Atmospheric Deposition of PCBs in Northern New Mexico

ESHID-602508

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Introduction

Polychlorinated biphenyls (PCBs) are persistent organic pollutants (POPs) that are observed globally in environmental media, including those regions with no anthropogenic development or industrial activity. In 2005 Los Alamos National Laboratory (LANL) began using the congener method (EPA method 1668A) for PCB analysis, and began to detect PCBs in surface water and storm water runoff, even at remote locations with no industrial activity. These findings suggest that the source for PCBs may be related to atmospheric deposition. Figure 1 shows the range of PCBs in base flow and storm water runoff from various drainages in the upper Rio Grand system, northern New Mexico. In order to quantify and understand the PCB source term, wet/dry atmospheric deposition samplers were deployed from 2009 to present. These automated samplers are deployed at elevations from 6,500 feet on the Pajarito Plateau to 8,700 feet in the Valles Caldera in the Jemez Mountains. Figure 2 shows a map of the monitoring locations and study area. The Bandelier and Valles Caldera Headquarters monitoring locations are shown in Figure 3.

LANL is located in Northern New Mexico, which has a mild, semiarid, continental climate characterized by low precipitation totals dominated by summer monsoons and winter snows. It has low relative humidity, and relatively large diurnal and annual temperature ranges. Elevation ranges from 6,000 to just above 10,000 feet above ground level (AGL). The wind direction is predominately from the southwest, as shown in Figure 2. The western-most wind rose shows measurements from 300 feet, and the eastern wind rose near Los Alamos County Airport shows measurements observed at 150 feet AGL.

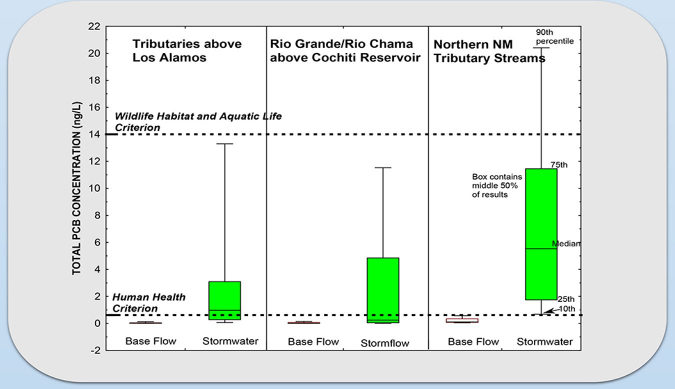

Figure 1. Box plots of base flow and storm water runoff PCB concentrations for various drainages in the upper Rio Grand system.

What are PCBs?

PCBs are mixtures of synthetic organic chemicals with the same basic chemical structure, and physical properties that range from oily liquids to waxy solids. No known natural sources of PCBs exist. Because of their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were historically used in hundreds of industrial and commercial applications. These applications included electrical, heat transfer, and hydraulic equipment; plasticizers in paints, plastics, calking, and rubber products; pigments, dyes, and carbonless copy paper; and many other uses. More than 1.5 billion pounds of PCBs were produced in the United States until the domestic manufacture of commercial mixtures, known as Aroclors, stopped in 1977. Approximately 450 million pounds of PCBs have been released into the environment.

Methods

Samples were collected using N-CON wet/dry atmospheric deposition samplers, deployed at select locations on and adjacent to the Pajarito Plateau in northern New Mexico. In addition, snowpack samples were manually collected by excavating a pit, then sampling the face of the pit by running a bottle vertically from bottom to top along the face of the snowbank.

PCB concentrations were measured by U.S. Environmental Protection Agency (EPA) Method 1668A, a high-precision analytical method capable of measuring concentrations as low as a few parts per quadrillion. Approximately 209 individual congener results are generated from a single PCB analysis. The results were statistically reviewed to identify any anomalous contamination present at the sites. The New Mexico Water Quality Control Commission (NMWQCC) water-quality criteria (WQC) for total PCBs in surface water are 0.64 nanograms/Liter (ng/L) for the protection of human health and 14 ng/L for the protection of wildlife habitats and aquatic life.

