Contamination of Vegetation by Tetraethyl Lead

Abstract. Tetraethyl lead is a normal constituent of vegetation growing along our highways. Washed grass near Denver contained 3000 ppm (in ash) near major intersections and > 50 ppm for 500 feet downwind. Vegetables grown within 25 feet of a road in upstate New York and western Maryland averaged 80 to 115 ppm.

The presence of lead in vegetation growing near major highways was first noted by Warren and Delavault (*1*). Their studies of anomalous lead in soils and plants in England and Canada compared with health data suggest possible correlations with several diseases (*1, 2*). Because of the implications of their work, the U.S. Geological Survey in cooperation with the U.S. Public Health Service has tested vegetation for lead in three areas: Denver, Colo.; Canandaigua, N.Y.; and Washington County, Md.

In the Denver area, samples of pasture grasses were collected along 1000-foot traverses in east-west and north-south directions from two major highways to determine the extent of lead contamination of vegetation. The samples were washed and ashed, and the lead content was determined on an emission spectrograph. The results are shown graphically in Fig. 1. The lead content of plant ash ranged from 100 to 700 ppm in samples collected within 5 feet of the highway, but consistently decreased to a minimum ranging between < 5 ppm and 50 ppm in samples collected 500 to 1000 feet from the highway. Two factors control the distribution of lead shown in the graph: first, a difference in traffic volume on the two highways along which vegetation was collected, and, second, the effect of prevailing wind directions. Grass with a lead content of more than 50 ppm was collected for a distance of 500 feet both north and south of U.S. Highway 6, which has a traffic volume of 8000 cars per day (*3*). Grass collected at the intersection of U.S. Highways 6 and 40, which carries a heavy volume of traffic, contained 3000 ppm lead. In contrast, grass collected at a less heavily traveled intersection (Highway 6 and Kipling Street) contained 500 ppm lead. The effect of wind direction is shown by sampling along north-south U.S. Highway 287 (Federal Boulevard), which has a traffic volume of 4300 cars per day; grass that contained more than 50 ppm lead extended 100 feet east from the highway but for only 10 feet to the west against the prevailing winds.

