Chapter 2

METAL POLLUTION LEVELS IN THE BRICKYARD

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Introduction

The Berkeley Waterfront development project is the subject of great debate at the present time. The debate is primarily about how the land along the waterfront should be utilized. This study deals specifically with the Brickyard, a 28-acre parcel of that land (Figure 1). One of the main concerns is whether to leave the land as open space or to develop it commercially. The purpose of this study is to find out if there is a heavy metal problem at the Brickyard and whether it would affect use of the site.

The land is currently owned by the Santa Fe Land Improvement Company. Both the City of Berkeley and Santa Fe have proposals for the future development of the waterfront. The City of Berkeley proposes to use the Brickyard area to accommodate public access and to increase open space. According to the City, the Brickyard should be a strong focal point for access to the waterfront area and should preserve the view from the City and the waterfront to San Francisco. The Revised Preferred Alternative approved in April, 1986 by the City proposes a restaurant on the upland portion and a nature preserve on the peninsula of the Brickyard. The shoreline open space and the Brickyard Cove Nature Preserve would support the Bay Conservation and Development Commission's (BCDC) two primary objectives: protection of Bay resources, and maximum public access to the shoreline (Wakeman, 1985, pers. comm.).

This study analyzes metal pollution in the soil at the Brickyard and compares it with the metal pollution found in vegetation at two Bay Area salt marshes, Emeryville Crescent and Tomales Bay (Kaplan, 1984). From results of soil sampling, the effect of metal emission from traffic along Highway 80 and the correlation of lead content with the distance from the highway can be analyzed.

Site Description

The Brickyard is an interestingly shaped 28-acre parcel of land (Figure 1) composed of fill placed in the early 1950's (Hall et al., 1983). It is located on the southwest corner of the intersection of University Avenue and Frontage Road in Berkeley. The Brickyard was not utilized as a refuse landfill area; the fill is largely a heterogenous mixture of concrete and brick rubble and clayey soils. The thickness of fill is 20 feet in the westerly portion, and it is estimated to vary littlr over the remainder of the site (Hall et al., 1983). A prevailing wind blows from the south, west and southwest. The wind is heaviest during the sumer months (Robinson, 1982). At low tides the Brickyard is bordered by an extensive mudflat that provides a feeding area for shorebirds.

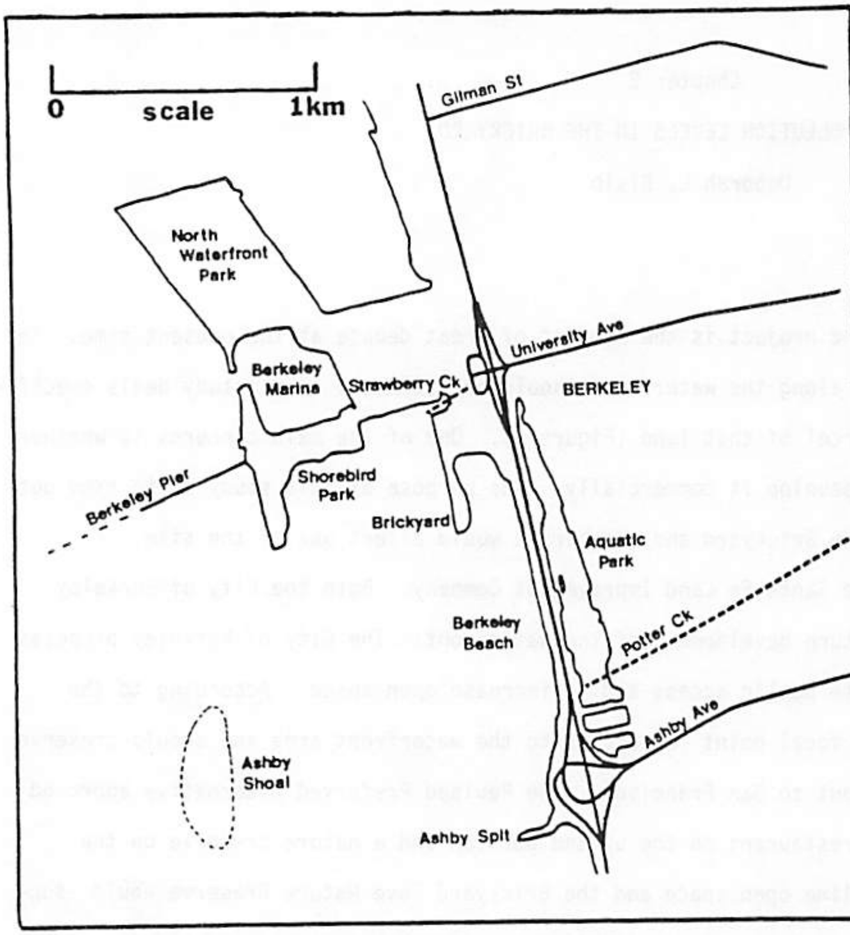

Figure 1. Location of the Brickyard.
Source: Sloan, 1982, p. vi.

