No Nuclear Fallout Radioactivity Was Found on Public Zones Around the Nevada National Security Site: A Recent Study

Haven Searcy[1], Krishnakumar Nangeelil[1], Beverly Parker[2, 3], Zaijing Sun[1]

1. *Department of Health Physics and Diagnostic Sciences, University of Nevada, Las Vegas, Las Vegas, NV 89154*
2. *Community Environmental Monitoring Program, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV 89193*
3. *Division of Hydrologic Sciences, Desert Research Institute, Las Vegas, NV 89119, USA*

Purpose: Located 65 miles northwest of Las Vegas, the Nevada National Security Site (NNSS) was a key location in the production and development of nuclear weapons during and after World War II. Over 900 atomic bomb tests were conducted from 1951 to 1992, culminating with the global nuclear weapons testing moratorium and subsequent test ban treaty. Out of these tests performed, 100 of them were performed above ground, resulting in significant amounts of contamination in the area. While stringent decontamination efforts have been undertaken in the area and surroundings, this study was performed to determine the presence of fallout and retained radionuclides in the air or in the flora in the surrounding region.

Methods: Samples were collected from common desert flora, including desert bushes, creosote bushes, and Joshua trees, to assess potential environmental uptake. The plant samples were pre-processed before gamma spectrometry. Additionally, samples were obtained from the Community Environmental Monitoring Program (CEMP), a collaborative effort between the Department of Energy and the Desert Research Institute of the Nevada System of Higher Education. This program monitors air and water quality in neighboring communities of the Nevada National Security Site (NNSS). Air sample filter papers from 13 CEMP stations and plant samples from various locations surrounding the test site were collected and analyzed at the University of Nevada, Las Vegas. Analysis was conducted using a CosmicGuard High Purity Germanium (HPGe) Detector to minimize interference from external radiation sources. Figure 1 and Figure 2 shows the locations of CEMP stations and plant sample collected areas, respectively.

