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A SURVEY OF LEAD LEVELS IN SOILS AND VEGETATION OF SELECTED AIRFIELD ENVIRONMENTS

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PROJECT 2303

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This report has been reviewed by the Chief Scientist and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

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A SURVEY OF LEAD LEVELS IN SOILS AND VEGETATION OF SELECTED AIRFIELD ENVIRONMENTS

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October 1977

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Soil and vegetation from a control area and from areas immediately adjacent to the airfields at USAF Academy and Peterson AFB, CO, were analyzed for elemental lead using a Model 403 Perkin-Elmer Atomic Absorption Spectrophotometer. Mean lead levels in soil of 2.4, 10.2, and 6.2 ppm were found for the three locations, respectively. Mean lead levels in vegetation of 3.4, 25.4, and 40.4 ppm were found for the three locations, respectively. These data suggest the need for studies of indigenous herbivores for possible lead accumulation.

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INTRODUCTION

Lead is a soft insoluble heavy metal that occurs naturally in air, soils, water and biological tissue. Among the natural sources of lead in the atmosphere are silicate dusts, volcanic smoke and smoke from forest fires (10). The combustion of fossil fuels contributes approximately 4 percent of atmospheric lead (4). The United States is the major lead consuming country in the world with automobile manufacturing comprising the largest industrial use of lead. Use of lead in gasoline antiknock additives is second and accounts for 21 percent of all lead used in the United States (13).

It is generally accepted that the world's mean soil concentration of lead is 16 parts per million (ppm) (4). Cannon and Swanson (3) indicated that 20 ppm was the mean lead level for soils in the United States. Berry et al. (2) reported that, in general, lead levels in rural areas ranged from 10-15 ppm while levels in urban and industrial areas ranged from 17 to 12,000 ppm. Seeley et al. (11) found that in studies of soil profiles, lead levels were greatest in surface increments with decreasing concentrations at lower increments. Arvik et al. (1) suggested that lead may form an insoluble complex in soils, thus restricting its movement in a soil profile.

Although lead is not considered an essential trace element in plants, significant concentrations have been reported in plants from urban areas (5), along highways (8), and near smelters and foundries (6). Motto et al. (9) reported lead levels in plant tissue of 5-10 ppm for rural areas, while Goodman and Roberts (6) reported levels of 45-500 ppm in vegetation growing near a smelter operation. Ter Harr (12) concluded that translocation of lead occurred in both leaves and roots; however, the root was the major organ for uptake and storage of lead. Thus, lead burden in vegetative tissues should be determined by examination of the entire plant, i.e., roots, stems and foliage. Factors that influenced lead uptake in plants included soil pH, organic matter, soil moisture and climatic effects (7). Moreover, Ter Harr (12) found that a genetic component may also exist in plants which may influence affinity for lead.

Although there is abundant literature on environmental levels of lead generated from many urban and industrial activities, no data are apparently available on levels of lead in and around military or commercial airports. The Air Installation Compatible Use Zone, AICUZ, is a concept designed to provide air bases and airports with environmental impact zoning districts. These zones encompass areas of significant accident potential and noise impact. However, data are needed to extend the concept to include determinations of environmental quality on and around air installations. Many airports, e.g., Peterson AFB, Colorado Springs, Colorado, have a long history of continuous use by both reciprocating and jet aircraft, yet no data are available as to the concentrations of lead generated by aircraft engines. Nevertheless, the flight approach paths to many airports, including those at Peterson AFB, are routinely used for agricultural activities. Concentrations of lead in vegetation and soils are not known in these environments. As more stringent environmental qualities and standards are applied by the Environmental Protection Agency, it becomes essential that the Air Force develop monitoring programs to measure levels of environmental pollutants around air installations.

METHODS AND MATERIALS

Sampling Dates

Soils and vegetation were collected from the USAF Academy and Peterson AFB airports in May and August 1976, respectively. Control samples were collected near the southwest corner (upper Horse Pasture, Pine Valley) of the Air Force Academy in April 1976.