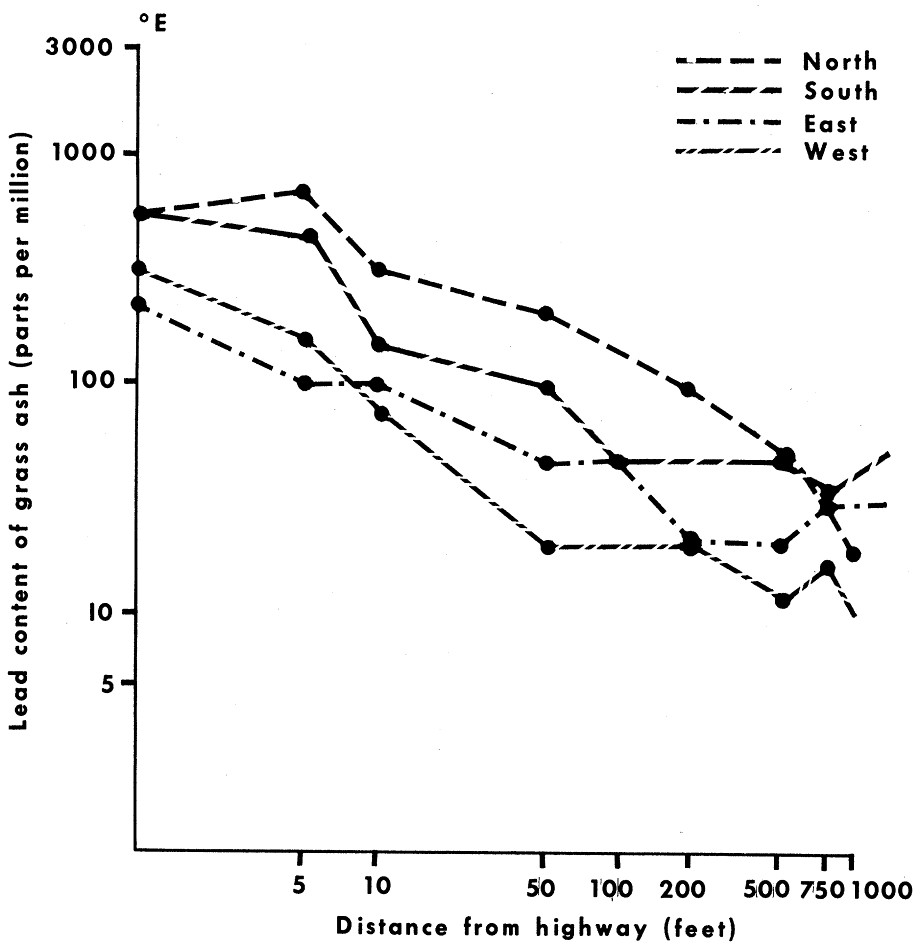

Fig. 1. Variation in lead content of ash of grass marginal to two major highways in the Denver, Colorado, area. North and south curves (from U.S. Highway 6, West Sixth Ave.) indicate lead content of grass to 1000 feet from highway. Samples were collected 7 miles west of the state capitol; volume of traffic was 8000 cars every 24 hours. East and west curves (from U.S. Highway 287, Federal Blvd.) indicate lead content to 1000 feet from highway. Samples were collected about 8.5 miles north-northwest of the state capitol; volume of traffic was 4300 cars every 24 hours. Point *E* indicates content at intersection of U.S. Highways 6 and 40, 9.5 miles west of the state capitol. The volume of traffic was about 20,000 cars every 24 hours.

Table 1. Lead content of vegetation along paved roads in Washington County, Md. [Analyst: E. F. Cooley]

Distance from road (ft)	Mean lead content in the ash (ppm)	Range (ppm)	Plant samples analyzed (No.)
1–25	80	10–500	29
25–50	66	10–700	29
50–500	45	<10–150	43
Over 500	20	<10–200	28

The distribution of other metallic elements in pasture grass was also studied in relation to proximity to the highways. The content of boron, zinc, iron, and titanium is greater in grass that grows within 5 feet of a major highway, but the effect is not noticeable at any greater distance. Analysis of the ash of washed grass from the major intersections showed maximum contents of 3 percent Fe, 2000 ppm Ti, 1000 ppm Mn, 1000 ppm B, 2000 ppm Sr, 100 ppm Cr, 300 ppm Zn, 150 ppm Cu, 100 ppm V, 70 ppm Zr, and 50 ppm Ni. The grass contained normal amounts of Si, Mg, Ba, Be, and Mo.

A check of homegrown vegetables was made in Canandaigua, N.Y. The gardens were generally less than 50 feet from the street. Sixteen vegetable samples averaged 115 ppm lead and ranged from < 10 ppm to 700 ppm in contrast to an expected background of < 5 to 20 ppm. Six soil samples averaged 515 ppm and ranged from 100 ppm to 1000 ppm.

Analytical studies of vegetation in Washington County, Md., revealed a similar relationship. Samples of vegetables collected within 25 feet of any road contain an average of 80 ppm lead, but samples collected more than 500 feet from a road contain an average of only 20 ppm lead. The analytical data are shown in Table 1.

Thus our studies confirm the findings of Warren on the concentration of lead in vegetation near highways. We hope that the data presented here will encourage further study of the problem by interested members of the medical profession (*4*).

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4. Publication of this report has been authorized by the director, U.S. Geological Survey.

4 May 1962

Sorbitol Translocation in Apple

Abstract. A report of glucose translocation, an apparent exception to the hypothesis that sucrose is the major carbohydrate translocated in plants, was investigated. Carbon-14 studies of the carbohydrates in the bark of apple suggest that rather than glucose the sugar alcohol, sorbitol, in addition to sucrose, is a principal compound translocated in this species.

There is general agreement that sucrose is the most important translocatory carbohydrate in most higher plants (*1*). Few reports exist in which glucose and fructose are proposed as transport molecules (*1*). The work of Dana (*2*) constitutes one of the few clear-cut examples of apparent translocation of a hexose sugar.

