Lead and Mercury Levels in Vegetation From Strip-Mined Areas in Eastern Ohio

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Coal has been strip mined in 27 of Ohio's eastern counties; in 9 of these counties surface mining affected more than 5% of the land area. Although a limited amount of farming is being done on this land, the largest part of it seems destined to be utilized for wildlife and wildlife-associated recreation. The quantity and kinds of vegetation on strip-mined land frequently are different from that on nearby unmined sites. This gave us reason to question whether nutritive levels of plant tissues also might differ from those of undisturbed lands. Accordingly, we examined the effects of strip mining on the nutritive quality of vegetation (LINDSAY 1974). We also wished to measure the concentrations of lead and mercury in vegetation on stripped areas and to evaluate these findings as they relate to the suitability of such vegetation as food for wildlife. Levels of mercury and lead in vegetation are presented here.

STUDY AREAS

Samples of vegetation were obtained from study areas in Harrison and Perry counties in east-central Ohio. These sites were chosen to provide samples from distinctly different types of overburden where considerable mining has occurred. The important difference in the two areas, for purposes of this investigation, was the contrasting pH of the spoils; those in Perry County were acidic, whereas those in Harrison County were calcareous.

The Perry area lies just beyond the easternmost extent of glaciation in Ohio. The principal coal seam mined on the area, No. 6 Middle Kittanning, usually occurs in two or three minable benches, and the intervening partings are composed of highly acid, pyritic shales and clays (LIMSTROM and MERZ 1951). Soil samples from our mined study plots had pH levels of 3.7 to 4.0; pH levels from nearby unmined plots were 4.1 to 4.3. Mining began on the area in 1948, and the latest activity occurred in 1960 (BOOKHOUT et al. 1968:5).

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The principal coal seam in the Harrison area, No. 8 Pittsburgh, lies under 15 feet of limestone and 13 feet of shale. Overburden is classed as shaly-limestone-clays (LIMSTROM 1950). The pH of soil samples taken from our Harrison mined study plots ranged from 6.7 to 7.6; soil pH levels on control plots were 4.1 to 4.6. Erosion was less severe than in Perry County, and unvegetated areas were small rather than entire spoil banks.

MATERIALS AND METHODS

Six 16.2-hectare plots were established on each study area. Four were on strip-mined sites and were selected by random sampling, with the prerequisite that each plot have at least 75% of its surface affected by strip mining. Two additional plots on undisturbed land were subjectively selected for vegetation representative of the area and proximity to the four stripped plots.

Two 274.3-m belt transects were laid out on each plot. Each transect was divided into three 91.4-m segments, and samples from each segment were kept separate for statistical treatment. These transects extended approximately 3 m on either side of the center line, and were placed so as to offer as much diversity in terms of site and vegetation types as could be obtained within the confines of the 274.3-m plot. Transects were established along the long axes of valleys and ridgetops, and along slopes parallel to ridgetops.

The distal 13-15 cm of forbs and grasses, including flowers or seeds present, were clipped. Only the present year's growth within 1.5 m of ground level was taken from red maple (*Acer rubrum*); leaves and twigs were analyzed separately.

Collections were made in August (summer) of 1972 and February (winter) and June (spring) of 1973. Samples were air-dried, ground in a Wiley mill, and stored in polyethylene bags. Lead and mercury levels were measured by atomic absorption spectrophotometry with a Perkin-Elmer Model 303. Sensitivity levels were 0.03 and 0.001 ppm for lead and mercury, respectively.

Data were analyzed with the nonparametric Wilcoxon rank sum test (HOLLANDER and WOLFE 1973:68).

RESULTS

Few significant differences were found between levels of lead and mercury in vegetation from stripped and control plots. When differences were significant, higher values were from control plots (Table 1).

Median lead levels in forbs and grasses showed a seasonal trend. They were lowest in spring and highest in winter, with winter medians of 14 and 16 ppm (dry wt) in forbs and 20 and 22 ppm in grasses from stripped plots in Harrison and Perry counties, respectively. Similar seasonal changes occurred in red maple twigs, but levels were much lower. Lead levels in blackberry (*Rubus* sp.) tended to change little from spring to

TABLE I

MEDIAN LEVELS (PPM, DRY WEIGHT) OF LEAD AND MERCURY IN VEGETATION FROM STRIPPED (t) AND CONTROL (c) PLOTS IN PERRY AND HARRISON COUNTIES, OHIO, 1972-1973.