Sampling Protocol

Using a square-foot quadrat, five 0.093 m^2 sites were randomly selected within each of the 10 designated study areas (1 control, 4 USAF Academy and 5 Peterson AFB study areas). Figure 1 illustrates the use of a square-foot quadrat. All vegetation within the quadrat was removed by clipping at the surface level and placed in a paper bag. For each study area, grasses, broad leaves, and shrubs (for five quadrats) were placed in separate bags. Soil samples for each of the five quadrats were taken following the removal of the vegetation and also placed in paper bags. The soil samples were collected, using a porcelain spatula, in 3 cm increments to a depth of either 6 cm (USAF Academy and control) or 9 cm (Peterson AFB). Soil samples were combined by depth and thoroughly mixed for each study area.

Preparation and Analysis of Samples

All samples were dried in a laboratory oven at 50°C for 2 weeks, after which the vegetative samples were ground in a Wiley Mill to pass a 40-mesh screen. One gm samples of vegetation and 5 gm samples of soil were weighed on an analytical balance to the nearest 0.001 gm.

FIGURE 1. SQUARE-FOOT ANALYSIS TECHNIQUE USED FOR VEGETATIVE ASSESSMENT AND FOR COLLECTION OF PLANT AND SOIL SAMPLES.

Samples were transferred to 125 ml erlenmeyer flasks and 20 ml of 50:50 (v/v) concentrated nitric acid and concentrated hydrochloric acid were added to each flask. The flasks were covered with two layers of parafilm and placed in a water bath at 50°C for 1 week. The samples were shaken frequently each day to assure complete mixing and dissolution. The samples were allowed to cool to room temperature and filtered through a Whatman Number 541 filter paper. The flasks and filter apparatus were washed with glass distilled water and the washings added to the filtrate. The samples were stored in plastic bottles at room temperature until analyzed by atomic absorption spectroscopy.

All samples were analyzed using a Perkin Elmer Atomic Absorption Spectrophotometer Model 403. The parameters for the analysis were:

Source:	Hollow Cathode Lead Lamp
Flame:	Air-Acetylene
Wave Length:	283.3 nm - UV
Slit:	4 (0.7 nm)
Function:	Absorbance
Mode:	Peak

Analytical standards were prepared by first dissolving 0.1598 gm of high purity lead nitrate in 20 ml to 100 ml glass distilled water. This resulted in a stock solution of 1000 μg/ml. Dilutions of the stock solution were prepared to make analysis samples of 1, 3, 5, 7, 10, 12, 15 and 20 μg/ml. The Beer's Law plot of these solutions is shown in Figure 2. Each of the test samples were run several times with the standard solutions and the average results recorded.

