

HIGH LEAD CONCENTRATIONS IN COLUMBUS SNOW^{1, 2}

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ABSTRACT

Lead concentrations in snow collected on the ground within 100 feet of streets and roads in January, 1970, were determined by atomic absorption spectrophotometric analysis of dissolved and particulate fractions of impurities. Twenty-seven samples of snow were collected over a 20 square-mile, suburban, mainly residential part of Columbus, Ohio. Measured concentrations were between 0.05 and 1.09 ppm Pb, with an average of 0.41 ppm. In all but one sample the lead concentration exceeded the U.S. Public Health Service safe limit for drinking water of 0.05 ppm. The temporal and areal distributions of concentrations, together with a comparison with iron concentrations measured in the same samples, indicated that automobile exhaust was the probable source of the lead.

INTRODUCTION AND SAMPLING METHOD

As a part of an initial survey of precipitation chemistry in Columbus, Ohio, by the Institute of Polar Studies, samples of fallen snow were collected in the northeast part of the city, and analyzed for lead. Samples were collected from within 100 feet of streets and roads, on January 15th and 18th, 1970. Ten samples were taken along the east side of the sampled area on the 15th, after about 6 inches of snow had accumulated between the 1st and 15th of January. Seventeen samples were taken over the rest of the area three days later. During the interval between the two times of sampling, the snow cover had compacted because of light rain and melting. The sampled area is shown in Figure 1.

Samples were collected with an aluminum coring cylinder of one-inch inside diameter by pushing the cylinder down into the snow against a clean lucite plate which had been inserted horizontally into the snow to insure that no soil was included. Each snow sample was put into a pre-cleaned polyethylene bottle and kept frozen until ready for analysis.

ANALYSIS

Each melted sample was treated with 1.5 ml of concentrated HCl and allowed to stand for one hour. Most of the liquid was then decanted into a polyethylene graduated cylinder, leaving a few ml of liquid in the bottle with some visible particulate material. Approximately 10 ml of concentrated HCl was added to the sediment portion, which was then boiled down to 1 to 3 ml in a teflon beaker, covered with a teflon watchglass. After being diluted back to volume with distilled water, the boiled fraction and the decantate were analyzed separately so that the composition of water-soluble and insoluble pollutants could be compared. A Perkin-Elmer model 303 atomic absorption spectrophotometer was used for the analyses, and the concentration in the original sample was calculated knowing the dilution factor. The lead concentration in blanks made from distilled water and HCl was below the detection limit of 0.01 ppm.

RESULTS

Measured concentrations of lead and information on the locations of sampling sites are given in Table 1. The lowest lead concentration, 0.05 ppm, was measured in sample 24, taken 50 feet upwind from a lightly travelled intersection (the resultant wind direction over the first half of January was about 240°, or about

¹Contribution No. 196 of the Institute of Polar Studies, The Ohio State University, Columbus, Ohio 43210.

²Manuscript received September 27, 1970.

west-southwest). The sample with the highest lead concentration (sample 5), 1.09 ppm, was collected only 10 feet from a busy road and downwind from U.S. 62. The average lead concentration for the ten samples collected on the 15th was 0.42 ppm, and for the second set, taken on the 18th, 0.40 ppm. Both the ranges in concentrations and the averages were almost identical in the two sets of samples.