	Lead				Mercury			
	Perry		Harrison		Perry		Harrison	
	t	c	t	c	t	c	t	c
			Spring					
Grouped forbs (7-16)[a]	2.33	5.94	4.81	2.91	0.02*	0.03	0.02*	0.04
Blackberry (1-11)	3.09	12.42	3.49	12.68	0.02	0.02	0.03	0.03
Red maple leaves (2-6)	3.69	1.77	6.70	2.72	0.03	0.03	0.04	0.05
Red maple twigs (2-3)	0.79	--	--	--	0.0	--	--	--
Grouped grasses (6-8)[b]	6.05	--	0.89	--	0.03	--	0.02	--
			Summer					
Grouped forbs (8-42)	6.09	9.14	4.73	5.01	0.04**	0.08	0.04**	0.10
Blackberry (1-18)	4.50	5.58	2.22*	12.41	0.03	0.05	0.08*	0.30
Red maple leaves (3-8)	4.09	4.99	3.24	4.35	0.07	0.07	0.12	0.10
Red maple twigs (2-7)	2.04	3.34	7.91	3.16	0.02	0.05	--	--
Grouped grasses (8-12)	4.51	--	1.50	--	0.05	--	0.17	--
			Winter					
Grouped forbs (4-24)	14.35	--	16.01	12.92	0.04	--	0.06	0.05
Blackberry (1-11)	1.57	0.0	0.0	1.55	0.01	0.01	0.01	0.01
Red maple twigs (1-5)	4.08	4.45	--	--	0.01	0.02	--	--
Grouped grasses (6-7)	20.42	--	21.97	--	0.05	--	0.08	--

[a]Ranges of sample sizes, counties and treatments combined.

[b]No grasses were collected from control plots.

*Difference between stripped and control plot levels significant at $\alpha < 0.05$.

**Difference between stripped and control plot levels significant at $\alpha < 0.01$.

summer but declined substantially between summer and winter.

Mercury levels in plants from strip-mined sites ranged from non-detectable in red maple twigs to 0.30 ppm in blackberry (Table 1). Significant differences between levels in control and stripped areas occurred only in forbs in spring and summer and in blackberry in summer. All values, however, were below the general background concentration of about 0.50 ppm (dry weight basis) of mercury in plants (SMITH 1972:1238).

DISCUSSION

Factors to be considered in evaluating lead levels in vegetation include season, year, species, and airborne contamination. In our study, lead levels in forbs from stripped sites clearly reflected the seasonal trend also observed by MITCHELL and REITH (1966) in pasture herbage in Scotland (1.5 ppm or less during the period of active growth to 30-40 ppm in late winter). GAMBIE (1963:65) sampled vegetation in summer at one New Jersey location for five successive years and found large variation in lead content between years. Additional sampling at our study sites might have shown a similar trend. GAMBIE (1963) also observed a high degree of species specificity; understory and ground cover generally had highest concentrations of elements at each site. He found leaf tissue from 5 woody species contained an average of 5.7 ppm lead on one soil type and 14.4 ppm on another. Forbs and grasses contained the highest levels of lead that we found (Table 1). MITCHELL and REITH (1966) similarly reported much higher lead levels in pasture herbage than the 2.50 ppm found by WARREN and DELAVAULT (1962) in tree leaves and twigs. We believe that the plants we examined were affected little by airborne contamination (i.e., automobile emissions), because the two state-owned areas we studied appeared to be used mainly by hunters and other recreationists. Neither is close to a major highway.

The tendency for vegetation from our control plots to contain higher levels of lead and mercury followed GOLDSCHMIDT'S (1937) observation that tree roots take up certain "rare" elements, including lead and mercury, that they accumulate in the detritus of forests, and that over long periods of time they are concentrated in the organic matter of the A horizon. There they are at least partially available for uptake by forest plants.

SWAINE and MITCHELL (1960) observed that the surface accumulation of lead is the outstanding effect in the total trace-element content of soil profiles examined in Scotland. The effect was found to be greatest in organic-rich, uncultivated surface horizons. Their explanation was that lead accumulates through plants, in a manner more pronounced than for other elements, and that an insoluble complex that holds the lead in the surface horizon is formed on the decaying plant material. This may have been the situation on our control plots, which, in both counties, were established in woodlots containing mature beeches (*Fagus grandifolia*) and sugar maples (*Acer saccharum*). Spoil banks, in contrast, have detritus layers of more recent origin.

We do not believe that the possibility of potentially toxic concentrations of heavy metals in spoil bank vegetation should be dismissed. Lead levels from individual forb samples ranged up to 52 ppm in Perry County in spring; forbs from control plots contained up to 18 ppm. In Harrison County during winter, forbs from mined plots had up to 48 ppm lead, and some levels in forbs from undisturbed plots reached 16 ppm (LINDSAY 1974:74). Only a few of these samples containing high residue levels occurred, however, and our results indicated that plants growing on overburden in east-central Ohio generally can be expected to contain low levels of lead and mercury.

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