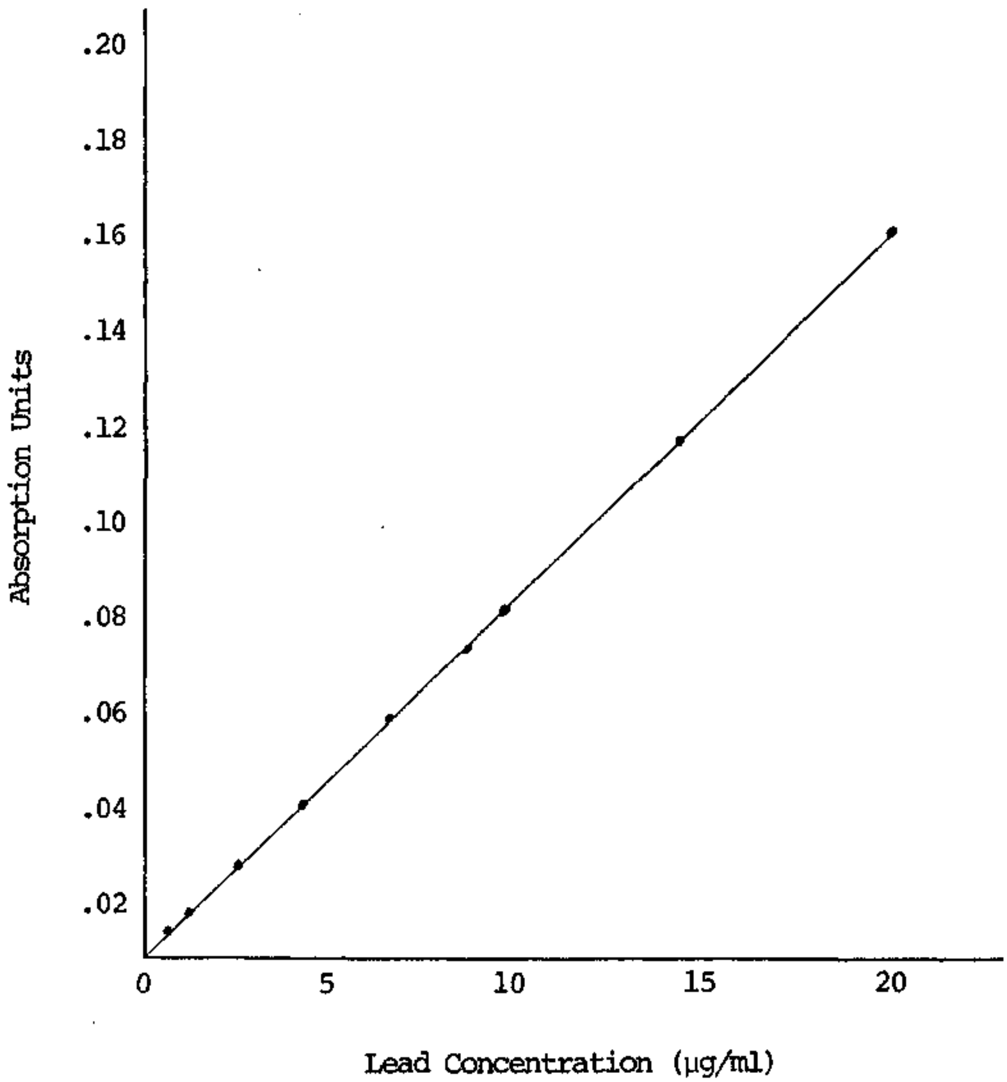

FIGURE 2. BEER'S LAW PLOT OF STANDARD SOLUTIONS OF ELEMENTAL LEAD AS DETERMINED BY ATOMIC ABSORPTION SPECTROPHOTOMETER

RESULTS AND DISCUSSION

Comparisons of aircraft use, i.e., the number of individual aircraft operations or sorties, for Peterson AFB and the USAF Academy airports, are shown in Tables 1 and 2, respectively. The number of aircraft operations at Peterson AFB also include those for the Colorado Springs Municipal Airport since they share the same runways. Although the Peterson AFB airport has had almost eight times more monthly missions than the Air Force Academy, a significant number of those operations probably involved jet aircraft that used non-lead containing fuel. All of the aircraft at the Air Force Academy used 100 octane low lead fuel.

Figure 3 shows a portion of the airfield at Peterson AFB. Figures 4 and 5 show typical vegetation adjacent to the concrete and/or paved runways and taxiways at Peterson AFB and the Air Force Academy, respectively. In general, 8 different grasses, 19 herbs (broadleaves) and 2 shrubs dominated the vegetation at either airport or in the control area. The dominant grasses included blue grama (*Boutelova gracilis*), crested wheatgrass (*Agropyron cristatum*), needle-and-thread grass (*Stipa comata*), and sand dropseed (*Sporobolis crytandrus*). The dominant herbs or broadleaves included fireweed or kochia (*Kochia scoparia*), hairy golden aster (*Chrysopsis villosa*), Russian thistle (*Salsola kali*), sunflower (*Helianthus annuus*), and western ragweed (*Ambrosia psilostachya*). The two shrubs common to all study areas were fringed sagebrush (*Artemisia frigida*) and green sagebrush (*Artemisia canadensis*).

Levels of lead, ppm, for soil and vegetation from all sites for each study area are shown in Tables 3 and 4. It should be noted that

TABLE 1. NUMBER OF JOINT AIRCRAFT OPERATIONS AT PETERSON AFB AND COLORADO SPRINGS MUNICIPAL AIRPORT FOR 1973*

TYPE	NUMBER OF OPERATIONS	AVERAGE PER MONTH
Air Carrier Operations	20,746	1,728
General Aviation Operations	101,663	8,472
Military Operations	86,751	7,230
Total	209,160	17,430

*Source: "Environmental Impact Assessment Report for The Proposed Master Plan Development at Colorado Springs Municipal Airport, Colorado Springs, Colorado," October 1974, Prepared by Isbill Associates, Inc., Airport Consultants and Engineers, Stapleton International Airport, Denver, CO 80207

TABLE 2. NUMBER OF MILITARY (TRAINING) OPERATIONS AT THE USAF ACADEMY AIRPORT FOR 1976*

TRAINING PROGRAM	AIRCRAFT	NUMBER OF OPERATIONS	AVERAGE PER MONTH
Pilot Indoctrination	T-41	13,000	1,083
Soaring	Piper Super Cub	13,500	1,125
Parachute Free Fall	U-4	1,780	148
Total		28,280	2,356