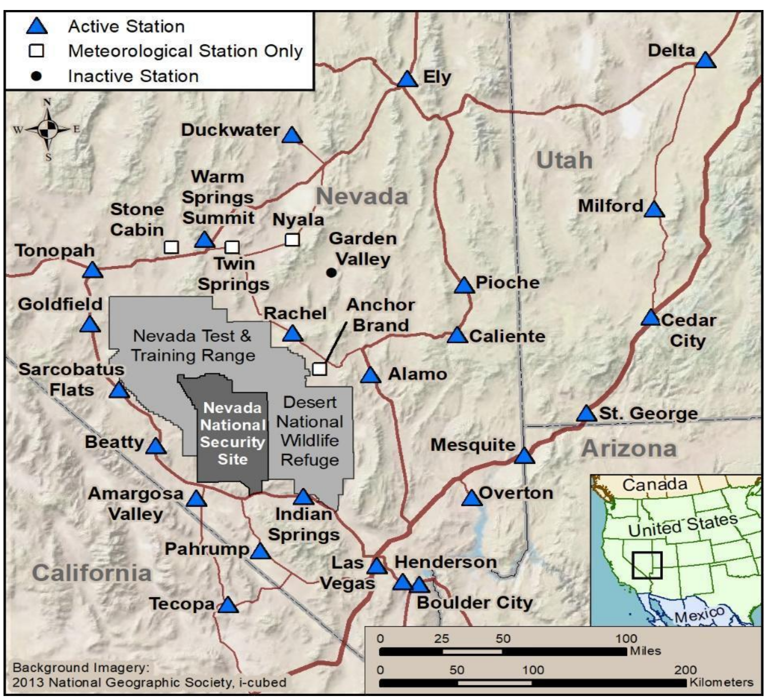

Figure 1. Location of CEMP monitoring stations

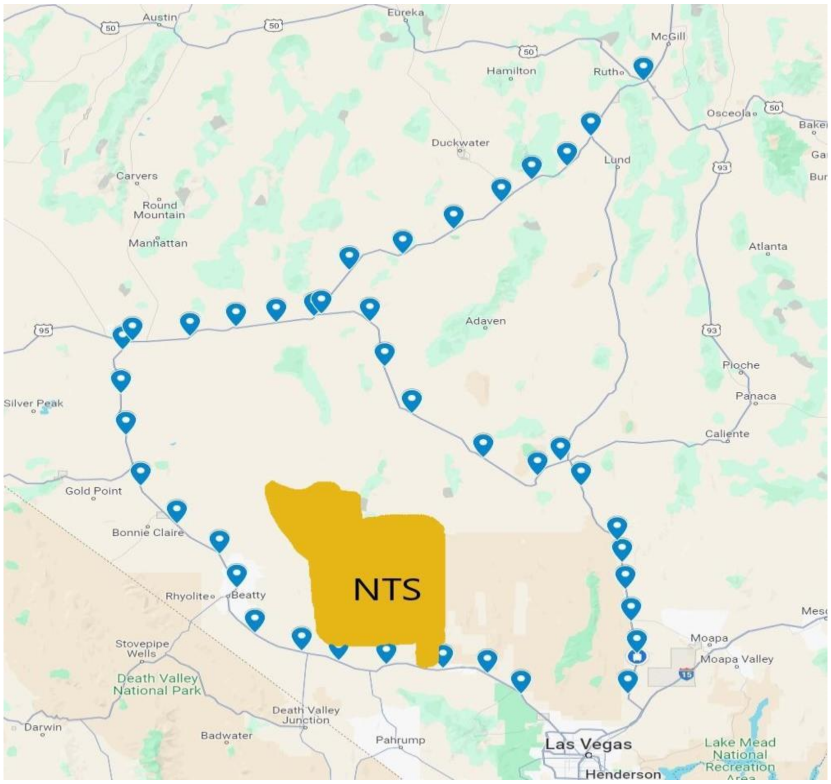

Figure 2. The location where plant samples were taken

Pre-processed plant samples and NIST standards (Urban Particulate Matter and Tomato Leaves) were irradiated at the TRIGA Mark I nuclear reactor at the University of California, Irvine (UCI). Subsequently, gamma spectrometry was performed on the samples, and the elemental concentrations in each plant sample were determined using the Instrumental Neutron Activation Analysis (INAA) technique. Using this technique, the concentration of radionuclides can be determined using Eq. 1 assuming the concentration of the reference material C_R, decay constant λ, the net counts for the gamma-ray peak for the sample and reference P, masses of the sample and reference, the time between the irradiation and counting t_d, and finally the counting time t_c are known.

$$C_S = C_R \cdot \frac{P_S}{P_R} \cdot \frac{m_R}{m_S} \cdot \frac{e^{-\lambda t_{dR}}}{e^{-\lambda t_{dS}}} \cdot \frac{1 - e^{-\lambda t_{cR}}}{1 - e^{-\lambda t_{cS}}} \qquad (1)$$

Results: A comparison of typical spectra from the Alamo CEMP station with that of the unused filter paper is illustrated in Figure 3. The spectra exhibit a standard background gamma spectrum, featuring several well-defined peaks originating from natural radioactivity and peaks arising from contamination in the detector, shield, and surrounding laboratory materials, such as walls and other components.

Activity estimated from the gamma peaks of filter papers from 13 CEMP locations is presented in Table 2, indicating activity attributed solely to radioisotopes from the natural decay series of 238U and 232Th. Gamma spectrometry analysis of plant samples surrounding the NNSS revealed no trace of radionuclides related to nuclear fallout in the public domain.

Concentrations of various elements in the different samples were estimated and tabulated in Table 2. These values serve as baseline measurements, indicating potential elemental contamination levels. Further research and analysis are necessary to elucidate the underlying causes of these variations and assess any potential ecological implications.

