

Division of Science, Research and Technology

Research Project Summary

December, 2008

Chromium Exposure and Health Effects in Hudson County: Phase I

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Introduction

During much of the twentieth century, Hudson County, and particularly Jersey City, was one of the world centers of chromate production from chromite ore. The slag and waste products from this production referred to as COPR (chromite ore processing residue) was disposed in various locations and given away *gratis* for fill, berms etc. This resulted in a legacy of approximately 200 COPR waste sites in Hudson County. COPR contains variable amounts of hexavalent chromium (Cr^{+6}) as well as trivalent chromium (Cr^{+3}). Cr^{+6} is a known human inhalation carcinogen (USEPA, 1998). Recent evidence indicates that it is also an ingestion carcinogen (NTP, 2008). Because of its carcinogenic potential, Cr^{+6} is the substance of greatest concern in COPR. Studies conducted in Jersey City by the NJDEP Division of Science, Research, and Technology in collaboration with the Environmental and Occupational Health Sciences Institute (EOHSI) in the 1990s showed that houses located adjacent to known COPR waste sites had elevated levels of total chromium (Cr) in their household dust (Lioy et al., 1992; Freeman et al., 1997). These studies also showed that total Cr in household dust was associated with increased levels of Cr in urine particularly in young children (Stern et al., 1992; Freeman et al., 1995; Stern et al., 1998). These results demonstrated that residing near a COPR waste site could lead to internal (systemic) exposure to Cr in the residential environment that was associated with waste from those sites. It was also shown that following the remediation of COPR sites adjacent to residential locations, the levels of Cr in the house dust declined to background levels (Freeman et al., 2000). This finding provided some assurance that the remediation process had effectively addressed the potential for residential exposure to COPR. Nonetheless, the Jersey City community remained concerned that exposure to Cr^{+6} from COPR was continuing as a result either of incomplete remediation of known sites (e.g., ineffective capping of sites), or the presence of as-yet-undiscovered COPR sites. Therefore, at the request of the community, then Commissioner Campbell instructed the Division of Science, Re-

search, and Technology to undertake a study to revisit the potential for Cr^{+6} exposure from COPR in Jersey City.

This study was designed to be similar to the earlier studies that investigated the occurrence of chromium in household dust. This study differed significantly from the previous studies, however, in focusing on Cr^{+6} , the toxic component of COPR. In the previous studies, it was not possible to accurately measure Cr^{+6} in dust samples and total Cr ($\text{Cr}^{+6} + \text{Cr}^{+3}$) was measured.

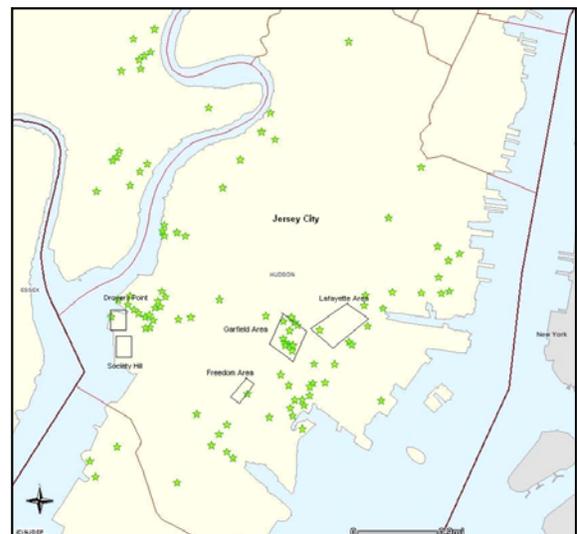


Figure 1

Methods

Site Selection

Five neighborhoods in Jersey City were identified for study. Two, Droyer's Pt., and Garfield Ave., were selected because they had residences adjacent to capped COPR sites. Three additional neighborhoods in proximity to COPR sites, Freedom Pl., Lafayette and Society Hill were identified on the basis of community concerns expressed at public meetings. These locations are shown in Fig. 1. In addition,

residents from diverse locations in Jersey City requested sampling of their homes. Since these locations did not constitute a specific neighborhood, they were grouped into an “other” category.

