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Mapping the Urban Lead Exposome: A Detailed Analysis of Soil Metal Concentrations at the Household Scale Using Citizen Science

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Abstract

An ambitious citizen-science effort in the city of Indianapolis (Indiana, USA) led to the collection and analysis of a large number of samples at the property scale, facilitating the analysis of differences in soil metal concentrations as a function of property location (i.e., dripline, yard, and street) and location within the city. This effort indicated that dripline soils had substantially higher values of lead and zinc than other soil locations on a given property, and this pattern was heightened in properties nearer the urban core. Soil lead values typically exceeded the levels deemed safe for children's play areas in the US (<400 ppm), and almost always exceeded safe gardening guidelines (<200 ppm). As a whole, this study identified locations within properties, and cities, that exhibited the highest exposure risk to children, and also exhibited the power of citizen science to produce data at a spatial scale (i.e., within a property boundary) that is usually impossible to feasibly collect in a typical research study.

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Introduction

Urban soils bear a lingering legacy of sometimes centuries of human occupation and industrialization (e.g., Bellinger, 2011; Chambers et al., 2016; Filippelli and Taylor, 2018). Among the many anthropogenic inputs to surface soils are metals, many of which, such as lead (Pb), have a very strong and permanent impact on human health and urban well-being. Indeed, the social, health, and economic cost of Pb exposure from urban soils is steep—far greater than the cost of targeted remediation of soil Pb hotspots(Nevin, 2000; Needleman et al., 2002; Needleman, 2004;Nevin, 2007; Nevin, 2009; Mielke and Zahran, 2012; Obeng-Gyasi et al., 2018a, b). The problem is that soil metal concentration are highly heterogeneous at the small scale because of multiple sources (house paint, automobile exhaust and debris, particulate matter from utilities, industrial sources, etc.), and barring the identification of particular emission sources and sinks, these metal hotspots prove exceedingly difficult to pinpoint (Zahran et al., 2013a, b; Filippelli et al., 2015; Laidlaw et al., 2017). Although new remote sensing techniques are promising as future geochemical mapping tools in cities (e.g., Pandit et al., 2010), many obstacles remain to their effective deployment.

One of the sad realities when it comes to soil contamination is that it is often identified not through soil measurements but rather through human disease. For example, we wait until hundreds or even thousands of kids appear on public health records through high blood Pb levels before we can use this to map the urban Pb

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exposome (e.g., Filippelli et al., 2005; Laidlaw et al., 2005; Leech et al., 2016), using children as the veritable "Canary in the Coalmine," which is a harmful and backwards approach to protecting public health (e.g., Filippelli and Laidlaw, 2010; Bellinger, 2011). What is needed is a better understanding of the soil metal dynamics and patterns of distribution and associations in the urban environment, with an eye toward identifying those processes and sources that have the highest potential to cause human harm and ultimately remediating those sources in a surgical fashion (Mielke et al., 1999; Clark et al., 2008; Laidlaw and Filippelli, 2008; Laidlaw et al., 2012, 2016).

We present results from one such effort to map the urban metal exposome in the city of Indianapolis, Indiana (USA), with a pollution of about 1 million people residing the in the heart of the post-industrial Midwest region. Indianapolis is a typical older (>150 year) city with a substantial legacy of industrialization, manufacturing, and vehicle use, with urban and near-urban residential areas marked by 80-100 year old single-family dwellings. Indianapolis shares another characteristic of many Midwest cities—high rates of blood Pb poisoning, with ~25% of children below 7 years old exhibiting blood lead levels above the level of concern (5 microgram/dL) in some of the central census tracts (Fig. 1; data from 2005-2015; Reuters, 2018). The majority of Pb exposure to these children comes from soil Pb, with the mechanism being inadvertent ingestion or inhalation of Pb-contaminated soils and/or dusts generated from soils.