Most of the Brickyard is flat and lies approximately three meters above the Bay (Robinson, 1982). Much of the area was covered by rubble consisting of old bricks and miscellaneous trash. Until recently the peninsula was colonized by weeds, grasses and broadleafed plants, including thistles, mustard, curly dock and fennel (Robinson, 1982).

In August, 1985 the Brickyard was bulldozed and rototilled. Trucks came in and out approximately ten times a day transporting soil. The Brickyard is used as a storage facility for soil until it is sold. Hence, much of the soil has been moved around and trampled over. The major portion of the native vegetation on the upland area has been rototilled into the soil.

Past Work

The Brickyard area has been the topic of various reports by UC Berkeley students, including a zoning study (Hagman, 1982) and a history of the Brickyard (Robinson, 1982). The City of Berkeley and Santa Fe Railroad have both studied the future status of this area (Roma, 1985; Hall *et al*., 1983).

Seismic and geologic surveys have been done for Santa Fe (Hall et al., 1983), but no soil testing, to my knowledge, in the Brickyard. The City has, to date, not done any soil testing at the Brickyard (Reynolds, 1985, pers. comm.).

Many studies have shown that automotive traffic contributes heavy metals to roadside ecosystems (e.g., Yousef et al., 1985; Caltrans, 1977; Page et al., 1971), but evidence in the Bay Area is lacking. For example, Page and others (1971) found that 5000 vehicles produced only minor lead in the soil, but that 35,000 vehicles influenced the lead content in the soil to a great extent. Specifically, 16 micrograms of lead per gram (μg/g) were present in roadside grass near a highway with a traffic density of 32,000 cars per 12 hours. The direction of the prevailing wind also had a significant effect on the lead content. Lead levels in plants on the leeward side of the highway exceeded those in similar plants on the windward side.

Most studies of the connections between soils and their heavy metal content have focused on the chemical forms and mobility of the metals and their availability to the food chain. These studies further indicate that the metals cause a range of problems in crop, animal and human health. In large concentrations, many of the metals may be toxic to plants and/or animals, or may affect the quality of foodstuffs for human consumption (Lepp, 1981). The accumulation of heavy metals through the soil-plant-herbivore-carnivore food chain, resulting in increased concentrations and effects, is well documented (Lepp, 1981). The effects on soil and plants of potentially toxic elements have also been studied: they include cadmium (Ganje and Page, 1974), copper (Pendias-Kabata and Pendias, 1984), lead (Singer and Hanson, 1969) and zinc (Collins, 1981).

Background

Metals in Soils

Metals occur as natural constituents of the earth's crust, and are ever-present constituents of soils and living matter (Lepp, 1981). Several of the metals are essential to the functions of living organisms, others appear to interact with living matter only in a toxic manner, whereas a decreasing number do not fall conveniently into either category.

Once the metals have been taken up by the plants, they may help or hurt the plant, depending on the metal. The survival of a species might be threatened as a function of the metal concentration contained in the soil. Common effects of metals include impairment of photosynthesis, impairment of growth, and chlorosis (Lepp, 1981). Uptake, toxicity and deficiency of the four metals that are the subject of this study will be considered here.

Cadmium - Cadmium is a naturally-occurring element present in all soils in at least trace quantities. It is one of several trace metals existing in nature in small quantities that have no known value and are capable of producing a toxic effect (Oehme, 1979). Cadmium is relatively mobile in some soils and may be redistributed due to leaching both down the soil profile and between neighboring soils (Page et al., 1981). Plants take up more cadmium under acidic conditions and when soil cation exchange capacity is low (Page et al., 1981). Varieties within plant species also show substantial difference in the cadmium absorption characteristics.

Copper - Copper deficiency interferes with growth, reduces seed production, and it may suppress flowering (Pendias-Kabata and Kabata, 1984). Therefore, if copper were very deficient in a species, the deficiency might harm the future generations of that species. Problems of copper excess may arise from a variety of causes. Copper toxicity in plants is generally manifested as a general chlorosis and stunting of growth.

