

Chapter 7

TESTING OF HEAVY METALS IN THE SEDIMENTS OF THE SOUTH RICHMOND SHORELINE

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Introduction

Growth in the Bay Area is occurring at a rapid rate. The consequences of this growth are manifold, a major one being the increase of development to provide for the larger population. Another consequence is higher levels of pollution which, by their threat to human health, are a deterrent to development. Heavy metals are a major form of pollution, as they are released from the processing plants of many industries. Along the South Richmond shoreline, there is a possibility of pollutants contaminating the sediments because of current and past industrial uses. As the city of Richmond is presently considering setting aside part of this shoreline for recreational uses, a determination of the heavy metal levels could shed light on whether these lands are safe for such a use (South Richmond Shoreline Special Area Plan, 1977). It is important to make sure that land is safe for people even when growth entails a great demand for this land.

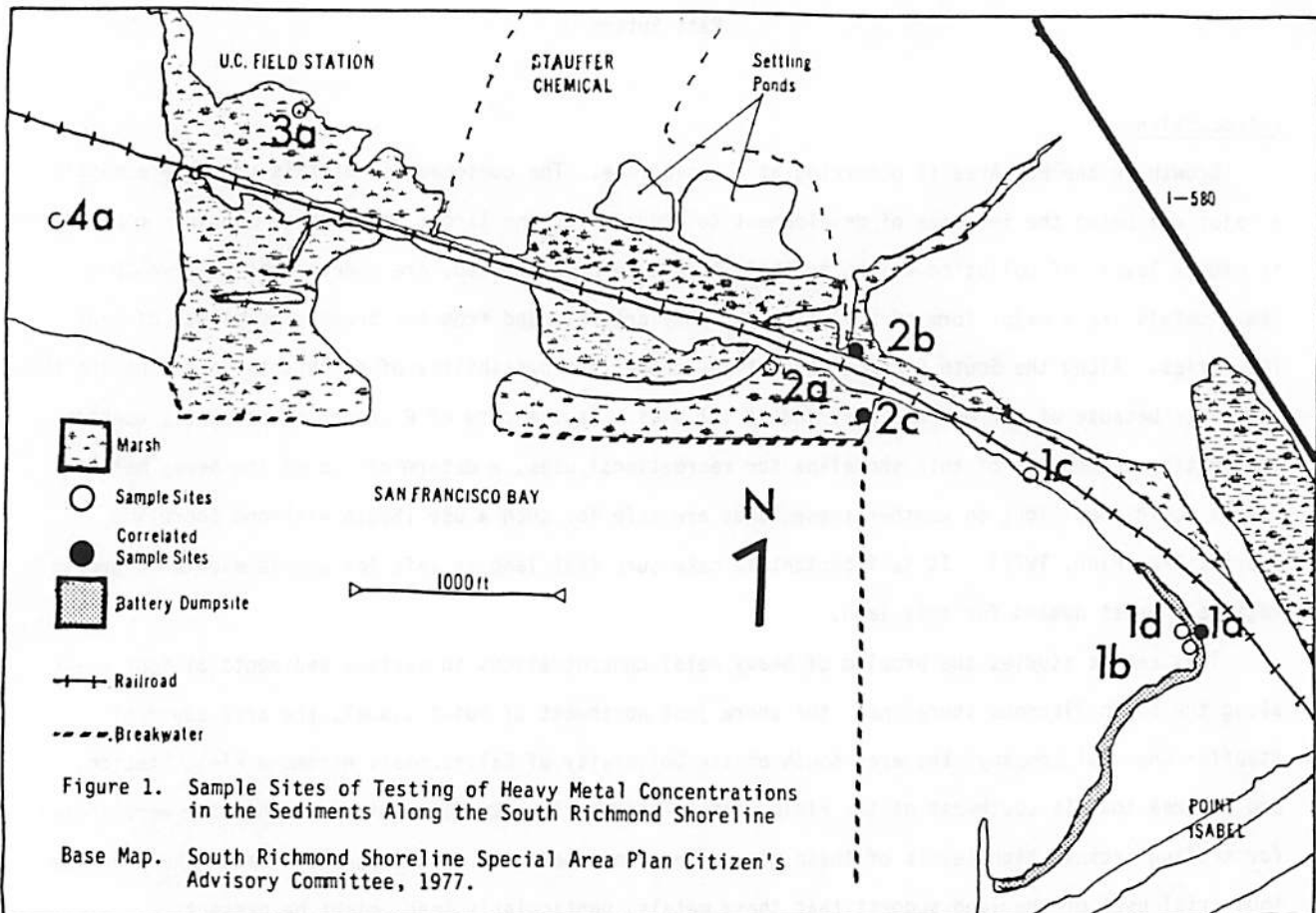
This report studies the problem of heavy metal concentrations in surface sediments at four areas along the South Richmond shoreline: the shore just northwest of Point Isabel, the area south of Stauffer Chemical Company, the area south of the University of California's Richmond Field Station, and an area that is southwest of the Field Station (Figure 1). Lead, cadmium and chromium were chosen for testing because high levels of these metals have toxic effects on humans and because the previous industrial uses of the land suggest that these metals, particularly lead, might be present.