Fig. 1 Map of elevated blood Pb values for children tested in Indianapolis from 2005-2015 aggregated at the census tract level (data from Reuter, 2018). These results

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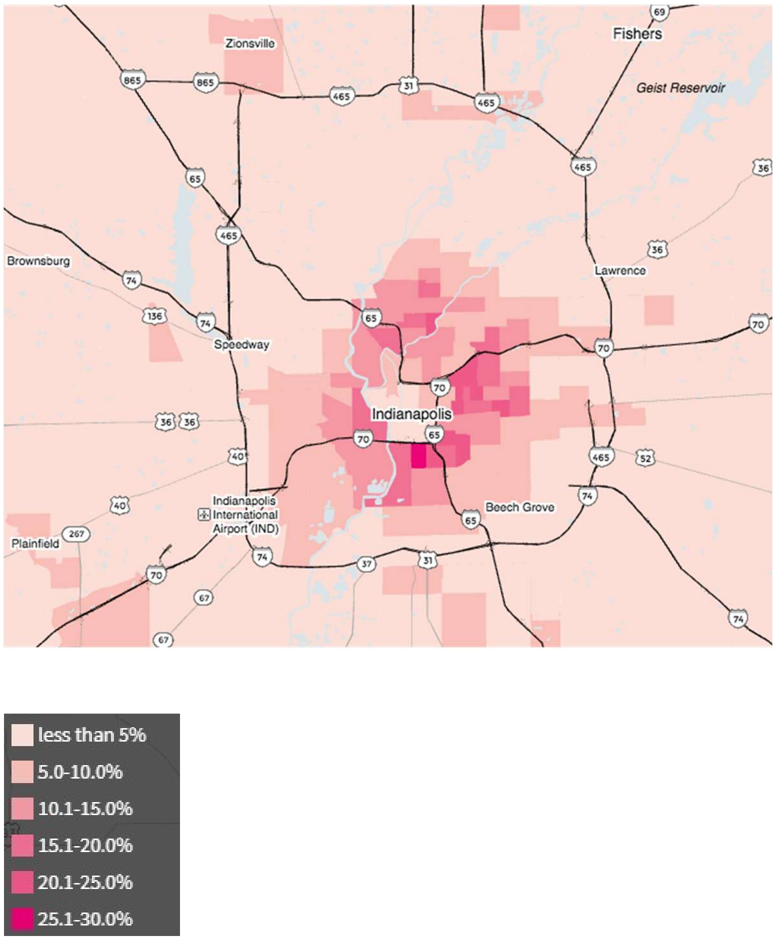
reveal areas in the city with persistent Pb exposure to children, which is likely driven largely by soil and dust sources of legacy Pb from a mixture of leaded gasoline, lead-based paints, and industrial sources (Laidlaw and Filippelli, 2008).



Citizen-science in action

A unique aspect of this study is that the majority of the samples themselves were taken by citizen scientists, under the support of the Healthy Cities Project (http://kheprw.org/healthy-cities-project/). The samples were guided by a soil Pb awareness and safety handbook, with instructions for sampling locations (one

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dripline sample, one street side sample, and up to three other yard samples), sample collection (aggregate samples of approximately the top 10 centimeters), and sample storage (new zip-type plastic bags), in a manner similar as that employed in other settings (e.g., Filippelli et al., 2015; Rouillon et al., 2017). The geochemical analyses were performed at the IUPUI Biogeochemistry and Health Core Facility as described in the Methods, and the results and recommendations were returned to the citizen scientists. A total of just under 2,000 samples were analyzed from ~500 residential properties (Fig. 2), broadly covering the city. The program is ongoing, with a particular focus on youth activation and science communication.