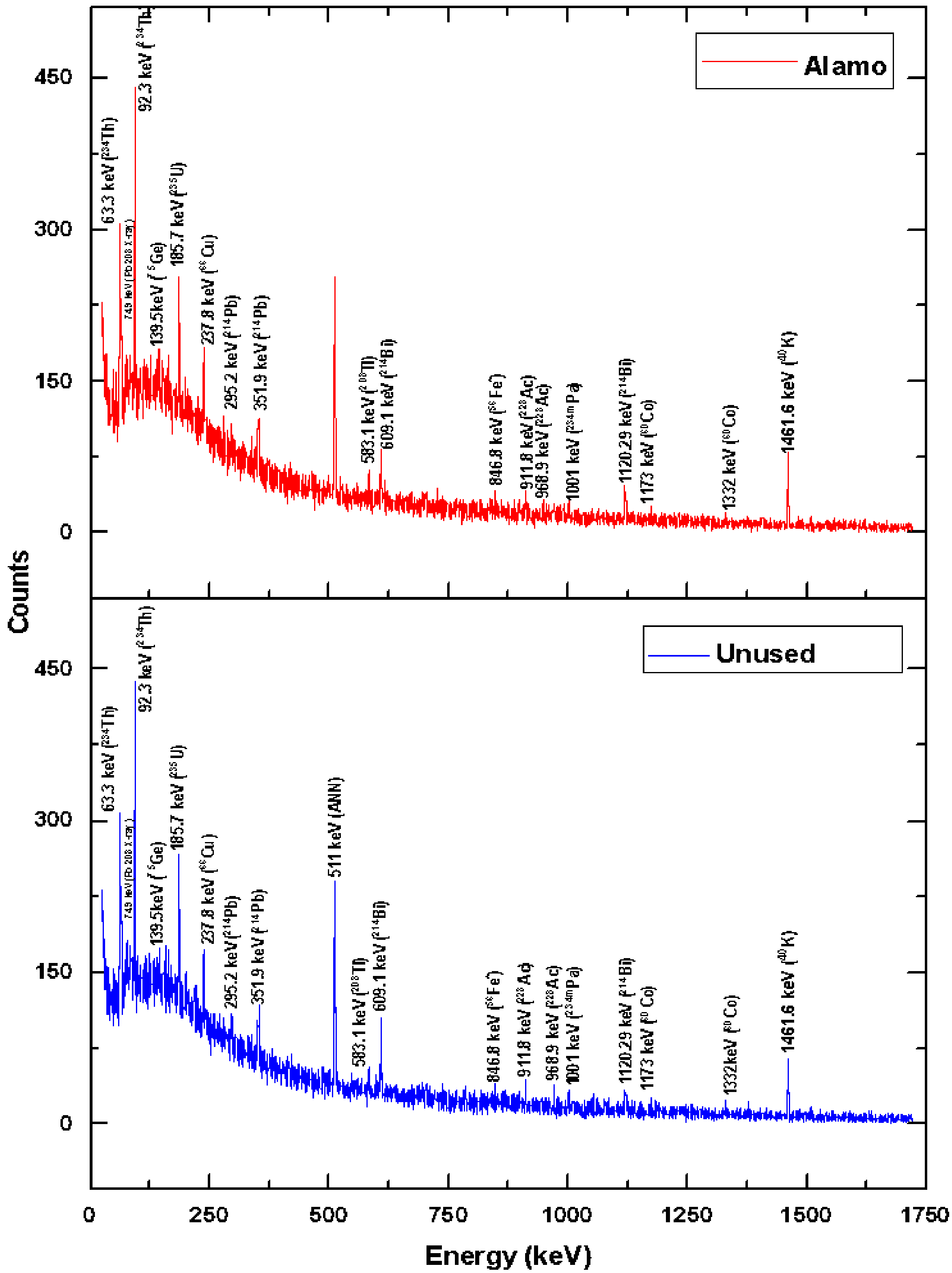

Figure 3. Comparison of Gamma spectra of typical unused filter paper and the filter from the Alamo CEMP station