Present land use proposals would affect all four of the areas being studied. Santa Fe Land Improvement Company owns the section of the shoreline just north of Point Isabel. The city of Richmond would like to turn this land into a park (Hall et al., 1986). In the early 1950's dumping of solid wastes occurred at this site (Thomas, 1982). In 1982, battery cases reportedly were lying on the shoreline just north of Point Isabel. These batteries have now been cleaned up and placed in a pit on the northeastern part of Point Isabel (Siri, 1986, pers. comm.).

The area just south of the Stauffer Chemical Company's plant is also being considered for recreational use (Hall et al. ., 1986). This plant has a treatment pond that discharges effluents into the Bay. This site is a possible cause of contaminated deposition to the soil from either air or water pathways.

The College of Engineering wants to create a campus that is appropriate for high technology instruction at the University of California's Richmond Field Station (University of California, 1986).

Previously, the land was used for a gunpowder plant and was classified as a hazardous waste site by the EPA (Siri, 1986, pers. comm.). These various industrial uses of this shoreline may be the cause of heavy metal contamination. If the contamination is severe, then using this region for recreation may be unwise.



Past Studies

Besides the report by Thomas (1982) on the levels of lead from the battery cases dumped north of Point Isabel, there have been several other studies concerning the South Richmond shoreline. Machado (1985) did an analysis of the pH and salinity in soils at the Hoffman Marsh, and Oddi (1982) conducted an ecological analysis of Hoffman Marsh. A study of heavy metals in the sediments around San Francisco Bay was made by the USGS (Peterson, 1982). Randolph (1980) also performed tests on heavy metals in sediments in San Pablo Bay. There have been several other reports on heavy metals in soils and sediments around San Francisco Bay (e.g., Bisio, 1986; MacDonell, 1986).

Toxic Heavy Metals

Cadmium, chromium and lead are toxic heavy metals that are used in industry. Exposure to high levels of any of these metals can be fatal to humans. Heavy metals may accumulate in areas near industrial operations that utilize these metals or at former industrial sites.

Lead

Although many heavy metals have toxic effects on humans, lead is one of the most notorious threats (Coleman and Piotrowski, 1980). About 45 percent of all lead produced is used in batteries. Another 15 percent is used in chemical products, 7 percent in alkyllead fuel additives, and the rest in metal products. Lead is especially abundant on the surface of soils because much lead is emitted from car exhaust and industrial sources. In fact, about 450,000 tons per year is released from these sources. The average level of lead in soils is 20 ppm (dry weight). Lead in soils occurs at much higher levels than average near refining plants. Thus, in areas near sources of lead emission, the level of lead in soils can be high.

High levels of lead intake in humans is a cause for concern. Children are susceptible to lead intake because of their affinity for putting their hands in their mouths (Sittig, 1985). Lead reaches the human through his diet and exposure to airborne dust particles (Coleman and Piotrowski, 1980). This lead is deposited in all the tissues of the body. Thus, toxic levels of lead intake may degrade many parts of the body. Cerebral injury affects concept formation, learning ability, and fine motor function. Renal impairments include gradual atrophy of kidneys. The gastrointestinal and cardiovascular systems are also affected by lead intake. In urban areas, lead in the blood of humans is about 30 micrograms per day per liter. It is thought that at about 50-100 micrograms per day per liter brain damage will occur.

Cadmium

Although cadmium does not have the same bad reputation as lead, it is still known for its potential toxicity, and its level in soils should be monitored. Cadmium is very soluble in many compounds (Iimura, 1980). It is used in electroplating (35 percent of cadmium produced), in pigments (25 percent), and in plastic stabilizers and nickel cadmium batteries (40 percent) (Elinder, 1985). Its occurrence in soils is about 1 ppm (dry weight). Worldwide, about 17,000 tons of cadmium were produced annually in the 1970's. Most of the cadmium in soils is released by industry as a by-product in the production of zinc, copper and lead (Elinder, 1985). Other sources of cadmium pollution include refuse incineration, disposal of pigment and plastic stabilizers, phosphate fertilizer, and sewage sludge (Coleman and Piotrowski, 1980). Cadmium, like lead, occurs in high concentrations near industry.