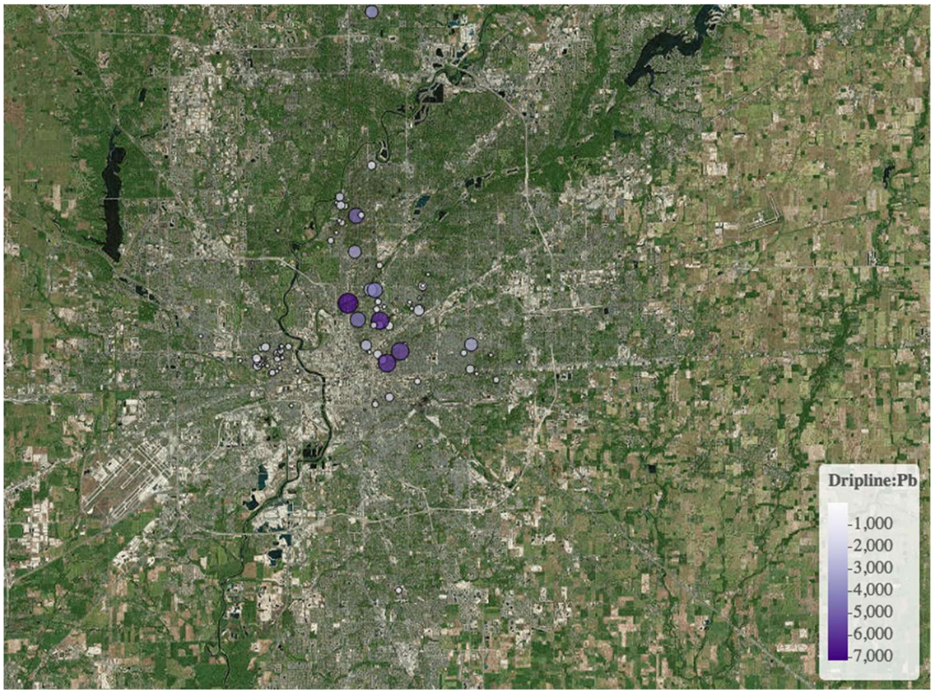

Fig. 2. Example sample location map for Pb concentrations in dripline soils from Indianapolis, Indiana (USA), displayed as output from an application under development to assist citizen scientists in understanding the distribution patters on metals in the city. Note that this represents roughly 500 individual properties, with

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multiple locations "hidden" under circles with high soil Pb concentrations.(Filippelli et al.)

We found clear patterns in soil metal concentrations and relationships between various metals at the household and the city level, providing insight into patterns of legacy metal deposition, patterns in human health risks, and potential sources of metals. The city-wide patterns for Pb in particular correlate strongly to blood lead levels of children, and the particularly high values found at house driplines provide further evidence that household-scale interventions that aim to isolate or cover near-home soils might go a long way toward reducing personal exposure risks for those dwelling in the homes.

Methods

A combination of open-call and campaign-style sampling schemes were utilized to collect soil samples from properties in Indianapolis. The open-call samples were solicited generally via on-line and in-person (community events, flyers, etc.) contacts. The campaign-style samples came from individual communities or community groups who would canvas neighborhoods and take samples at high sampling densities—sometimes as frequently as every other property on a given block. This led to a total sample location pool that was neither random nor equally distributed around the city.

As noted above, instructions were provided as to the preferred location of samples, sampling depths, and sample labeling. But with any citizen-generated science, the actual implementation of sampling was up to non-experts, and thus inevitably some

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uncontrollable inconsistency is present in the sample pool. It is likely not biased in a specific direction, and furthermore, the sheer number of samples (~2,000) is likely to effectively normalize some variations in sampling procedures, via the "normalization to the mean" nature of high sample n's numbers. Some inconsistency in sample labeling was experienced which could be controlled for. In some cases, this inconsistency was straightforward to interpret, such as "next to house" or "near road" which translate into our pool of "dripline" and "street" categories. In some cases, however, samples were labeled in a manner than must have made sense to the citizen scientist (e.g., 1, 2, 3, 4, 5 or A, 2A, 3A, etc.) but could not be interpreted into functional categories and thus were excluded from this study. Finally, one key aspect of this analysis is the identification of spatial patterns in legacy metal concentrations, and in some cases the sample address could not be uniquely geocoded to a specific location, and thus these samples were also excluded. Altogether, about 600 samples that fell into these exclusion criteria, and thus the total number of samples presented here is about 1,400.