Lead - Reduced rates of photosynthesis and reduced shoot growth are observed with an increase in soil lead concentrations (Lepp, 1981). Lead is available to plants from soil and aerosol sources. The largest source, by far, of lead emission to the atmosphere in California is the exhaust of motor vehicles powered by gasoline containing lead additives; between 50 percent and 80 percent of the lead contained in the fuel is emitted from the exhaust system of automobiles (Yaffe and Winkelstein, 1979). Plants growing near highways are usually exposed to more lead than at most other locations (Zimdahl and Hassett, 1977). The content on plant leaves of aerosol lead particles from automobile exhaust has been well documented (Zimdahl and Hassett, 1977). The uptake into plant cells of such lead has been a source of much controversy. Deposition is dependent upon the characteristics of the leaf surface as well as wind speed and other environmental conditions. Most lead accumulation is limited to a narrow zone within 30 meters of a highway (Page et al., 1981). In general, lead in and on vegetation on the east side of freeways was greater than that on the west side of freeways--probably due to prevailing winds from the west (Page et al., 1971).

Zinc - Zinc is a nutrient on which plants depend. Both a deficiency and an excess of zinc can harm plants (Collins, 1981). It is now known that zinc plays an important role in protein synthesis, and metabolism of hydrates, nucleic acids and lipids. In addition, zinc plays an active role in plant enzymes. Zinc is also known to form stable complexes with DNA and RNA. An inadequate supply and an excess of zinc results in chlorosis and stunted growth.

Methods

Soil analysis was done on the southwest corner of the Brickyard (Figure 2) for two reasons: first, because this corner is closest to Highway I-80 (10 meters away), and second, because all the other areas have been extensively bulldozed. Soil samples taken in these bulldozed areas would be irrelevant for determination of soil contaminants at the surface.

Soil was collected late in September before the first heavy rain had occurred (to prevent contamination by surface runoff from the highway). The soil was collected along five transects, at distances of three to thirty meters from the Frontage Road (Figure 3). Four to six kilograms of soil, from the upper five to seven centimeters, were taken at each site.

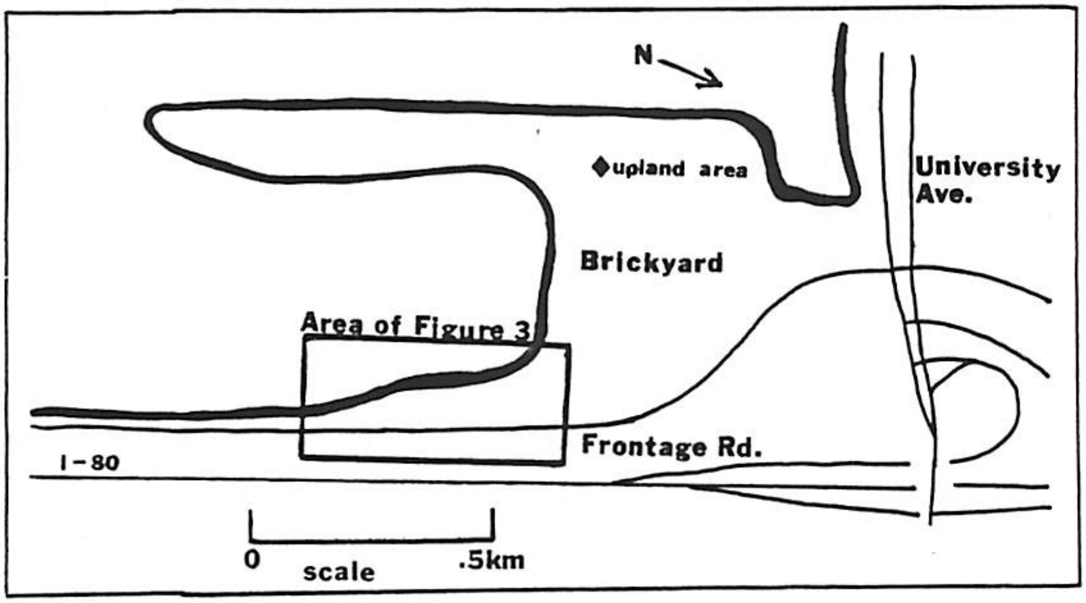

Figure 2. Brickyard Area.
Source: Chan, 1982.