In 1952 Dana (*2*) reported that when $C^{14}O_2$ was supplied to leaves of dwarf yellow Delicious apple trees, most of the radioactivity recovered from bark samples was present in glucose. A secondary amount of labeling was detected in sucrose, and very little activity was present in fructose. Since Dana's results were unique, it was decided that a more complete investigation of carbohydrate translocation in apple should be undertaken. Our data are the results of that investigation.

Carbon-14 labeled carbon dioxide was supplied to the terminal leaves of a 2-year-old Malling IX dwarf yellow Delicious apple tree; a closed generating system was used (*3*). Then the stem below the supply area was sectioned, and the bark was separated from the wood. The bark and wood samples were prepared and analyzed essentially by Burley's method (*4*).

These procedures involved one-dimensional paper chromatography with the solvent system of n-butanol, ethanol, and water in volumes of 45:5:50; this system is used routinely to separate sucrose, glucose, and fructose. The amounts of activity corresponding to known sucrose, glucose, and fructose agreed with the data of Dana. Most of the radioactivity appeared to be present in glucose, with a secondary amount in sucrose and very little in fructose. Table 1 presents the results from this experiment, which is one of a series showing similar results.

While our investigations were progressing, we noted findings by Zimmermann (*5*) that sieve-tube exudate of ash contained large amounts of the sugar alcohol, mannitol. While this observation was essentially unexplained at the time, the presence of mannitol in the sieve-tube exudate did indicate its possible role as a transport compound (*6*). In an effort to find suitable analytical procedures for the separation and quantitative determination of mannitol, we noted that R_f values of sugar alcohols were similar to glucose in the solvent system used for the apple analysis. Sorbitol was subsequently identified by rigorous chromatographic procedures as the compound containing the major portion of activity in the stem of apple after exposure of the leaves to $C^{14}O_2$. This identification is in basic agreement with the observation that sorbitol is a major constituent of various genera of the Rosaceae, including apple (*7*).

The solvent system of butanone, acetic acid, and water saturated with boric acid, in volumes of 9:1:1, proved to be satisfactory for the separation of sucrose, sorbitol, glucose, and fructose. Duplicate samples of the experiment reported in Table 1 were analyzed by using this solvent system (Table 2). It is apparent that most of the activity originally thought to be in glucose was actually in sorbitol.

The carbohydrates occurring in the sieve-tube exudate of several varieties of apple were analyzed. Sorbitol and sucrose were the major components, and small concentrations of raffinose together with traces of stachyose were tentatively identified. We consider the evidence ample to regard sorbitol along with sucrose as principal carbohydrate transport material in the phloem of apple and perhaps in other species of the Rosaceae (*8, 9*).

Table 1. Relative radioactivity of C^{14}-labeled sugars in the bark of yellow Delicious apple after chromatography with the butanol, ethanol, and water solvent system.

Distance of translocation* (cm)	Activity (count/min mg dry weight)†		
	Sucrose	Glucose (and sorbitol)	Fructose
Supply leaf	3136	14,137	236
2.5	673	1,947	103
46	482	1,581	84
60	114	325	17

* Distances are from node of C^{14} supply leaf to center of sample. † All counts ± 2 percent at the 95 percent confidence level.

Table 2. Relative radioactivity of C^{14}-labeled sugars in the bark of yellow Delicious apple after chromatography with the butanone, acetic acid, and boric acid solvent system.

Distance of translocation* (cm)	Activity (count/min mg dry weight)†			
	Sucrose	Sorbitol	Glucose	Fructose
Supply leaf	2967	9426	693	278
2.5	711	2276	137	90
46	500	1671	71	57
60	127	346	23	21

* Distances are from node of C^{14} supply leaf to center of sample. † All counts ± 2 percent at the 95 percent confidence level.

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8. This report is contribution No. 660 of the department of botany and plant pathology, Ohio State University.
9. This work was supported by a Muellhaupt postdoctoral scholarship awarded one of us (K.L.W.).
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29 June 1962