Upon delivery to the laboratory, soils were processed and analyzed as per Filippelli et al. (2005). Briefly, soil samples were dried, sieved to 150 microns, and weighed and ashed in a muffle furnace at 550 degrees Celsius to degrade organic matter. The ashed sample was then transferred to 15 mL HDPE disposable centrifuge tube and digested overnight in 2N HCl at room temperature on a shaker table. After centrifugation, a subsample of the supernatant was diluted (1:100) with Milli-Q water and analyzed on a Perkin Elmer ICP-OES for a suite of metals, specifically lead (Pb), manganese (Mn), barium (Ba), chromium (Cr), copper (Cu), and zinc (Zn).

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Typical sample reproducibility, calculated from multiple measurements of the same soil ashed, digested, and analyzed was 5% for all elements. Cadmium was also included in the initial analysis, but unacceptably high levels of detection and poor sample reproducibility precluded its effective use in this study.

Results

One of the critical components of predicting how, where, and to what metals people are exposed involves understanding both the origin of metal distribution patterns and the patterns of distribution at the personal (i.e., property) and community (i.e., neighborhood) scales. Our results for Indianapolis (Supplementary Materials) reveal two origin classes of metals found in surface soils, an anthropogenic source that dominate Pb and Zn distribution, and an ambient soil mineral source that defines the relatively homogenous distribution at the household and neighborhood scale of the other studied metals. The results confirm existing paradigms that elevated soil Pb in cities has a clearly anthropogenic origin and is generally highest near home driplines. But the results also reveal the power of citizen science to take an active role in understanding the urban Pb exposome and to help fill the gap in the currently poor state of urban soil geochemical mapping.

Property-scale distribution of soil metals and metal sources

Lead and Zinc. The greatest predictor of soil Pb and Zn concentration is location on a particular property. For both metals, concentrations are much greater at the dripline that in a given yard or near the street. For Pb, this results in mean concentrations near the home driplines of 805 ppm, with maximum values as high

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as 8,816 ppm, and for Zn, the mean is 575 ppm and the maximum is 3,814 ppm (Table 1). For Pb, mean yard samples are lower (345 ppm) and street samples even lower (240 ppm) than driplines, resulting in a relative dripline enrichment of 2.33. For Zn, mean yard samples are also lower (312 ppm) and street samples even lower (262 ppm) than driplines, resulting in a relative dripline enrichment of 2.19, quite similar as that for Pb. This property-scale distribution pattern is an indicator of anthropogenic source(s) for these metals. Indeed, a strong correlation is observed between Pb and Zn when considering the entire individual sample population by location category, with r^2 ranging from 0.637 for dripline samples, 0.635 for yard samples, and 0.706 for street samples (Fig. 3). The consistency in correlation between these two elements across location category (and nearly identical slope; Fig. 3) suggests a similar source for both metals.

Table 1. Metals concentrations (ppm) for soils as a function of location on a property. Enrichment factor is calculated as highest value/lowest value for each mean metal concentration.

Location		Drip	Yard	Street	Enrichment	U.S. mean*
N		187	976	192		(ppm)
Pb						
	Mean	805	345	240	2.33	18
	Median	282	193	143		
	Maximum	8,816	6,619	2,654		
Mn						
	Mean	635	695	646	0.98	492
	Median	603	666	616		
	Maximum	1,359	2,597	1,358		
Ba						
	Mean	147	132	118	1.25	510
	Median	124	116	104		
	Maximum	1,100	1,200	969		

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Cr						
	Mean	23	22	20	1.15	30
	Median	20	19	19		
	Maximum	249	1,183	79		
Cu						
	Mean	41	28	29	1.46	14
	Median	21	18	16		
	Maximum	1,469	1,332	888		
Zn						
	Mean	575	312	262	2.19	58
	Median	313	216	149		
	Maximum	3,814	3,660	3,892		

* USGS soil geochemical survey of conterminous US 0-5 cm (Smith et al., 2014)