Dust Sample Collection

Dust samples were collected from three locations in each house. Side-by-side samples were collected from each location. Where feasible, samples were collected from a window well, a living area (e.g., living room, bedroom dining room), and the basement. Side-by-side samples were collected to allow assessment of sampling and analytical variability. Surfaces sampled in each household location were selected on the basis of adequate dust loading and an adequate surface area. Most samples (71%) were collected using a standardized apparatus that applied uniform pressure over a uniform area (the LWW sampler). When this method was not feasible due to uneven surfaces or excessive dust loading, samples were collected by a freehand wipe or by a brush. When the Cr⁺⁶ concentration of any sample exceeded 10 µg/g (parts per million) one of the corresponding side-by-side samples was analyzed for total Cr. Side-by-side samples from additional houses were also analyzed for total Cr. In total 11% of samples were analyzed for total Cr. Each house that had a sample with Cr⁺⁶ concentration that exceeded 20 µg/g (the current NJDEP soil remediation criterion for Cr⁺⁶) was revisited. A new sample was obtained from the surface that produced the elevated sample and two additional samples were obtained from other surfaces

Sample Analysis

Cr⁺⁶ in the dust samples was determined using ion chromatography to separate the species of Cr and inductively coupled plasma mass spectroscopy (ICP/MS) to quantitate the mass of Cr⁺⁶. Total Cr was determined by ICP/MS following microwave digestion with nitric acid. The mass of Cr⁺⁶ or total Cr was divided by the mass of collected dust to calculate the Cr concentration in the dust (mg/g). The mass of Cr⁺⁶ or total Cr was divided by the area that was sampled to calculate the Cr surface loading (ng/m²).

Results

Summary of Cr⁺⁶ Results

Two hundred eight nine samples were collected from 100 homes in Jersey City. The mean (standard deviation) Cr⁺⁶ concentration in all samples was 3.7 (7.5) µg/g (parts per million). The values ranged from non-detect to 90.4 µg/g. The mean loading in all samples was 6.4 (17.3) µg/m³. Repeat sampling visits were made to 6 houses that had a Cr⁺⁶ concentrations greater than 20 µg/g. In each case, that elevated concentration was found on a single surface and in each case, that surface

was wood. Only two of these surfaces had concentrations greater than 20 µg/g when sampled for the second time. All other repeat samples from the original surfaces and from additional surfaces had Cr⁺⁶ concentrations less than 20 µg/g.

Summary of Total Cr Results

On average, Cr⁺⁶ concentration was 12% of total Cr concentration based on comparison of side-by-side samples. With the omission of a single sample with a total Cr concentration of 4054 µg/g, the mean total Cr concentration was 285 (403) µg/g. It should be noted that these total Cr data are derived, in part, from those samples with elevated levels of Cr⁺⁶. It is likely, therefore, that they reflect higher values than would have been found had total Cr been analyzed in all samples.

Comparison of Sampling Methods and Surfaces

Cr⁺⁶ concentration and loading varied according to the sample collection method with the LWW giving the highest values. Most of the surfaces that were sampled were wood, vinyl or laminate. There was no significant difference between wood and laminate for either Cr⁺⁶ concentration or loading. Vinyl had significantly smaller concentration and loading values than wood and laminate. It appears that prior to 1970, chromium was commonly used in wood stains (<http://cat.inist.fr/?aModele=afficheN&cpsidt=4092777>). This raises the possibility that the wood surfaces, themselves, could be a source of Cr⁺⁶ in the dust on their surfaces.

Comparison of Sampling Locations Within Houses

Cr⁺⁶ concentrations in dust in living areas and basements were similar (mean = 3.9 and 2.2 µg/g respectively). However, concentrations of Cr⁺⁶ in window wells were much lower (mean = 0.3 µg/g). Dust collected from window wells originates mostly from the outdoor environment. The much lower Cr⁺⁶

Table 1
Comparison of Cr⁺⁶ Concentration (µg/g) by Location: LWW Wipe Samples from Wood and Laminate Surfaces in Living Areas*

Location	N	Mean	Std Dev	CV**	Median	5th Pctl	95th Pctl	Min	Max
Droyer's Pt.	29	3.7	4.1	112.5	2.3	0.39	16.2	0.23	19.3
Freedom	7	7.7	6.6	85.6	4.8	1.22	19.2	1.22	19.2
Garfield	16	5.1	4.5	89.1	3.6	0.33	15.4	0.33	15.4
Lafayette	11	5.1	2.4	47.5	5.1	1.41	9.7	1.41	9.7
Society Hill	10	3.9	2.1	54.0	4.0	0.58	7.20	0.58	7.20
Other	25	6.6	4.7	71.5	5.2	2.02	20.7	1.97	24.6
All samples	98	5.1	4.4	85.1	4.0	0.60	14.5	0.23	24.6