Table 1. The activities of various filter papers from CEMP station

Radionuclide	Activity (kBq)									
	Pb-210 (U)	Th-234 (U)	U-235	Pb-212 (Th)	Pb-214 (U)	Ac-228 (Th)	ANN	Tl-208 (Th)	Bi-214 (U)	K-40
Un-used Filter paper	149.3± 40	571.9± 44	607.0± 66	317.8± 70	141.2± 4	359.5± 156	3105.8± 131	317.8± 94	866.1± 110	2398.9± 202
Pahrump	157.9 ± 32	558.7± 42	660.1± 68	277.3± 66	BDL	316.3± 119	3125.0± 127	BDL	772.0± 118	2308.3± 230
Tonopah	145.5± 39	596.3± 43	722.2± 67	246.2± 62	BDL	BDL	3327.3± 133	BDL	867.8± 119	2517.7± 218
Alamo	147.6± 33	581.2± 44	696.6± 58	262.3± 58	BDL	418.7± 142	3259.8± 130	375.0± 104	829.7± 106	2515.6± 200
Caliente	BDL	608.5± 30	624.5± 68	261.2± 55	BDL	BDL	3214.9± 131	160.9± 83	862.1± 100	2322.1± 185
Pioche	186.4± 36	591.3± 44	663.7± 66	BDL	BDL	425.8± 138	3529.6± 132	247.1± 87	838.2± 103	2861.2± 192
Delta	134.2± 40	583.0± 45	624.5± 70	314.7± 54	BDL	BDL	3192.4± 129	BDL	880.4± 122	2331.1± 191
Milford	180.9± 39	586.3± 40	708.5± 68	220.5± 73	BDL	482.0± 272	3237.4± 130	BDL	895.9± 100	2315.2± 199
Cedar City	206.4± 34	566.2± 37	681.1± 69	327.6± 70	BDL	429.9± 125	3439.7± 130	BDL	818.4± 102	2653.9± 202
St. George	139.0± 39	568.4± 44	546.0± 58	313.7± 73	BDL	BDL	3282.3± 130	BDL	812.8± 115	2660.8± 203
Overton	BDL	599.2± 44	760.5± 68	321.2± 71	119.9± 6	450.0± 135	3597.1± 129	BDL	833.9± 104	2308.3± 182
Boulder City	160.9± 37	596.0± 41	730.4± 65	147.5± 56	173.4± 6	461.0± 109	3237.4± 131	380.3± 87	869.2± 112	2557.1± 209
Henderson	135.5± 36	596.9± 44	671.1± 68	401.4± 69	BDL	BDL	3597.1± 128	513.3± 90	832.5± 98	2522.5± 194
Las Vegas	BDL	606.0± 43	752.3± 65	BDL	152.9± 6	BDL	3349.8± 125	BDL	850.9± 105	2467.3± 192

Table 2. Elemental concentration in various plants in different areas

Radionuclide	Isotope identified	Concentration (mg/Kg)		
		Joshua Tree	Desert Bush	Creosote Bush
Cr	Cr-51	80e-1 – 53e+1	0e+0 – 75e+1	71e-1 – 16e+0
Br	Br-82	20e-1 – 95e+1	95e+1 – 22e+2	12e-1 – 15e+2
La	La-140	20e-1 – 38e+1	0e+0 - 35e+1	BDL
Zn	Zn-65	20e+1 – 11e+2	29e+2 – 4e+4	10e+2 – 38e+2
Co	Co-60	22e+0 – 86e+0	50e+0 – 47e+1	39e+0 – 65e+0
Fe	Fe-59	19e+1 – 26e+3	18e+2 – 55e+3	2e+3 – 2.4e+3
Na	Na-22	20e+4 -83e+5	46e+2 – 66e+5	28e+2 – 94e+2
K	K-40	64e+2 – 11e+4	80e+3 -11e+4	47e+3 – 56e+3
Zr	Zr-95	50e-1 – 49e+1	20e+0 – 35e+0	16e+0 – 28e+0
Mn	Mn-56	40e-2 - 50e-1	70e-3 – 30e-1	12e-1 – 13e-1
Mg	Mg-27	10e+1 – 36e+3	17e+3 – 28e+3	21e+3 -22e+3
V	V-52	50e-1 – 14e+1	91e-1 – 12e+0	59e-1 – 75e-1
Al	Al-28	87e+2 – 11e+3	60e+2 – 81e+2	37e+2 – 44e+2

Conclusions: No substantial radioactive fallout was observed in the air or in the plants within the public domain. Gamma spectrometry peaks detected in the CEMP filter papers were attributed to natural radioactivity decay series. The higher elemental concentrations observed in INAA analysis of Joshua trees were attributed to differences in soil chemistry and environmental conditions. However, these elevated levels were not observed in creosote bushes, which may have been alive during the timeframe of nuclear weapons testing. This discrepancy in plant samples is due to soil uptake, as Joshua trees have deeper roots compared to other plants being measured, especially when contrasted with creosote bushes, which exhibit minimal soil uptake and display the lowest observed concentrations. These findings suggest that decontamination and remediation efforts have been successful, rendering the area surrounding the test site safe. Consequently, the results of this study serve as a valuable baseline, indicating no radiological impact in public zones attributable to retained radioactivity or operations associated with NNSS, for future reference.

Relevance to CIRMS: One of the aims of the Council on Ionizing Radiation Measurements and Standards is radiation protection and homeland security. There are always issues convincing the public of the safety of nuclear energy or nuclear experimentation and this work shows that even with over 100 nuclear weapons being detonated in an area that with proper efforts and personnel the radiological effect seen by the community can be nonexistent.

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