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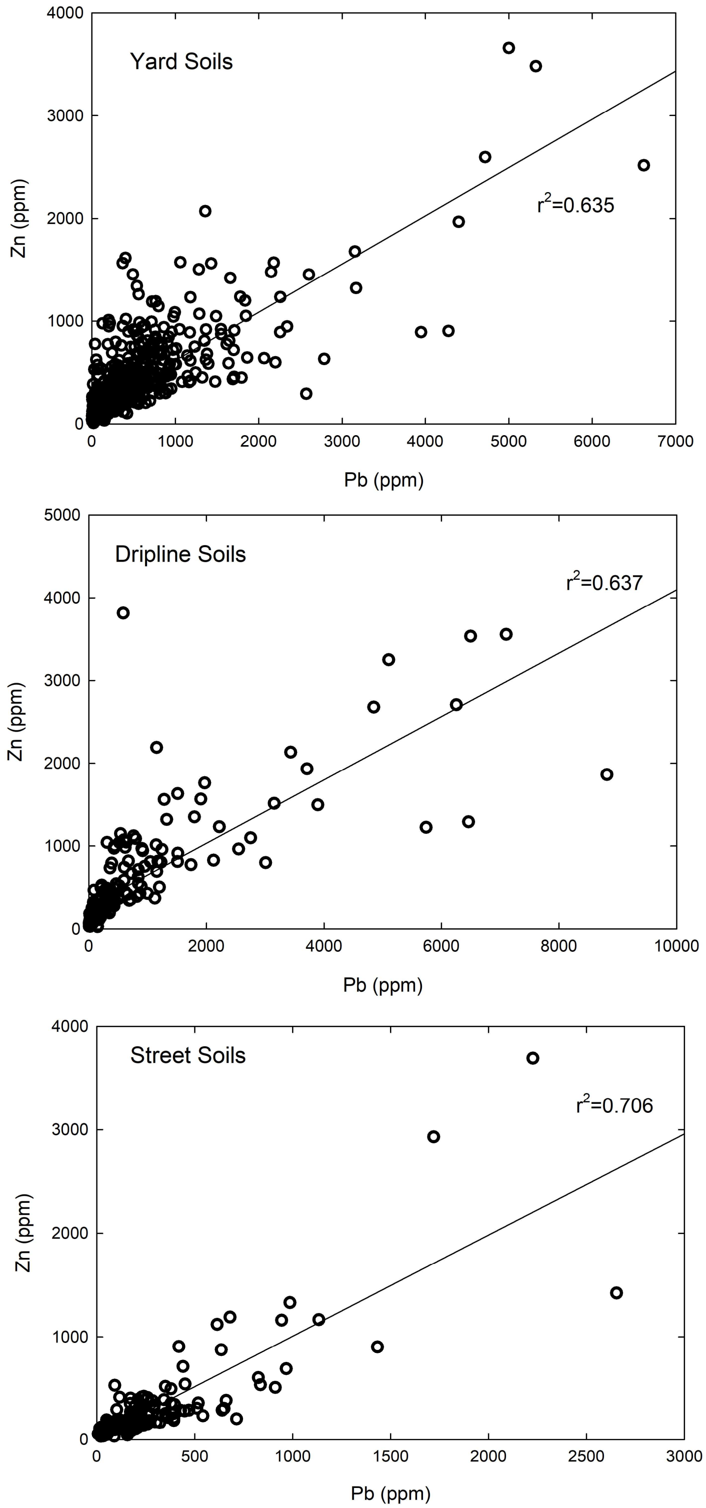

Fig. 3. Correlation plots of Pb and Zn for all soil location types. The similar slopes for each setting, the strong correlation between them, and their relative enrichment

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over average soil indicate a strong anthropogenic source impacting their distribution in urban soils. (Filippelli et al.)

Perhaps the best baseline with which to reference urban soil metal concentrations is the comprehensive nation-wide USGS analysis (Smith et al., 2014). This baseline encompasses rural regions that have no clear anthropogenic sources and others semi-urban and urban regions with a strong imprint of anthropogenic inputs. This US average was chosen as it spans multiple soil types and mineralogical compositions. It is heavily biased toward non-urban settings given that the sample locations were based on a geographic grid that provides a "normal" spatial sample distribution, whereas urban and industrial centers are anything but normally distributed, with strong concentration and non-random distributions in the spatial sense.

