Unit 1079, Los Alamos National Laboratory report LA-UR-92-850, 1992.
19. C.D. Blackwell, and F. Babich, Removal of all Structures in Bayo Canyon, Los Alamos Scientific Laboratory memorandum, Environmental Restoration Records Processing Facility I.D.# 2070, 1963.
20. D.L. Mayfield, A.K. Stoker, and A.J. Ahlquist, Radiological Survey of the Bayo Canyon, Los Alamos, New Mexico, Department of Energy report DOE/EV-0005/15, 1979.
21. W.F. Wicker, and V. Schultz, Radioecology: Nuclear Energy and the Environment, CRC Press, Inc., Boca Raton, FL., 1982.
22. W.D. Purtymun, W.D., R.J. Peters, T.E. Buhl, M.N. Maes, and F.H. Brown, Background Concentrations of Radionuclide in Soils and River Sediments in Northern New Mexico, 1974-1986, Los Alamos National Laboratory report LA-1134-MS, 1987.
23. J. Newlin, Strontium-90 Data From OU 1079 Bayo Canyon Boreholes, Los Alamos National Laboratory memorandum CST-ER/JN-95/01, 1995.
24. R.G. Menzel, Soil-Plant Relationships of Radioactive Elements, Health Phys., 11 (1965) 1325-1332.
25. A. Dorries, July 1994 Screening Action Levels, Los Alamos National Laboratory memorandum EM/ER:94-S390, 1994.
26. C. Yu, A. J. Zielen, J. J. Cheng, T. C. Yuan, L. G. Jones, D. J. Lepoire, Y. Y. Wang, C. O. Loueiro, E. Gnanapragasam, J. E. Faillace, A. Wallo III, W. A. Williams, and H. Peterson, "A Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.60," Argonne National Laboratory report ANL/EAD/LD-2, 1995.

27. A. Dorries, Draft SALs Policy Paper, Los Alamos National Laboratory informal memorandum, 1995.
28. Environmental Protection Group, Environmental Surveillance at Los Alamos During 1994, Los Alamos National Laboratory report LA-12973-ENV, in press, 1995.
29. P. Longmire, S. Reneau, P. Watt, J. Garner, C. Duffy, and R. Ryti, Natural Background Geochemistry, Geomorphology, and Pediogenisis of Selected Soil Profiles and Bandelier Tuff, Los Alamos, New Mexico, Los Alamos National Laboratory report LA-12913-MS, 1995.
30. P.R. Fresquez, M.A. Mullen, J.K. Ferenbaugh, and R. Perona, Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 Through 1994: Concentrations, Trends, and Dose Comparisons, Los Alamos National Laboratory report LA-13149-MS, 1996.