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Ambient air monitoring during the 2011 Las Conchas wildland fire near Los Alamos, U.S.A.

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Abstract

Air monitoring data collected during the Las Conchas fire near the Los Alamos National Laboratory during 2011 are presented. Data included are for selected radionuclides and selected metals found in particulate matter. None of these analytes were seen at levels which exceeded any state or federal standards.

Key words: air monitoring, radionuclides, metals, fire, Las Conchas

Introduction

The Las Conchas wild land fire was started in northern New Mexico, USA, at 1 p.m. on Sunday, June 26th, 2011 by a tree falling onto a power line in the Jemez Mountains, about 20 kilometers southwest, and upwind, of Los Alamos. The next day the town was evacuated and the Los Alamos National Laboratory (LANL) closed. Los Alamos residents were allowed back to town on Sunday, July 3rd and the laboratory reopened on Wednesday, July 6th. A total of 633 km^2 were burned. Of this only 0.5 km^2 was on laboratory property and most of this was due to a preventative burn along the western perimeter of LANL's 110 km^2 property. An unplanned one acre (0.004 km^2) fire occurred on the property, but was rapidly extinguished and was not in a contaminated location. The fire mostly followed a northerly trajectory, skirting to the west of the laboratory and Los Alamos town-site. The fire did however also burn to the south including the Bandelier National Monument along the southern boundary of the laboratory.

Air quality in Los Alamos was unhealthy by EPA standards with respect to concentrations of suspended particulate matter smaller than 2.5 micrometers (PM2.5) only. This added to the justification to evacuate the town. Levels of particulate matter with particle sizes between 2.5 and 10 micrometers were also elevated. We refer the reader to Whicker et al. 2011 for their coverage of these data and also real time plutonium-239 measurements using continuous air monitors.

Background data

Forest fire smoke contains naturally occurring radioactive materials, such as uranium, thorium and their associated decay products (Reinhardt et al. 2004; Hao et al. 2009, Eberhart 2010). Public concern over a possible fire on LANL property prompted an immediate expansion of the extensive existing air monitoring program AIRNET. We used next day preliminary data analyzed on-site to assure the public through press releases that no unexpected LANL-created radionuclides or metals were in the smoke plume (Whicker et al. 2002, Whicker et al. 2006a, b; Eberhart 2010) which covered thousands of square kilometers. This report covers the statistically more significant results from an independent off-site analytical laboratory (ALS Environmental in Colorado) using the same samples.

Monitoring and Analysis

LANL has a continuously running ambient air monitoring network (AIRNET) of about sixty stations. Some samples are of all-size particulate matter, collected on a filter by applying a negative pressure to the back of the filter. All samples are changed every two weeks and analyzed subsequently for selected alpha-emitting isotopes of uranium, plutonium and americium, and a suite of about fifteen gamma-photon-emitting radionuclides.

In response to the fire, AIRNET filters were changed more frequently than usual, and additional, mostly higher flow-rate, monitoring stations were deployed. Three sets of supplementary monitoring stations were deployed: eleven (11) high flow-rate samplers around the laboratory by the AIRNET team; a further five (5) stations on LANL property by the field monitoring team (FMT) of LANL's emergency response organization; and eight (8) stations regionally by a team from the Radiological Assistance Program (RAP) of the Department of Energy. Most of these response stations were high-volume samplers.

The same alpha and gamma analyses usually done on AIRNET samples were performed for the additional (high flow-rate) stations. Alpha spectroscopy was performed for uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239 and americium-241. Radiochemical analysis was done for the gamma photon emitting nuclides beryllium-7, sodium-22, potassium-40, cobalt-60, iodine-131, cesium-134, cesium-137, thallium-208, bismuth-212, lead-212, bismuth-214, lead-214, actinium-228, protactinium-234m, thorium-234 and. americium-241.

Additional analyses, of gross alpha and gross beta radiation, were requested, as well as an expansion of the suite of metals analyses. Analysis was done for. the Target Analyte List TAL for metals, consisting of over twenty metals (silver, aluminum, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, sodium, nickel, lead, antimony, selenium, thallium, vanadium, and zinc) as well as for mercury. The frequency and types of analyses are summarized in Table 1 below.

In total, over 9,500 analyses were made on the roughly 220 samples collected.

Table 1. Distribution of radio-isotopic and metal analyses.