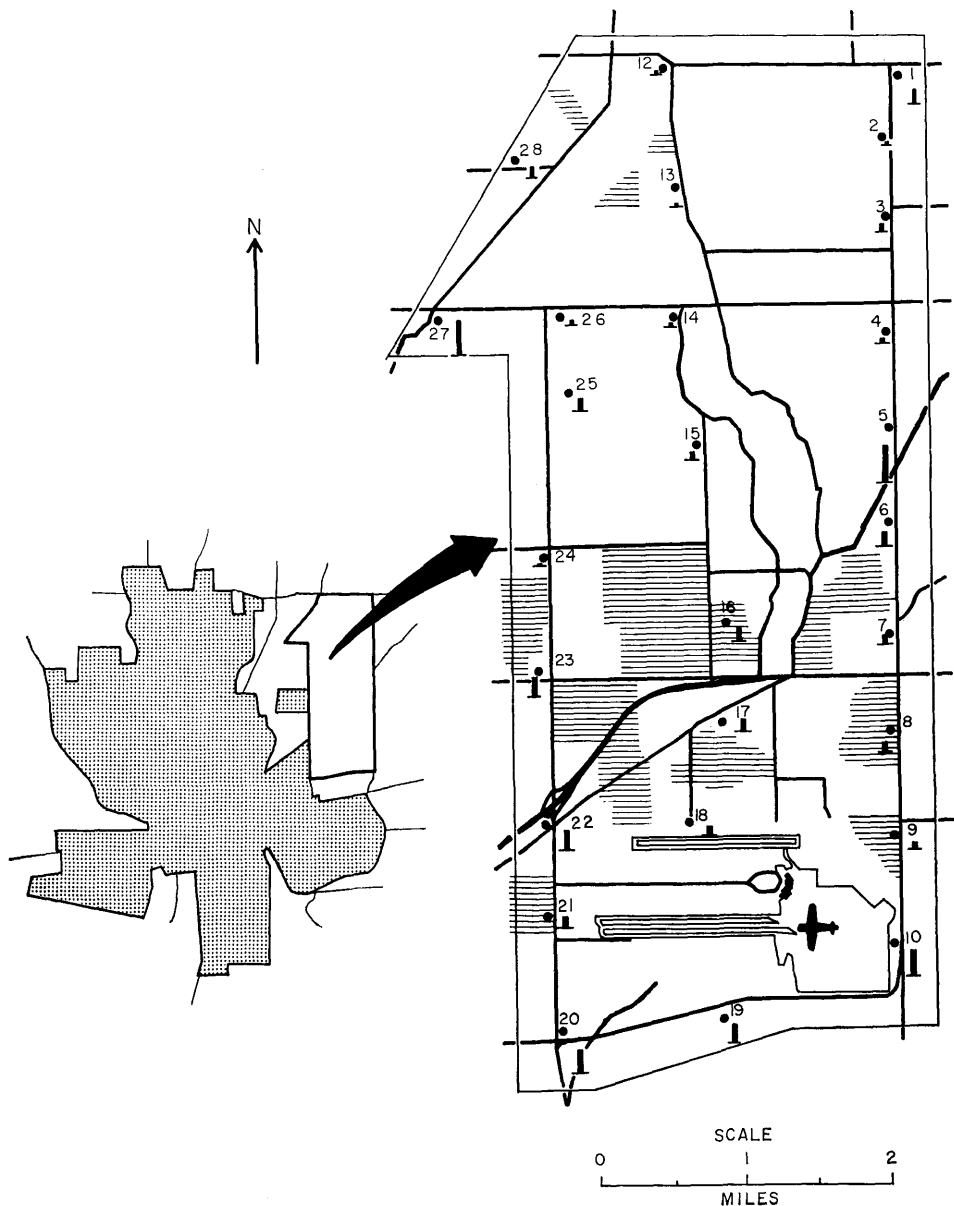


FIGURE 1. Location of Columbus, Ohio, and sampled area. Areas indicated by stippling and horizontal lines are areas of high population density. Streets and roads are shown by heavy lines. Sampling sites are shown by black dots, together with sample numbers and small bar graphs indicating the relative concentrations of lead measured in each sample.

Iron concentration was also determined in the samples; the measured values ranged from 1.4 to 9.5 ppm. There was no significant correlation between iron and lead concentrations, indicating that the mechanism of transport and deposition, the source, or both, of the two metals was different. If iron was derived from industrial processes, lead probably was not. Brar *et al.* (1970) have used a similar correlation method to locate pollutant sources in Chicago.

The average concentration of iron increased from 2.9 to 3.7 ppm between the 15th and 18th, suggesting that direct fallout or scavenging (removal of airborne particles by falling precipitation) by light rain (as distinct from scavenging

TABLE 1

Sample number	Lead concentration (ppm)	Distance from road (ft)	Remarks
1	0.44	80	gas station
2	0.11	30	
3	0.26	30	
4	0.15	30	
5	1.09	10	downwind US 62
6	0.40	50	
7	0.35	50	
8	0.35	50	
9	0.25	50	
10	0.80	25	aircraft approach
11			no sample
12	0.15	30	construction
13	0.11	50	
14	0.15	25	
15	0.23	100	cornfield
16	0.41	75	schoolyard
17	0.42	50	
18	0.31	15	dead-end road
19	0.58	60	railroad yard
20	0.72	50	parking lot
21	0.37	30	
22	0.59	50	
23	0.69	75	woods
24	0.05	50	
25	0.38	45?	woods
26	0.15	50	
27	1.08	30	busy intersection
28	0.36	50	

Average concentration Pb samples 1-10=0.42 ppm.

Average concentration Pb samples 12-28=0.40 ppm.

by snow), was significant in the deposition of iron. The absence of a similar increase for lead during the three-day interval suggests that direct fallout or rain-scavenging of lead was insignificant. This points to automobile exhaust as the lead source, because most lead in exhaust is associated with sub-micron-size particles that would not settle out from air (Anon., 1969, p. 43). Rain-scavenging typically leads to concentrations of lead in urban rain of only about 0.05 ppm (Anon., 1969, p. 43). The enhancement of lead in snowfall is not surprising, because it has been observed that ice scavenges about 16 times more effectively than does water (Vittori and Prodi, 1967).

Most of the iron was present in the sediment fractions of the samples, while the lead concentrations were about the same in the decantate and sediment fractions. This also indicates that lead was associated with much smaller particles,

or with water-soluble compounds such as lead bromochloride, and suggests that automobile exhaust was the principal source.

The average lead concentration measured in this experiment, 0.41 ppm, is about eight times greater than the value (0.05 ppm) considered safe for drinking water by the U.S. Public Health Service (U.S. Dept. of H.E.W., 1962). The results reported here indicate that, while leaded gasolines continue to be used in large quantities, urban and suburban watersheds near streets and roads may be significantly contaminated with lead. Children should be discouraged from eating snow, and birdbaths should be thoroughly cleaned in the spring.

ACKNOWLEDGMENTS

The analyses were performed in the laboratory of The Ohio State University Department of Chemical Engineering. We thank Mr. Paul Smith for his generous help and Dr. Edwin E. Smith for granting us permission to use the laboratory facilities.

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