*Source: Airmanship Division, USAF Academy, CO 80840

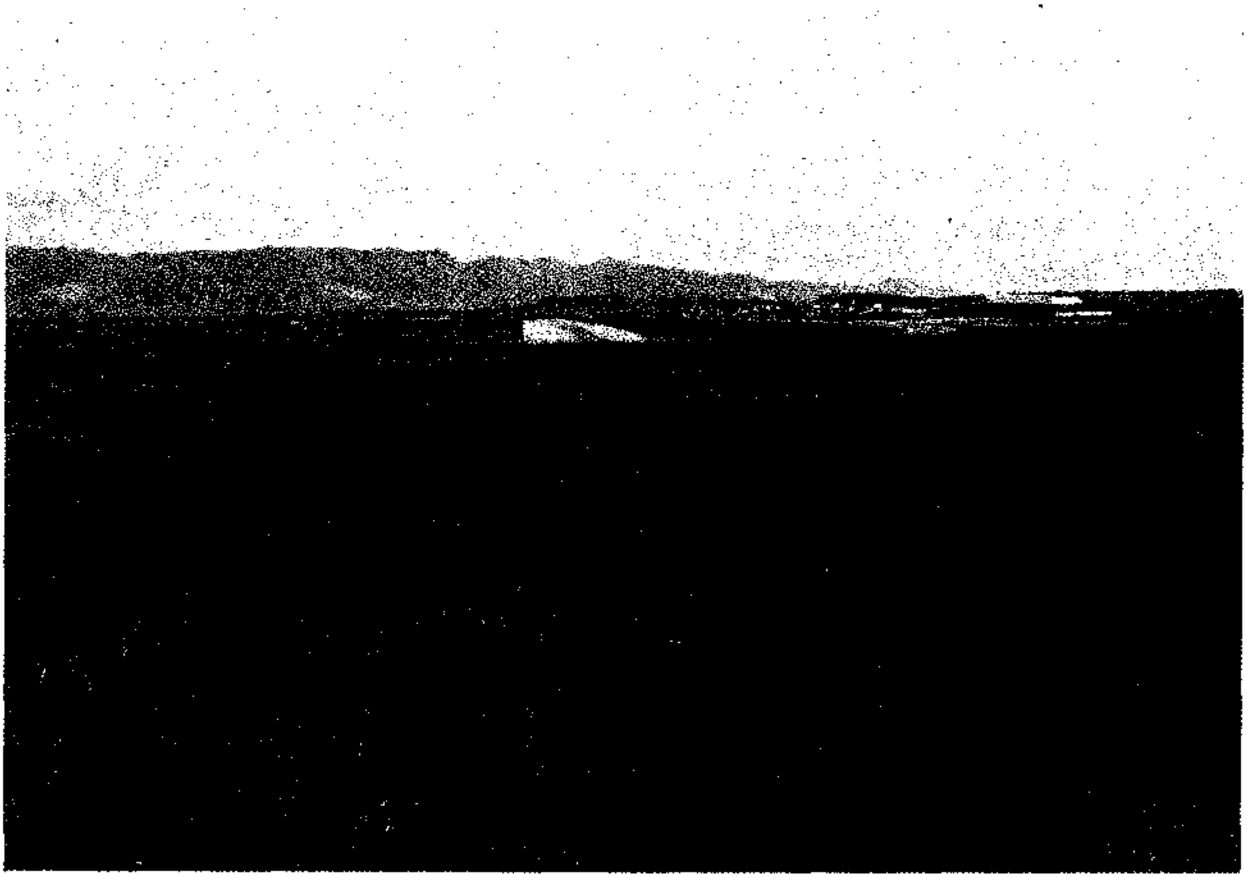

FIGURE 3. LOOKING NORTH FROM SOUTH END OF NORTHWEST-SOUTHEAST RUNWAY (SAMPLING STATION E-5), PETERSON AFB, COLORADO

FIGURE 4. TYPICAL VEGETATION ADJACENT TO THE AIR FORCE ACADEMY AIRPORT. VEGETATIVE COMPOSITION INCLUDES BLUE GRAMA, CRESTED WHEATGRASS, SAND DROPSEED, FRINGED SAGEBRUSH, AND HAIRY GOLDEN ASTER.

