

## LEAD CONCENTRATIONS of plants, soil, and air near highways

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Lead found in and on crops in these highway proximity tests was caused principally by aerial deposition. Substantial amounts of Pb were removed from exposed plant tissues by distilled water washing. Amounts of Pb in and on crops were influenced by distance from the highway, extent of plant surface exposed, external plant characteristics, duration of plant exposure, motor vehicle traffic density, and direction of prevailing winds. In soils and suspended air particulates, concentration of Pb was influenced by distance from highways, and the direction of prevailing winds.

**L**EAD (Pb) IS EMITTED into the atmosphere from numerous sources, the most common of which is motor vehicles

powered by leaded gasolines. Results of investigations in areas outside of California show Pb accumulation by crop plants near highways varies with motor vehicle traffic densities (ADT) and generally decreases with distance from heavily traveled roads.

The California coastal area is subject to frequent, unusually low thermal inversions, which means that the upper air flow is not always available for removal of contaminants. Since these conditions prevail and could also influence Pb content of plants and soils, interactions between atmospheric Pb particulates and Pb content of plants and soils in southern California were investigated.

Lead contents of several consumer crops, soil, and air near two major highways—the Santa Ana Freeway and Riverside Freeway—are given in this report. Trends and the amount of Pb on or in plant constituents are illustrated in graphs and tables. The Pb contents of

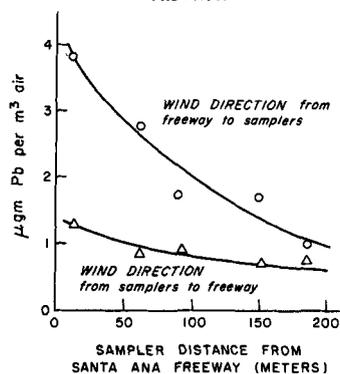
air, plants, and soils were determined by the dithizone method.

Two of the test areas in southern California were fields at the Irvine Ranch, south of Tustin, that straddled the Santa Ana Freeway, and a field straddling the Riverside Freeway south of San Bernardino. When the samples were collected, the Santa Ana Freeway carried 69,000 motor vehicles per day at the site sampled and the Riverside Freeway carried 37,000 motor vehicles per day at the site sampled.

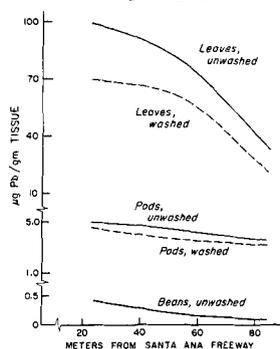
### Airborne lead particulates

Portable air samplers operated from a mobile laboratory were used to collect air particulates on 4 cm Gilman filters at various distances from the pavement edge of the Santa Ana freeway in March, 1968. The filters were digested in hot acids, and Pb was determined by the dithizone procedure. Wind direction was measured by automatic instrumentation. By separating

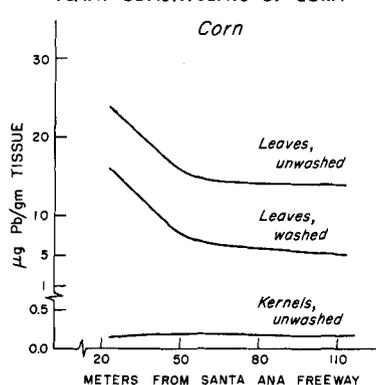
GRAPH 1. AVERAGE AMBIENT Pb CONCENTRATIONS IN FIELD AS INFLUENCED BY SAMPLER DISTANCE AND WIND DIRECTION FROM SANTA ANA FREEWAY



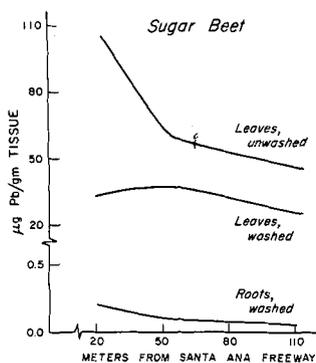
GRAPH 2. EFFECTS OF DISTILLED WATER WASHING AND DISTANCE FROM FREEWAY ON Pb CONTENT OF PLANT CONSTITUENTS OF LIMA BEAN



GRAPH 3. EFFECTS OF DISTILLED WATER WASHING AND DISTANCE FROM FREEWAY ON Pb CONTENT OF PLANT CONSTITUENTS OF CORN



GRAPH 4. EFFECTS OF DISTILLED WATER WASHING AND DISTANCE FROM FREEWAY ON Pb CONTENT OF PLANT CONSTITUENTS OF SUGAR BEET



air samples according to wind direction, in relation to freeway heading, average curves representative of the ambient Pb levels were obtained under conditions in which the wind direction was from the freeway toward the field, and vice versa. The two average curves representing these conditions are shown in graph 1.

