Lead Concentrations in Soil and Vegetation Associated with Highways of Different Traffic Densities

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INTRODUCTION

There is much concern about man's uses of lead and the consequences when lead is released into the environment. Several major sources of environmental contamination by lead are exhaust products of leaded gasoline, metal smelting plants, lead arsenate pesticides, phosphate fertilizers, lead-base paints and spent lead shot from hunting activities. The scope of the present report will deal with lead from automobile exhausts. Elevated lead levels in soil and vegetation have been demonstrated along highways in many studies (CANNON AND BOWLES, 1962; MOTTO, et al., 1970; GANJE AND PAGE, 1972; HOPKINSON et al., 1972; GISH AND CHRISTENSEN, 1973; WYLIE AND BELL, 1973). Lead from exhausts is thought to effect a zone within approximately 30 m of the highway (MOTTO et al., 1970). Although effects of lead may be largely restricted to this zone, this should not be discounted as unimportant as thousands of kilometers of highways with increased lead levels, will result in considerable areas of land that are used by wildlife for food and cover, as well as vast areas used for crop (SCHUCK AND LOCKE, 1970; LAGERWERFF et al., 1973) and forage production (DAVIES AND HOLMES, 1972; WILLIAMS, 1974). It was the purpose of this study to determine the effect of various traffic densities on lead concentrations in soil and vegetation collected along roadsides.

PROCEDURES

Four study areas located near Blacksburg, Virginia, U.S.A. were chosen on the basis of traffic densities. The areas were labeled A, B, C, and D. Areas A, B, and C had average daily traffic densities of 21,040, 8,120, and 1,085 vehicles, respectively, in 1974 (Virginia Department of Highways, 1975). Area D, which was an interstate entrance loop, was at the junction of two highways each having a daily average of 11,905 and 11,640 vehicles, respectively. Control soil and vegetation samples were collected from a mature forested area, 500 m from the nearest road, in the Jefferson National Forest in Virginia near Blacksburg. The sampling procedure for soil and vegetation in the traffic areas consisted of laying out lines parallel to the edge of the roadway at distances 3, 6, 12, and 18 m. Samples of soil and vegetation were taken every three meters along each line for 30 m. Soil was sampled to a depth of 2.5 cm, while available vegetation was sampled at all levels at each sampling point, i.e. ground, understory, and overstory. Control samples of mountain laurel (*Kalmia latifolia*) and Virginia pine (*Pinus virginiana*) were collected from the forested area. Soil and vegetation samples were dried in a forced air oven at 75-80 C to constant weight. Samples of each species of vegetation were then ground in a Wiley Mill using a #40 mesh sieve, while soil samples were ground to a fine dust with a mortar and pestel. One gram of each sample of soil and vegetation was then ashed in a muffle furnace at 500 C for four hours. The ashed samples were dissolved in 10 ml of concentrated nitric acid, filtered, and made to 25 ml with distilled water. Analyses for lead were performed with a model 290 Perkin-Elmer atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Soil lead concentrations for all traffic areas are given in Table 1. Soil samples were not available at all distances

TABLE 1

Soil lead concentrations (μg/g d.w.) in areas sampled.

Study area	Distance from highway (m)					
	3	6	12	18	50	500
A	--	87.30	79.60	47.44	--	
B	109.74	47.25	27.37	19.91	--	
C	22.43	26.44	19.92	27.47	--	
D	--	126.74	42.34	32.31	22.35	
Forest						7.84

because of the presence of gravel or asphalt road edges on sample sites. All soil lead levels in the traffic areas were well above lead levels found in the forest area soils which had a mean of 7.84 μg/g dry weight (d.w.). Areas with higher traffic densities had higher soil lead concentrations. Soil lead levels in all areas which had the lowest traffic density and an upward sloping bank decreased with increasing distance from the highway. These findings are in agreement with those of MOTTO et al. (1970), GANJE AND PAGE (1972), GISH AND CHRISTENSEN (1973) and WYLIE AND BELL (1973). A nonparametric procedure was felt to be most appropriate here. Page's test for ordered alternatives (HOLLANDER AND WOLFE, 1973) was modified in this study to account for missing data. Decreases in lead levels with increasing distance from the highway were found to be significant ($P<0.05$).

TABLE 2

Vegetative lead concentrations (μg/g d.w.) at 6, 12, and 18 m from the roadway in Area A.

Vegetative group	Species	Distance (m) 6	12	18
Grasses	Narrow-leaf grasses	32.44	--	29.98
Forbs & Herbs	Crown vetch	74.87	42.32	27.43
	Chicory	--	--	24.46
	Dandelion	--	--	39.93
	Japanese honeysuckle	--	29.86	--
	Narrow-leaf plantain	--	--	27.50
Shrubs	Coralberry	--	71.98	--
	Multiflora rose	115.10	--	--
Conifers	Virginia pine	49.85	--	--
Deciduous	Apple	--	72.36	--
	Black locust	74.96	--	--
	Viburnum	72.22	--	--
	Viburnum berries	29.90	--	--

TABLE 3

Vegetative lead concentrations (μg/g d.w.) at 3, 6, 12, and 18 m from roadway in Area B.

Vegetative group	Species	Distance (m) 3	6	12	18
Grasses	Narrow-leaf grasses	20.97	19.99	--	17.50
	Panic grass	--	--	33.50	--
Forbs & Herbs	Coralberry	--	57.42	--	--
	Coralberry fruit	--	27.35	--	--
	Japanese honeysuckle	32.39	17.48	25.00	--
	Periwinkle	35.73	24.95	--	--
	Rubus	--	--	40.84	--
Deciduous	Apple	--	--	39.87	--
	Sumac	--	24.88	--	--

TABLE 4

Vegetative lead concentrations (μg/g d.w.) at 3, 6, 12, and 18 m from the roadway in Area C.

Vegetative group	Species	Distance (m) 3	6	12	18
Grasses	Narrow-leaf grasses	12.49	--	14.97	
Forbs &	Japanese honeysuckle	32.31	19.97	--	
Herbs	Lespedeza sericea	--	--	19.97	
Shrubs	Multiflora rose	--	32.40	--	
	Multiflora rose fruit	--	17.49	--	
Deciduous	Black locust	--	34.82	--	

TABLE 5

Vegetative lead concentrations (μg/g d.w.) at 6, 12, 18, and 50 m from the roadway in Area D.

Vegetative group	Species	Distance (m) 6	12	18	50
Grasses	Narrow-leaf grasses	69.76	29.88	19.95	24.85
Deciduous	Black locust	154.61	--	--	--

SUMMARY

Soil lead levels were found to decrease significantly in all traffic areas as distance from the highway increased. Areas of higher traffic volume had greater soil lead levels. Strong trends were shown in vegetation with areas of greater traffic density having greater lead levels than areas of lower traffic density. A decrease in lead levels was also noted in vegetation as distance from highway increased.

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