Analytes	Number of analyses
Gross alpha/Gross beta	265
Metals: Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn.	235
Gamma spectroscopy for Be-7, Na-22, K-40, Co-60, I-131, Cs-134, Cs-137, Tl-208, Bi-212, Pb-212, Bi-214, Pb-214, Ac-228, Pa-234m, Th-234, Am-241	136
Alpha spectroscopy for Am-241, Pu-238, Pu-239, U-234, U-235, U-238	235

A quality assurance program was used during analysis, including analyses of process and field blanks. Data were also verified and validated. The analytical laboratory has a federally approved calibration program in place.

Results

In interpreting the results, it must be noted that the sampling described in this document covers the period 20 June to 5 July 2011. A number of days are included before the fire started, during which normal laboratory operations were underway. With this in mind, some measurements include material outside the period of the fire, 26 June (fire starts) to 6 July 2011(LANL back to work).

Gross alpha and gross beta

The gross alpha and gross beta measurements were not particularly useful. All uncertainties for the gross alpha results are two standard deviations, representing roughly 95% confidence intervals. Typically gross alpha measurements in this geographic region fall in the range 500 to 2000 attocuries per cubic meter (aCi/m^3) with an average of approximately 900 ± 30 aCi/m^3 which is about half the national average of 2,000 aCi/m^3 (NCRP 1975, NCRP 1987). Measurements made during the fire had an average of 6900 ± 6500 aCi/m^3. This average is not statistically different from either the national or regional averages. The large uncertainties are due to both shorter sample counting and collection times.

Gross beta measurements in this region fall in the range 10,000 to 25,000 aCi/m^3 with an average around 18,000 ± 700 aCi/m^3. The national average is around 20,000 aCi/m^3 (NCRP 1975, NCRP 1987). Measurements made during the Las Conchas fire averaged 54,000 aCi/m^3 with an average uncertainty around 20,000 aCi/m^3. As with the gross alpha data, the large uncertainties are due to curtailed counting and collection times.

Further, little significance was attached to the gross determinations of alpha and beta radiation since elevated measurements may be attributed to a number of different isotopes and hence also to a number of different causes, including re-suspension of natural soil, suspension of radon decay products by the burning of forest foliage, LANL or other anthropogenic sources.

Metals analysis

Many metals were not detected at all. Of the detections made, all were attributable to constituents of soils in the region. No surprising detections were observed. The frequencies of detection are indicated in Table 2 below merely as a record. The metals most frequently detected here are those seen in the highest abundance in the local soil.

Table 2. Detections of gamma emitting nuclides.

Metal	Number of detections	Percentage of Detections
Ag	0	-
Al	221	94%
As	10	4%
Ba	64	27%
Be	0	-
Ca	196	83%
Cd	8	3%
Co	0	-
Cr	59	25%
Cu	130	55%
Fe	221	94%
Hg	0	
K	86	37%
Mg	70	30%
Mn	219	93%
Na	74	31%
Ni	21	9%
Pb	90	38%
Sb	6	3%
Se	1	
Tl	0	
V	40	17%
Zn	203	86%

Gamma-emitting radio-nuclides

Amongst the gamma analyses done there were very few detections besides those of naturally occurring, cosmogenically produced, beryllium-7 (see Table 3 below). Besides these the only detections were for other isotopes of natural origin. No detections were made of anthropogenic nuclides. No detections of gamma emitters are attributable to current operations at the laboratory.

Table 3. Detections of gamma emitting nuclides.

Analyte	Number of detections	Fraction of detections	Origin
Be-7	60	44%	Natural
Na-22	0		Anthropogenic
K-40	1	1%	Natural
Co-60	0		Anthropogenic
I-131	0		Anthropogenic
Cs-134	0		Anthropogenic
Cs-137	0		Anthropogenic
Tl-208	7	5%	Natural – Th-232 daughter
Bi-212	3	2%	Natural – Th-232 daughter
Pb-212	5	4%	Natural – Th-232 daughter
Bi-214	2	1%	Natural – U-234/8 daughter
Pb-214	4	3%	Natural – U-234/8 daughter
Ac-228	3	2%	Natural – Th-232 daughter
Pa-234m	0		Natural – U-234/8 daughter
Th-234	0		Natural – U-234/8 daughter
Am-241	0		Anthropogenic

Alpha-emitting radio-nuclides

The alpha-emitting isotopes provide the detections requiring the most careful analysis and commentary. The results are shown in Table 4. There were no detections of americium-241 or of plutonium-238.