### Lead content of crops are influenced by distance from highways, water washing, plant characteristics and exposure.

#### Lima bean

Lima bean plants were collected from a field at various distances due east of the Santa Ana Freeway in 1969. Leaves and pods were analyzed separately before and after being washed with distilled water. Beans inside pods were also analyzed. Graph 2 shows that Pb content of beans, leaves, and pods decreased with increased distance from the freeway—with a relatively high content on leaves from plants collected within 53 meters of the pavement edge. At 84 meters, Pb in unwashed leaves was 35 µg per gm, compared with 83 and 99 µg per gm at 53 and 23 meters, respectively, from the pavement. From the leaves sampled within 53 meters of pavement about 30% of the Pb was removed by washing. Pods contained about 80% less Pb than the leaves; washing the pods removed from 30 to 50% Pb.

Although leaves and pods were both exposed to the ambient air, their Pb contents varied considerably. These differences probably can be explained in terms of the duration of exposure, texture of the tissues and canopy effect. Pods appear late in the life cycle of the bean plant and are exposed for a shorter period of time. They are also shielded from surface exposure by the leaves. Finally, Pb particulates of the size present in the atmosphere would be expected to adhere more readily to the rough surfaces of leaves than do relatively smooth surfaces of pods. Unwashed beans, removed from the pod, showed very small amounts of Pb. Since these are not exposed to the ambient air, they are not subject to aerial Pb deposition.

#### Corn

Corn leaves collected in July, 1969, 23 meters west from the Santa Ana freeway contained nearly twice as much Pb as leaves collected 53 meters from the freeway (graph 3). Amounts of Pb were reasonably uniform at locations from 53 to 114 meters from the freeway. Washing with distilled water removed about 50% of the Pb from leaves. Kernels had only

Results are expressed as micrograms (µg) Pb in a cubic meter (m³) of air. At about 60 meters from the freeway, the field was continually exposed to an air mass containing about 1.8 µg Pb per m³ of air. Ambient Pb concentrations decreased substantially as distance from the freeway increased.

small amounts of Pb. Corn kernels, like lima beans, are not exposed to the ambient air.

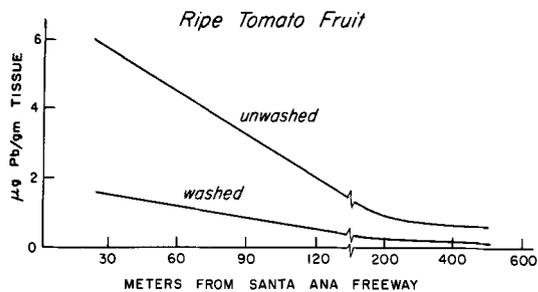
#### Sugar beet

Leaves and roots of sugar beets close to and east of the Santa Ana Freeway on the Irvine Ranch were collected in August, 1969, and analyzed for Pb. Leaves accumulated rather large amounts of Pb. The leaves were exposed to the ambient air for about eight months. Their surface area is large and rough, with most of it exposed directly to the air; these conditions, and prevailing winds, probably accounted for excessive Pb accumulation. At 23 meters from the freeway, Pb in unwashed beet leaves was about 100 µg per gm (graph 4). Lead was significantly higher in beet leaves close to the freeway and declined markedly as distance from the freeway increased from 23 to 114 meters. Washing leaf surfaces removed about 30 to 60% of the Pb. Lead content of the beet root was low; ranging from 0.2 and 2.3 µg in Pb per gm in unwashed beets. Washing reduced the concentration to about 0.1 µg per gm.

#### Tomato

The Pb contents of ripe tomatoes collected in 1969, and analyzed before and after distilled water washing, are shown in graph 5. At 23 meters from the pavement edge, unwashed tomatoes showed six times more Pb than was observed at distances greater than 183 meters. A decrease of Pb from 6.02 µg Pb per gm at 23 meters to 0.95 µg Pb per gm at 183 meters from the freeway was significant. About 70 per cent Pb was removed by washing. Apparently most of the Pb deposited on tomato is rather easily removed by washing because of the fruit's smooth surface. The more mature unwashed tomatoes contained higher amounts of Pb. This may have been related to the extent of exposure as well as duration of exposure. The young tomatoes are shielded by the leaves to a greater degree than the older tomatoes. When the fruit is mature, the canopy

GRAPH 5. EFFECTS OF DISTILLED WATER WASHING AND DISTANCE FROM FREEWAY ON Pb CONTENT OF RIPE TOMATOES

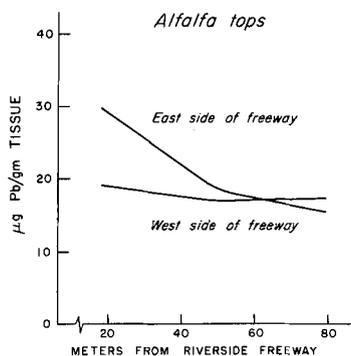


effect of the leaves is reduced, exposing more of the fruit to the ambient air.