* Kruskal Wallis p=0.011

** CV (coefficient of variation) = mean/standard deviation – a measure of the variability in the data

Table 2
Comparison of Cr⁶⁺ Loading (ng/m²) by Location: LWW Wipe
Samples from Wood and Laminate Surfaces in Living Areas*

Location	N	Mean	Std Dev	CV**	Median	5th Pctl	95th Pctl	Min	Max
DP	29	1594	1879	118	907	179	7591	100	9055
Freedom	7	9137	6444	71	10836	1559	20136	1559	20136
Garfield	16	4128	3772	91	3440	225	12342	225	12342
Lafayette	11	9711	20046	206	2894	522	69360	522	69360
SH	10	2928	2502	85	1975	363	7798	362	7798
Other	25	5815	4132	71	5157	652	16401	402	18288
All samples	98	4671	7738	166	2404	319	12345	100	69360

*Kruskal Wallis p<0.001

** CV (coefficient of variation) = mean/standard deviation – a measure of the variability in the data

concentrations in the window well dust suggests the possibility that most of the Cr⁶⁺ found in the living areas originated from materials inside the home (and possibly from the sampled surfaces, themselves) rather than from outside sources. However, window well samples were mostly collected by freehand wipe or by brush. Most of the living area samples, on the other hand, were collected with the LWW sampler. It is possible that the differences in sample collection methods contributed to differences in the Cr⁶⁺ concentration between window wells and other locations. Cr⁶⁺ loading was similar for living areas and window wells (1.9 and 1.5 µg/m³ respectively) and higher for basements (3.6 µg/m³). Differences in dust accumulation among these locations likely accounts for these values.

Comparison Among Jersey City Location

Given differences in sampling method, surface type, and location within the house, the comparison of Cr⁶⁺ levels in the different Jersey City locations/neighborhoods was confined to samples from wood and laminate surfaces in living areas that were sampled by the LWW method (98 samples). The comparison by Cr⁶⁺ concentration is shown in Table 1 and the comparison by Cr⁶⁺ loading is shown in Table 2. The Cr⁶⁺ concentrations among the different locations were fairly similar, differing by a factor of less than two in both the mean and 95th percentile values. Differences in Cr⁶⁺ concentration reflect differences in sources of the Cr⁶⁺. The similarity in the concentrations among the various neighborhoods suggests that there are no major differences in the sources of Cr⁶⁺ among the neighborhoods. The Cr⁶⁺ loading were more variable differing by a factor of 6 for the mean values and by a factor of 9 for the 95th percentile values. Since loading reflects not only the concentration of Cr⁶⁺ in the dust, but also the total amount of dust on the surface, the greater variability in the loading values is not surprising.

Influence of Housing Characteristics

The association of housing characteristics with Cr⁶⁺ levels was examined for each location separately because of the differences in the ages and construction of the houses in the different locations. Due to lack of variability among houses, only a limited number of housing characteristics could be investigated. Housing characteristics that were statistically significantly associated with Cr⁶⁺ levels were found in two locations, Lafayette and Other. In both locations, there was a suggestion that Cr⁶⁺ levels in house dust were affected by the presence of bare soil and/or having grass or a garden adjacent to the house. The implications of this observation are not entirely clear. There is no indication that these observations reflect the presence of COPR in the soil. They may reflect the occurrence of Cr⁶⁺ in some soil types, and/or additives used in turf or gardening.

Summary and Conclusions

Cr⁶⁺ was found in house dust in all locations investigated in this study. Nearly all concentrations were below the current NJDEP soil remediation criterion for Cr⁶⁺ of 20 ppm. The few samples that did exceed this level were confined to specific surfaces in isolated houses and appear to be associated with the specific surface rather than the house as a whole. There do not appear to be major differences in Cr⁶⁺ levels among the various locations in Jersey City investigated in this study. This suggests that individual areas are not impacted by major sources of ongoing COPR release.

This is the first study to examine the levels of Cr⁶⁺ in house dust. Previous studies could not distinguish Cr⁶⁺ from total Cr³⁺. There are many more sources of Cr³⁺, including naturally occurring soil minerals, than there are sources of Cr⁶⁺. Because there are no previous data to which these results can be compared, it is not currently known whether and to what extent the Cr⁶⁺ detected in this study reflect a ubiquitous urban background of Cr⁶⁺, a constituent of specific materials inside homes (e.g., wood stain used on furniture), or possibly, residual COPR specific to Jersey City. To help resolve this question, a parallel house dust study had been initiated in urban areas outside Jersey City. Regardless of the source, however, the levels of Cr⁶⁺ found in the house dust in Jersey City do not pose a significant public health risk.

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