FIGURE 5. TYPICAL VEGETATION ADJACENT TO THE PETERSON AFB AIRPORT. VEGETATIVE COMPOSITION INCLUDES BLUE GRAMA, CRESTED WHEATGRASS, NEEDLE-AND-THREAD GRASS, FRINGED SAGEBRUSH, AND GREEN SAGEBRUSH.

TABLE 3. LEVELS OF LEAD (PPM) IN SOILS AND VEGETATION FROM THE USAF ACADEMY AIRPORT. SAMPLES COLLECTED MAY 1976.

COLLECTION SITE	SOILS 0-3 CM	SOILS 3-6 CM	VEGETATION SAGEBRUSH[a]	VEGETATION GRASS[b]
East of New Runway (Midway)	10.0	16.0	10	30
East of Old Runway (Midway)	12.6	11.2	30	ND[c]
North End of Old Runway (Overrun)	10.4	11.2	29	29
South End of Old Runway	10.3	10.0	30	30
Control	2.2	2.6	4.5	2.3

[a] *Artemisis frigida* (Fringed Sagebrush)

[b] Composite samples of *Agropyron cristatum* (crested wheatgrass) and *Boutelova gracilis* (blue grama)

[c] Not determined

TABLE 4. LEVELS OF LEAD (PPM) IN SOILS AND VEGETATION FROM PETERSON AIR FORCE BASE. SAMPLES COLLECTED AUGUST 1976.

COLLECTION SITE	SOILS 0-3 CM	SOILS 3-6 CM	SOILS 6-9 CM	VEGETATION BROADLEAVES[a]	VEGETATION GRASSES[b]
Area Adjacent to Spanish House Recreational Center (E-1)	4.3	2.8	1.0	11.5	60.0
Area Adjacent to Baseball Field (E-2)	1.9	0.9	5.9	60.0	40.0
Area Adjacent to Taxiway near Base Operations (E-3)	5.9	4.7	4.4	40.0	42.5
Area Between N-S and N-W Runways (E-4)	15.5	14.0	12.7	47.0	40.0
Overrun at South End of N-W/S-E Runway (E-5)	9.8	5.9	4.4	1.0	22.5

[a] Composite samples of Salsola kali (Russian Thistle), Ambrosia psilostachya (Western Ragweed), and Chrysopsis villosa (Hairy Golden Aster)

[b] Composite samples of Agropyron crestatum (Crested Wheatgrass), Bouteloua gracilis (Blue Grama), and Sporobolis crytandrus (Sand Dropseed)

all values represented the mean of duplicate or triplicate analyses of each sample.

Soils from the control and Air Force Academy study areas generally contained more lead in the lower increment (3-6 cm) than in the surface increment (0-3 cm). This, however, was not true of the soil samples collected at Peterson AFB; the greatest concentrations of lead were found in the surface increment.

From Table 3, for the Air Force Academy, there was no apparent correlation of lead levels in soil with the age of the runway. Although the new runway was constructed in 1974, samples collected near it had lead levels comparable to those samples collected near the old runway. Vegetative samples from the same areas were similar but contained approximately twice the levels of lead as were found in soils.

In Table 4, the collection sites and soil level of lead corresponded with the distance from the flight line. The Spanish House Recreational Center and the baseball field were approximately one-half mile from the flight line and thus had the lowest concentrations of lead. In addition, the baseball field had recently received additional top soil. The data supported this field observation. The highest soil concentration of lead was found between the active runways. The concentration of lead was 15.5 ppm in the top 3 cm increment and decreased only slightly with depth. This suggested that lead did move in the soil profile. Additional sampling would be required to determine the depth and magnitude of this movement.

In general, the vegetation at Peterson AFB airport, Table 4, accumulated greater levels of lead than were present in the soils. The one exception to this was samples collected at the south end of the northwest-southeast runway (site E-5). This area had been recently reseeded. Whether or not this influenced the lead concentrations in the plants was not determined.

In conclusion, the data indicated that lead has accumulated in soils and plants adjacent to the airports at Peterson AFB and USAF Academy. The magnitude of this accumulation, however, is within the range found in soils and vegetation along highways and near industrial sites. The data support continued studies of the respective airports, and especially studies of indigenous herbivores for possible lead accumulation.

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