Other Metals. Unlike the case for Pb and Zn, there are no apparent location patterns, nor substantial enrichments, for soil Mn, Ba, Cr, or Cu (Table 1). Driplines tend to have slightly higher Ba, Cr, and Cu values, but only by about 15-46%. The strongest dripline signature is for Cu (46% enrichment), which might support a weak relationship to an anthropogenic source. Meanwhile, Mn shows no enrichment at all at the property scale, which indicates a geogenic driver for soil Mn concentrations, even in an urban environment.

City-scale distribution of soil metals

There were typically three yard samples taken per property, as opposed to one each for dripline and street samples. Thus, the most statistically significant measure of

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city-wide patterns in soil metals lies in an analysis of yard soil samples. This analysis yields mean values for soil Pb of between 263 and 494 ppm for Center Township properties (i.e., downtown or near downtown), and between 323 and 468 ppm Zn (Table 2). Soil values were significantly lower outside of the downtown, with mean values between 157 and 175 for Pb and 239 and 244 for Zn (Table 2). It is important to note that fewer samples were taken outside of the downtown, and thus only two zipcodes had adequate (i.e., more than 20) samples from which to determine a mean value. No clear downtown to outside of downtown patterns were observed for the other elements analyzed as part of this study.

Table 2. Concentration of yard soil Pb and Zn sorted by Zipcode (only where over 20 samples were tested). Indianapolis, Indiana. Center Township represents the downtown and near downtown zipcodes.

Zipcode		Pb ppm	Zn ppm
Center Township			
46218	mean	373	323
	median	216	236
46222	mean	471	374
	median	257	292
46201	mean	401	340
	median	261	246
46202	mean	666	468
	median	376	293
46203	mean	495	421
	median	279	289
46208	mean	263	340
	median	183	247
46205	mean	388	365
	median	263	285
Outside Center Township			
46219	mean	157	244

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	median	123	204
46220	mean	175	239
	median	110	156

Discussion

Anthropogenic sources for Pb and Zn

As has been amply documented, higher-then-background Pb and Zn values are consistent with an anthropogenic footprint in cities (e.g., Datko-Williams et al., 2014; Harvey et al., 2017). The sources of these metals are multiple, and include leaded gasoline, lead-based paint, and industrial emissions for Pb and tire debris, fossil fuel combustion, and industrial sources for Zn (Mielke et al., 1999). This urban effect for Pb and Zn is even seen clearly in river and reservoirs sediment samples downstream of major metropolises (Callendar and Rice, 2000) and is interpreted to derive from soil and dust runoff. Urban sources drive strong correlation in downstream sediments and reservoirs surface samples.

The soil values that we found for all sample types (dripline, yard, and street) for Pb and Zn were significantly above the US mean (Smith et al., 2014). For Pb, that enrichment was over 1,000% for all sample types, and for Zn was over 400% for all sample types (Table 1). Although the strong correlation between Pb and Zn (Fig. 3) and the similar household-scale enrichment factor (Table 1) suggest a similar source for both in the urban setting, the increase above mean US soil values is much higher for Pb, with Pb being roughly 4.5 times higher than Zn in dripline soils, 3.6 in yard soils, and 2.9 for street soils. Collectively this trend points to a house-based

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proximal source for Pb that is greater than that for Zn. Although a likely culprit might be lead-based paints, it is difficult to rule out the potential impact of past combustion of leaded gasoline and barrier capture of that aerolized Pb next to structures.

Both Pb and Zn were much higher in downtown properties than those outside of downtown. One interpretation of this pattern is the growth trajectory of Indianapolis, and indeed that of many Midwestern industrial cities. Densely spaced residential and light industrial land uses were common in the first half of the 20th century in downtown areas, and this co-location of emissions sources with high anthropogenic footprints likely lead to significantly higher amounts of industrial and vehicular emission and deposition of Pb and Zn, which retained their urban footprint (Filippelli et al., 2005; Datko-WIlliams et al., 2014) long after the phase-out of leaded gasoline, lead-based paints, and emission controls for small scale Pb foundry and recycling facilities in Indianapolis (Filippelli and Laidlaw, 2010). Subsequent growth, in a relatively Pb-free time, occurred outside of the downtown area, and thus the anthropogenic legacies were significantly lower in these areas.