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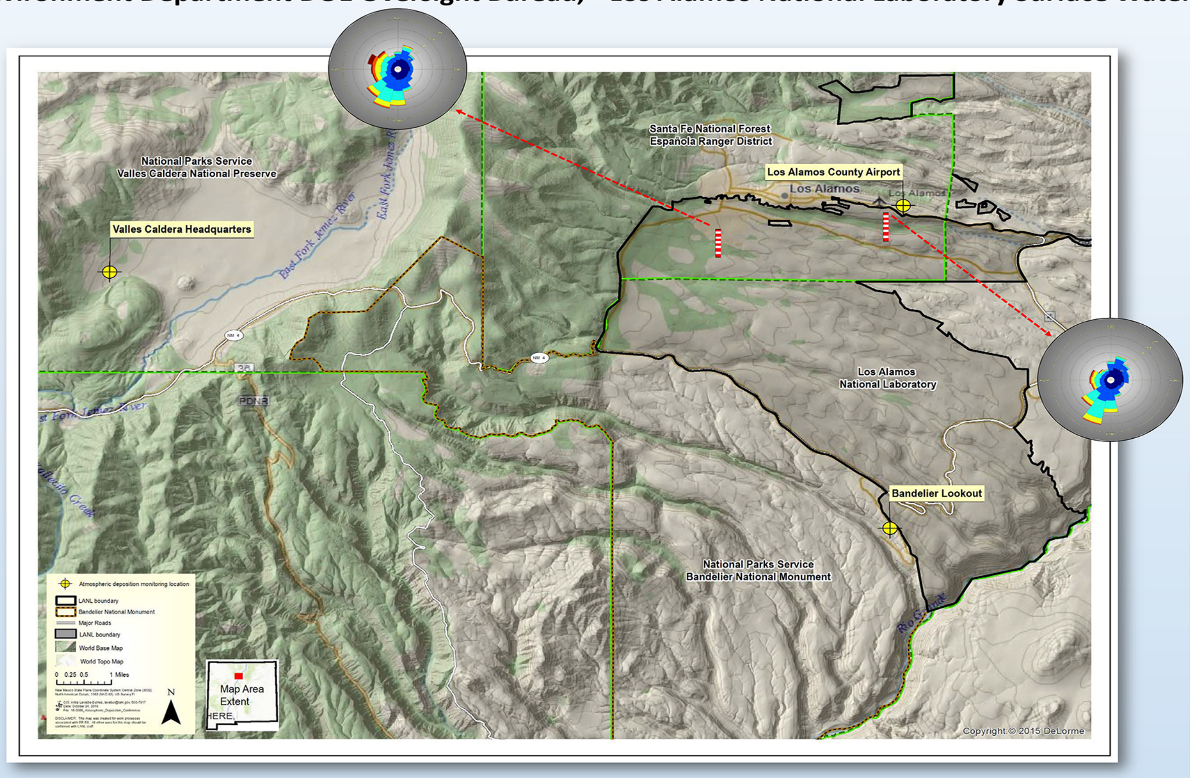

Figure 2. Map of the study area showing wind roses and monitoring locations.

Results and Discussion

Fifty-three wet deposition samples were analyzed for PCBs using the PCB congener method (EPA Method 1668A). Total PCB values for precipitation, summed from congener results, range from a minimum of 0.002 ng/L to 4.1 ng/L with an average value of 0.624 ng/L, a median value of 0.338 ng/L, and a standard deviation of 0.85 ng/L. A statistical summary is shown in Table 1, and box plots are shown in Figure 4. Both the highest and lowest values were observed at the Valles Caldera Headquarters monitoring location, a remote landscape with no known PCB use. Two dry deposition samples have been collected from Valles Caldera Headquarters as well. The first sample, collected in July 2015, was 11,000,000 ng/g. The second sample, collected in July 2016, was 12,600,000 ng/g. Less than a gram of material accumulated during the annual monitoring period each year. Although the location is remote and not associated with any development, the presence of dirt roads adjacent to the Valles Caldera Headquarters monitoring location may have contributed to the high observed values. PCBs are are thought to be associated with both a PCB volatile phase and atmospheric dust.

Snowpack samples were collected from 9 locations in northern New Mexico, with elevations ranging from 7,000 to 12,000 ft. Samples were collected from 2008 through 2013 and exhibited a wide range of values, from 0.008 ng/L to 4.58 ng/L, with an average value of 0.750 ng/L (Figure 4 and Table 1). The relationship between elevation and PCB concentrations are shown in Figure 5. There is a weak correlation between elevated PCBs in snowpack collected from locations close to cities; i.e., Sandia Crest, Tesuque Peak, and Kachina Peak and lower concentrations collected at locations distant from urban development. Although the correlation between altitude and PCB concentrations shows some correlation (Figure 5) it is not consistent or clear. Snow is often mixed with windblown organic and inorganic material in the southwestern United States, especially in the spring as well as enrichment of particulates in the snow pack during melting adding to the complex dynamics of PCBs archived in snow pack.