Cadmium is known to be toxic to humans, and thus is a cause of concern when it reaches high levels in the environment. Cadmium affects humans through inhalation, from which 25 percent of cadmium

present in air enters the body, and ingestion, from which 3-8 percent of cadmium present food enters the body (Coleman and Piotrowski, 1980). Most of this cadmium is concentrated in the liver and kidney. It has a half life of ten years. When cadmium reaches a concentration of 100-300 micrograms per gram (wet weight) in the body, it causes damage, although the average levels of intake are well below this. Excessive levels of cadmium cause damage to the kidneys. Cadmium may be a rare element, but when it concentrates in humans it is very harmful.

Chromium

Chromium is a rare element, but it is nevertheless an important metal (Sittig, 1980). It occurs in nature in many different compounds, some of which accumulate in sediments readily. Others don't accumulate as readily because of their water solubility (Sittig, 1980). Chromium salts are used in metal finishing, much of which is used on car bumpers. Other industrial uses are for cleaning, for cooling waters, and for manufacturing leather and clothing products. It is also used in pigments. Chromium's average natural abundance is 125 ppm in the continental crust (Sittig, 1980). Most of its non-natural occurrence results from industry, which produced 320,000 metric tons in 1972 in the United States alone.

Chromium enters the body through the normal processes of inhalation, ingestion, and skin contact (Sittig, 1985). It produces the greatest toxicity when it is in certain chemical compounds. Its most toxic effects are its corrosive actions on the skin, breathing tracts and on the veins that carry blood through the body. Some symptoms of excessive intake in humans are headaches, coughing, wheezing, fever and loss of weight. A more alarming effect has been revealed in studies that indicate a higher rate of lung cancer in chromium-producing workers. Needless to say, chromium contamination poses a threat to humans.

Methods

To collect samples for heavy metal analysis, I chose four areas that would give a good geographic distribution over the total study area (Figure 1) but that were also likely to be affected by industrial impacts. I took a total of nine samples, four samples on the shoreline just north of Point Isabel, three samples near Stauffer Chemical Company, one near the Richmond Field Station and one about 100 yards southwest of the Richmond Field Station (Figure 1). Of these nine samples, four (1a, 2b, 2c, and 3a) were taken near pickleweed plants. Sites 1a, 2b, and 2c correspond closely to sites sampled by Chase-Dunne (this report), who studied levels of cadmium and lead in pickleweed plants in the same study area. The purpose of this overlapping in sampling was to investigate generally how levels of heavy metals in sediments compare to those in plants. In addition, two of the Point Isabel sites correspond closely to sites reported by Thomas (1982). A fence blocking access to most of the area where the original sampling for lead content in soils had occurred prevented further sampling at Thomas' sites. Each sample consisted of 400-600 grams. Samples were taken at depths varying from the

upper 2-5 centimeters of sediment to about 10 centimeters. Because concentrations of metals may vary with the depth of the sediment (Linzon et al., 1976), this inconsistency in sampling could lead to some erroneous results. After collection, the samples were stored in plastic bags and placed in a freezer.

The samples were dried in an oven at 80°C and then digested with 35 milliliters (ml) 4N nitric acid. Once digested, the samples were diluted with 15 ml of distilled water to make 5.7N nitric acid. Each sample was filtered to remove the soils, and 5 ml portions were placed into three vials, one for each metal. In order to obtain readings on an Atomic Absorption Spectrophotometer, lead and chromium had to be diluted so that they would be at low enough concentrations to be detected by the machine. The chromium samples from sites 1d and 2a and the lead sample from site 2a were spilled during the procedure and were not analyzed. All of the other samples were tested using a Perkin-Elmer Atomic Absorption Spectrophotometer. A 10 percent error is expected with this method. However, other difficulties in taking readings from the spectrophotometer could also cause significant errors. In addition, large errors might result if the sediments weren't completely digested.

Data

As might be expected given the differences in sediment types and properties of the individual metals, the levels range widely and show few consistent trends (Table 1). Lead ranges from 24.7 ppm to 280 ppm with an average value of 125 ppm. Cadmium ranges from 0.90 ppm to 4.65 ppm and has an average value of 2.22 ppm. Levels of chromium are from 8.93 ppm to 17.87 ppm, and their average value is 11.68 ppm. The highest levels of lead, cadmium, and chromium are 280 ppm at site 1a, 4.65 ppm at site 2a, and 17.87 ppm at site 4a, respectively.

The concentrations of these metals exhibit only minor trends. There is wide variability of lead levels at sites within each area, but no trends between areas. Average metal concentrations in sediment samples taken near plants as compared to those taken away from plants are the following: 18.15 ppm to 6.81 ppm for lead; 2.09 ppm to 2.41 ppm for cadmium; and 12.00 ppm to 11.25 ppm for chromium. Thus average levels of lead are much higher in samples taken near plants in this study. Cadmium doesn't exhibit any such trends, but the concentrations are higher at site 2 than at sites 1 and 3. Chromium shows higher than average concentrations at sites 2 and 3 and lower than average at site 1. Both cadmium and chromium exhibit lower levels near Point Isabel (Figure 1, area 1). Other than this, there were no trends in relation to the shoreline or inland from the shoreline.