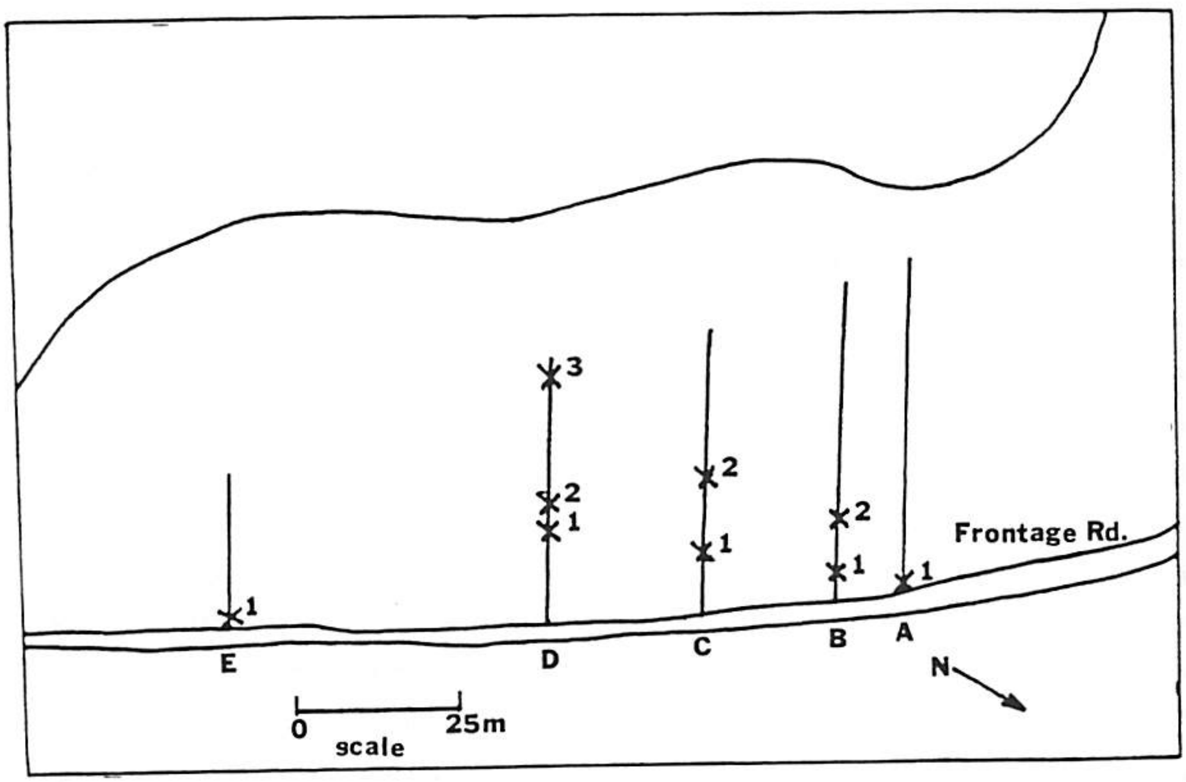

Figure 3. Locations of Sample Sites at the Brickyard.

The samples were then prepared to remove all the organic matter. Samples were sieved and digested with 4-normal nitric acid (prepared by combining 750 milliliter (ml) of water with 250 ml of 70 percent nitric acid) according to the procedure in Ganje and Page (1974). I would like to thank Professor Harvey Doner for all his help with the digestion procedure. Next, 1 to 3 ml of each sample, depending on the metal to be tested, was mixed with 50 ml of distilled water and tested for metals with a Perkin-Elmer 360 Atomic Absorption Spectrophotometer to determine concentrations of each metal. A machine error of 10 percent is possible (Morrison, 1986, pers. comm.). I would also like to thank Tom Morrison for his extensive help in using the Atomic Absorption Spectrophotometer.

Results

Concentrations of each of the four metals in the samples are shown in Table 1. Cadmium concentrations range from 0.414 to 2.96 parts per million (ppm). The copper concentrations range from 7.11 to 46.8 ppm. The zinc concentrations range from 42.6 to 95.4 ppm, and the lead concentrations range from 34.6 to 270 ppm.

Few trends are evident in the data. Some, but not all, metal concentrations decrease with distance from the road. For instance, this pattern is shown by lead concentrations in Transects B and C. In addition, this pattern is also shown by copper concentrations in Transects B and D. With respect to cadmium concentrations, the pattern is shown only in Transect B. Finally, no patterns emerge for zinc concentrations; they increase and decrease randomly. Transect E was a pure sand sample and has the lowest values for all metals.

Discussion

With the exception of cadmium and lead concentrations, the soil samples at the Brickyard area are relatively uncontaminated in comparison with the levels of metals in uncontaminated soils (Table 1). Almost all of the cadmium levels were higher than in the uncontaminated soil. However, as much as 30 ppm of cadmium have been observed in non-polluted soils derived from Monterey shale in the coastal ranges in Southern California (Page et al., 1981). The majority of the lead levels in the Brickyard are not higher than those of uncontaminated soils. Levels of copper and zinc in the Brickyard are well within the range of uncontaminated soils. Hence there would be no danger of a deficiency or an excess of copper or zinc.