### Wheat

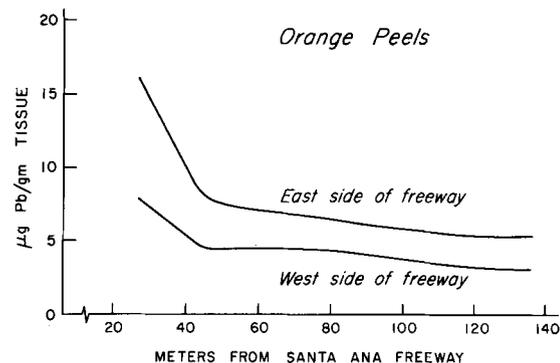
The Pb content of wheat spikes which were also collected in 1969 and analyzed before and after distilled water washing is given in table 1. In most instances, washing removed some Pb from the

GRAPH 6. EFFECT OF WIND DIRECTION ON Pb CONTENT OF ALFALFA



wheat spike. On unwashed bearded spikes, average Pb content was reduced over 50% at 38 meters from the pavement. Lead concentrations of the bearded spike were much higher than concentrations on tomatoes. Again this difference was probably due to the roughness of the wheat beard and duration of exposure.

GRAPH 7. EFFECT OF WIND DIRECTION ON Pb CONTENT OF ORANGES



some plant recycling. Lead values of soils also appeared to decrease at increasing distances from the pavement edge.

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### Wind direction influences on Pb content of crops

Lead concentrations of air samples were determined and wind direction measurements made at various distances east and west of the Riverside freeway south of San Bernardino. Prevailing winds were predominantly toward the east. Mean Pb concentration of air 8 meters from the east pavement edge was 6.3 µg per m<sup>3</sup>, compared with 2.4 µg per m<sup>3</sup> west of the pavement edge.

### Alfalfa

The Pb content of alfalfa plants collected in 1967 at distances from 18 to 80 meters east and west of the freeway are shown in graph 6. Lead content of alfalfa tops was influenced by direction of prevailing winds and distance from freeway. Since the prevailing winds were predominantly toward the east, greater

amounts of Pb were found on and in plants on the east side of the freeway, particularly at distances up to 50 meters.

### Oranges

Similar trends were observed with the orange peels of oranges collected in 1968 from a grove bisected by the Santa Ana freeway. Without exception, Pb in and on unwashed orange peels on the leeward side of the freeway exceeded that of orange peels on the windward side (graph 7). Direction of the prevailing winds have a definite effect on the Pb content of plants close to major highways. Again, as previously noted, Pb content of plants decreased with distance from the freeway. Distilled water washing removed 50 to 70% Pb.

TABLE 1. LEAD CONTENT OF WHEAT SPIKES COLLECTED EAST OF THE SAN DIEGO FREEWAY

Sample site distance from Harbor Blvd. at 177 meters from San Diego fwy:	Pb Content of Wheat Spikes	
	Unwashed	Washed
meters	µg/gm	
8	30.0	5.6
38	61.0	11.0
68	6.7	10.0
98	25.0	13.0
128	23.0	31.0
158	41.0	9.4
188	33.0	26.0
Mean	31.4	15.1

Sample site distance from Harbor Blvd. at 354 meters from San Diego fwy:	Pb Content of Wheat Spikes	
	Unwashed	Washed
meters	µg/gm	
8	30.0	16.0
38	12.0	8.6
68	14.0	9.8
98	14.0	14.0
128	13.0	3.1
158	29.0	16.0
188	17.0	0.8
Mean	18.4	9.8

TABLE 2. LEAD CONTENT OF SOILS SAMPLED ONE MILE NORTH AND DOWNWIND OF SANTA ANA FREEWAY

Distance from:	Pb content of soil to depth of:	µ/gm	
		0-15 cm	50-65 cm
Browning Rd.	Irvine St.		
4.6	7.6	67.0	1.6
65.0	7.6	67.0	1.6
126.0	7.6	67.0	2.0
187.0	7.6	17.0	1.1
	Mean	17.0	1.6
		40.0	1.6
4.6	38.0	11.0	1.1
65.0	38.0	1.4	1.6
126.0	38.0	2.9	1.1
187.0	38.0	7.5	0.7
	Mean	2.9	1.1
4.6	68.0	9.7	1.2
65.0	68.0	0.7	1.2
126.0	68.0	.	1.1
187.0	68.0	1.4	1.0
	Mean	3.9	1.1

### Lead distribution in soils of fields near freeways

Soils were collected from several fields at various distances from highways to depths of 65 cm. Lead values for soils shown in table 2 were from a field near the Santa Ana freeway ADT at this point on the freeway in 1968 was 70,000. Adjacent to the field on the west is Browning Road with an ADT of 4,000 and on the north is Irvine Road with an ADT of 5,000. Lead in the surface soils collected along Irvine Street was greater than in such soils from other locations in the test field. Surface soils at the intersection of

Irvine Street and Browning Road contained considerably more Pb than did surface soils from other locations in the field. These observations suggest some influence of local traffic, perhaps vehicular acceleration-deceleration, on the Pb content of soil next to the roads. In general, similar trends were observed in other areas. The Pb in surface soils was always considerably more than found at greater depths in the profile. These effects are probably due to deposition from automotive exhaust Pb particles, along with