Discussion

Lacking any consistent distribution, these results do not point to any one source as being responsible for higher levels of these metals. In fact, none of the results for any of the heavy metals tested were near levels considered excessive (Table 2). All of the concentrations of metals derived from the sediment samples, except cadmium, fall below the normal concentration in soils. This

Metal Concentration (ppm)			
Site	Pb	Cd	Cr
Sediments			
1a	280	1.33	8.93
1b	50.2	2.99	7.90
1c	110	0.90	7.98
1d	24.7	1.67	ND
2a	ND	4.65	ND
2b	102	2.27	16.05
2c	147	3.22	12.67
3a	193	1.53	10.84
4a	37.5	1.43	17.87
Plants			
A.5	37.4	1.9	
A.3	52.8	2.2	
A.4	46.5	2.2	

Table 1. Concentrations of heavy metals in sediments and plants (sites A.3, A.4, and A.5 are from Chase-Dunne this report) on the South Richmond Shoreline (ppm by dry weight).

ND. Samples were spilled during the procedure.

might be because levels in sediments tend to be lower than those in the metropolitan soils that these values were based on (Linzon et al., 1976), but it could also be the result of other influences than soil characteristics. In any case, there isn't much cause for concern over these levels (unless they are increasing over time), although it is possible that due to experimental error the actual concentrations are much higher than those reported here.

Metal	Average Concentration (ppm) 0-2.5cm	Excessive Concentration (ppm) 0-5cm
Cd	2.3	10
Pb	292	600

Table 2. Average and excessive concentrations of cadmium and lead in metropolitan soils (in top 2.5 and 5 cm of soil).

Source: Adapted from Linzon et al., 1976 Tables 2,3).

Before any serious consideration can be given to the results and the significance of the levels of concentration, the reliability of the data must be considered. This is a definite concern in this

study, as the average levels of cadmium and lead tend to be lower than would be expected, given normal concentrations in soils (Table 2). Another factor that leads to questioning of the results is a correlated study by Chase-Dunne (this report) in which she tested for levels of cadmium and lead in plants within the same study area that I used. She found higher cadmium concentrations in one of her plant samples (A.5) than I found in my correlated sample (1a) (three sample points had a very close correspondence in location) (Figure 1, Table 1). Her data also differ regarding the relative concentration of each metal. In my study lead is higher in 1a than 2b, but in her correlated samples this relationship is reversed.

The inconsistency between my results and those of Chase-Dunne, and the low levels of cadmium and lead, raises questions about the reliability of my results. Although I followed standard procedures, I may have lost lead in some of the dilutions, but only enough to affect the results by a few percentage points. As this in itself would not account for its low level, it is possible that I used improper methods in taking readings from the spectrophotometer. However, if the data are accurate, then potential problems from previous contamination at Point Isabel aren't very serious, but contamination from Stauffer Chemical's outlet may be of concern.

With this uncertainty regarding the accuracy of the data it is hard to reach any definitive conclusions. Assuming that these results are correct, it is interesting to consider what sources or processes are responsible for the variation in data. Cadmium exhibited a high level near an outlet channel from Stauffer Chemical's settling ponds (Site 2a, Figure 1, Table 1). There seems to be a source causing higher chromium levels near Stauffer Chemical and the northern part of the study area. Although lead tends to be at higher concentrations near plants, it is difficult to guess what might be causing this. None of these metals occur in such high concentrations that they indicate an obvious source.

The low levels of lead near Point Isabel where the batteries were once dumped are encouraging, considering the excessive concentrations reported by Thomas (1982). This indicates that the clean-up efforts that went into effect after his study succeeded in reducing the lead concentrations in the soil to safe levels. However, the high level of lead at site 1a suggests that there might be portions of the shoreline that are still contaminated.

Conclusion

This study does not confirm the fears of those who are concerned that the soils in this area may be too polluted for recreational use. There was only one site that conflicted with this assessment (Site 1a), but levels near Stauffer Chemical Company's plant suggest that heavy metals are deposited in the effluent in higher concentrations than in nearby soils which are unaffected by effluent deposition. Perhaps more attention needs to be paid to monitoring levels of heavy metals in Stauffer's effluent. The other soils tested in this study do not seem to contain dangerously high levels of

contaminants if the data are accurate. This finding presents evidence that this land would be suitable for usage which allows public access, such as the recreational usage currently proposed.

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