A comparison of this study's findings on the west side of the freeway with lead levels on the east side of the freeway at Aquatic Park (see paper by Janet MacDonell, this report) shows that, in general, lead in and on vegetation on the east side of the freeway was greater than that on the west side of the freeway. This is a good example of the effect of prevailing winds on lead levels along a freeway.

In comparison with metal levels in the salt marsh plants at Emeryville Crescent and Tomales Bay (Kaplan, 1984), the levels at the Brickyard are all much higher. The cadmium levels in the soil are

		Distance From Road (m)	Zinc	Cadmium	Copper	Lead
			Concentration (ppm dry wt)			
I.	Transcect A					
	Sample 1	3	84.3	1.02	29.8	181.0
	Transect B					
	Sample 1	7.5	68.4	1.39	16.2	199.0
	Sample 2	13.5	95.4	0.840	46.8	123.0
	Transect C					
	Sample 1	9.1	91.8	0.747	29.0	270.0
	Sample 2	18.3	90.6	0.801	27.2	154.0
	Transect D					
	Sample 1	13.5	72.9	1.83	43.5	100.0
	Sample 2	18.3	95.4	0.852	21.3	199.0
	Sample 3	36.6	63.9	2.96	26.3	129.0
	Transect E					
	Sample 1	3	42.6	0.414	7.11	34.6
II.	Tomales Bay Pickleweed		30.52	0.167	6.87	0.0
	Tomales Bay Salt Grass		15.06	0.143	5.34	0.0
	Emeryville Crescent Pickleweed		12.71	0.424	7.41	0.0
	Emeryville Cresent Salt Grass		16.17	0.480	6.79	0.0
III.	Uncontaminated Soil		10-300	.01-.7	2-200	2-200
	Uncontaminated Plant Tissues		15-200	.1-5.0	4-15	.1-10

Table 1. I. Concentrations of heavy metals in the Brickyard soils (this study). II. Concentrations of heavy metals in salt marsh plants (Kaplan, 1984). III. Elemental Composition of Typical Uncontaminated Soils and Plant Tissues (Freedman and Hutchinson, 1981)

approximately three times the levels found in the plants. In addition, the cadmium level in the soil exceeds the uncontaminated soil range, whereas the levels in the plants fall into the range for uncontaminated plant tissue (Table 1).

No lead was found in the plants at Tomales Bay and Emeryville Crescent salt marshes (Kaplan, 1984). This result is unexpected because Emeryville Crescent is also very near Highway I-80, and one would expect lead concentrations to be close to the levels found at the Brickyard. Kaplan states that her lack of lead findings is probably due to procedural problems with the lead analysis, and this author would agree.

The copper and zinc levels in the soil, as compared to the levels found in the plants, are five and three times higher, respectively. The copper and zinc levels for both soil and plants fall into the uncontaminated ranges. No comparison can be drawn about lead levels between the soil and the plants because no lead was found in the plants.

Recommendations

The Brickyard is of major importance in the Berkeley waterfront development plans because of its location. Designating the Brickyard as a nature preserve would also establish an important buffer between any upland activity areas and the environmentally-sensitive intertidal mudflats of the Brickyard Cove. This paper assumes that the Brickyard will be utilized as a nature preserve. If it were made into a parking lot or a hotel, it really would not matter how polluted the soil was because it would be covered.

The purpose of this study was to identify any heavy metal problems, and to see if they would affect the use of the site. The only problems that this study found were the levels of cadmium and lead in the soil at the Brickyard. The nature preserve is proposed to be built on the Brickyard Peninsula, which is 90 meters from the Frontage Road. Since the lead contamination level drops off very fast with increasing distance from the road, the nature preserve should not have a lead pollution problem. In comparison with the standards used for uncontaminated soils (Freedman, 1981), cadmium was found to exceed the values. There doesn't seem to be a rigid standard for excessive cadmium content in soil. The Environmental Protection AGency (EPA), a federal agency, has no standards, to my knowledge, for cadmium in soil. It would be helpful if the EPA were to set a standard to assess how much cadmium would be acceptable in the soil.

If the City of Berkeley or Santa Fe wanted to be sure that metal pollution levels would pose no problems to the nature preserve, I would suggest further soil analysis of the soils and plants of the Brickyard area.

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