There were LANL-associated detections of plutonium-239 but they occurred at locations at which this isotope is expected independently of the fire. Table 5 shows a breakdown of the detections by location.

Table 4. Detections of alpha emitting nuclides

Analyte	Number of detections	Fraction of detections	Origin
Am-241	0		Fall-out, LANL
Pu-238	0		Fall-out, LANL
Pu-239	20	9%	Fall-out, LANL
U-234	48	20%	Natural, LANL
U-235	0		Natural, LANL
U-238	51	22%	Natural, LANL
Depleted Uranium	0		LANL
Enriched Uranium	0		LANL

Table 5. Details of the plutonium-239 detections

Location (station number, description)	Likely Source	Number of detections	Individual doses from detections (mrem)
257 – South of Los Alamos Lodge	Hillside 137	3	0.10, 0.04, 0.02
320 – Hedge Row, East Rd	MDA-B	2	0.01, (<0.01)
327 – Ace Hardware, DP Rd	MDA-B	3	0.02, 0.01, (<0.01)
328 – Los Alamos Monitor, DP Rd	MDA-B	3	0.03, 0.02, 0.02
317 – West end A-15 Tract, DP Rd	MDA-B	3	1.04, 0.07, 0.06
329 – West center A-15 Tract, DP Rd	MDA-B	1	0.21
330 – East center A-15 Tract, DP Rd	MDA-B	1	0.02
331 – East end A-15 Tract, DP Rd	MDA-B	1	0.02
347 – Los Alamos Airport Hangar	MDA-B	1	0.30
161 – NW corner, Area G, TA-54	Area G	1	0.10
208 – Expansion pit, Area G, TA-54	Area G	1	0.28

Legacy plutonium-239 from the 1940s and 1950s remains on Hillside 137, the location of station 257, south of the Los Alamos Lodge. We have consistently detected plutonium-239 at this location for years, particularly during windy periods. Winds were strong at times during the Las Conchas fire. These detections are not thought to be related to the fire since it was more than 2 miles (3 kilometers) away from this location.

The majority of detections in Table 5 were at stations in the downwind vicinity of the remediation site MDA-B. Work was underway for much of 2011, spanning the period of the fire. All cleanup operations at MDA-B stopped during the fire. During work at MDA-B we have repeatedly measured plutonium-239 nearby so detections just before and possibly during the fire were expected. The doses detected were similar to doses previously measured at this location during the remediation work.

Plutonium-239 was also detected at TA-54, Area G over the period of the fire. This isotope has previously been measured around Area G and these measurements are in no way surprising given that Area G is LANL's primary radio-active waste handling site. The fire remained more than 6 miles (10 kilometers) away from Area G. Area G is not accessible to the public.

Summarizing, we observe that doses associated with any of the detections of plutonium-239 mentioned above did not pose health risk to workers or members of the public. It should also be noted that a number of the detections around MDA-B are measurements duplicated by different monitors at the same locations, and so adding doses is not appropriate.

Referring back to Table 4 we see that detections of uranium-234 and uranium-238 occurred in about 20% of all analyses for these radio-nuclides. Uranium occurs naturally in the regional soil. An indicator of the uranium being of anthropogenic origin would be a significant difference in the activities of these two isotopes. Comparison of the measured activities indicated no difference and therefore no presence of enriched or depleted uranium. Both these forms of uranium would most likely have been of LANL origin if detected. All indications are that all the uranium detections were of natural origin.

Geographical distribution

All samples collected by the RAP were more than 20 miles (30 kilometers) from LANL. None showed any impact from the fire. The FMT data, from stations closer in to LANL, also showed no impact. The regional AIRNET stations further form the laboratory supported these data. Only regular and high flow-rate AIRNET monitors near LANL provided any detection of non-natural radio-nuclides.

Summary

No unusual or unexpected detections of any of the TAL metals were made. Mercury was not detected.

Alpha and beta measurements did not indicate any increased levels of these types of radiation. No unusual or unexpected gamma-emitting measurements were made. All alpha-emitting radio-nuclides were either of natural origin or expected in the locations measured based on LANL operations.

Conclusion

We conclude that no detections of metals or radiation, including specific radio-nuclides, were identified as being caused by the Las Conchas fire of late June and early July 2011.

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