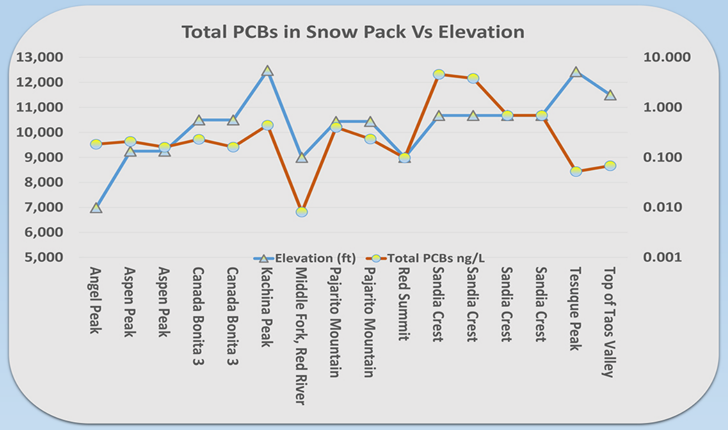

Figure 5. Plot of altitude and PCB concentrations in snowpack, northern New Mexico.

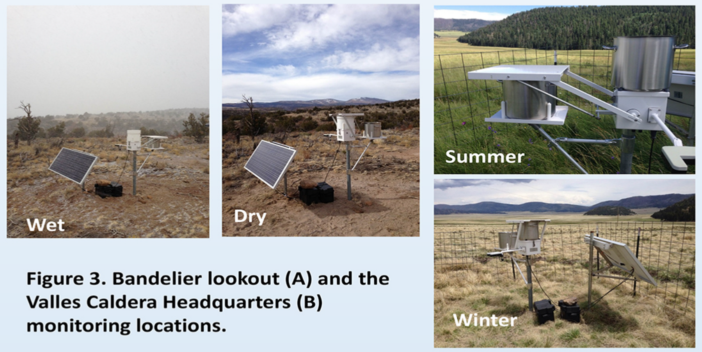

Figure 3. Bandelier lookout (A) and the Valles Caldera Headquarters (B) monitoring locations.

	Precipitation (ng/L)				Snowpack (ng/L)
	All	BNM	LA Airport	VCNP	All
No. of samples	53	25	17	10	16
Minimum	0.002	0.002	0.00289	0.4	0.00808
Maximum	4.1	4.1	3.97	2.22	4.58
Median	0.338	0.237	0.266	0.994	0.2195
Average	0.624	0.5	0.503	1.139	0.750
Std Deviation	0.85	0.84	0.903	0.529	1.322
HH-OO[a]	0.64	0.64	0.64	0.64	0.64
Wildlife Std[b]	14	14	14	14	14

[a] HH-OO Human Health - Organism Only NMAC WQCC surface water standard
[b] Wildlife - NMAC WQCC surface water standard for wildlife.

Table 1. Statistical summary of PCBs in precipitation and snowpack.

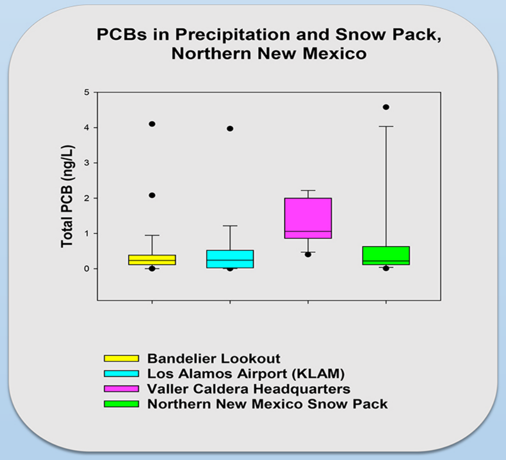

Figure 4. Box plots of PCB results in precipitation and snowpack.

Conclusion

The results of this study inform on the probable linkage between PCB concentrations in atmospheric deposition and PCB concentrations observed in surface and storm water in Northern New Mexico. Measureable PCBs are observed in precipitation and dust at all locations monitored. Atmospheric-derived PCB concentrations are not high enough to directly account for concentrations observed in storm water. However, PCBs are archived in terrestrial sediments and organic material that is mobilized and transported in storm water runoff and surface water. This represents a nonpoint source regional term that, from a regulatory standpoint, is difficult to manage. A new paradigm should be considered to account for the PCB global source term when regulating environmental media, especially surface and storm water.

Acknowledgement:
This material is based upon work supported by the Department of Energy Office of Environmental Management under Award Number *DE-EM0002420*.

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