Implications for human health

One of the clearest outcomes of this research is that soils near homes pose significantly greater contact risks of Pb to individuals than soils anywhere else on their property. Indeed, mean dripline soil concentrations (805 ppm) are above the screening level of 400 ppm for soil Pb in playground and children's play areas (US EPA, 2015), and those for mean yard soils (345 ppm) are barely below this cutoff.

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The consistent finding of high values at driplines is critical, as this is a source of soil and dust tracked into homes (Hunt et al., 2006; Hunt and Johnson, 2012). And the mean for all soil location types exceeds the safe gardening recommendations of 200 ppm Pb recommended by some researchers (e.g., Kessler, 2013), and would benefit from interventions to ensure that gardening in not a undue source of Pb exposure either through direct contact or through produce consumption (Mielke et al., 2011; Attanayake et al., 2015; Brown et al, 2016). If one takes the more conservative, risk-based screening level of 100 ppm adopted by European countries (Jennings, 2013), nearly all of the dripline and most of the full soil sample set would be in violation of standards.

To be sure, significant property-to-property variability exists, and beyond some city-scale patterns, it is impossible to predict in aggregate if a particular dripline soil Pb value will be 10 ppm (the minimum found in Indianapolis; Supplementary Materials) or 8,816 ppm, the maximum found (Table 1) and a level that clearly poses dangers to residents within and near to that home. Given the observed variability in dripline soils, and even those from yards and streets, it is fruitless to use mean values to predict Pb exposures to children based on a typical IEUBK soil exposure model. And indeed, even when property data was determined in those areas where denser sample coverage was achieved, such as on the near west side of Indianapolis, the property-to-property variability typically exceeded 50% across all sample types. Note that the data was aggregated at the zipcode level in this analysis to protect anonymity of individual property owners, and thus the source data for the block-scale analysis are not publicly available.

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City-wide patterns in anthropogenic metal distributions

Not surprisingly, downtown soils retained a much high legacy metal impact than those outside of downtown. This indicates that risks from metal exposure are also significantly higher near the downtown core of Indianapolis, and likely many other similar cities in the American Midwest and east coast with similar histories and growth trajectories. Basically, when a city developed and its growth patterns dictates its anthropogenic metal footprint, with younger cities largely avoiding the worst of harmful metal emissions and legacy metal contaminants because of much more rigorous environmental protections that were implemented over the latter part of the 20th century in the US.

Conclusions

The anthropogenic footprint or urbanization is easily observed in legacy metals distribution in Indianapolis, with the older urban core generally exhibition the highest values of those metals presumed to be most strongly related to human activities—Pb and Zn. Beyond this urban concentration is another spatial pattern—i.e., significantly elevated levels of Pb and Zn near home driplines. This indicates the role of structures in capturing fugitive dust as well as being point sources of metals via paint and other building products. Form a health protection standpoint, these findings reveal that urban core properties hold the greatest Pb exposure risk, and that soils proximal to structures are particularly concerning and warrant special attention to either remove the source or encapsulate it via robust groundcover. An

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interesting outcome of the approach to sample collection is that citizen-scientists can be effectively engaged to expand research and to provide data at a scale that is both not feasibly collected by an individual research and that are most characteristics of the household's individual soil exposure risk situation. Future work focusing on the efficacy of risk communication and more spatially-explicit examination of soil Pb values versus blood lead levels at the neighborhood scale would further increase the public health impact of citizen-science studies such as this one.

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Supplementary Material (to be published online)

Filippelli et al., IJERPH Urban Exposome

Table of all data of each location type. Rows are multiple elements of the same samples. Soil samples were dried, sieved to 150 microns, and weighed and ashed in a muffle furnace at 550 degrees Celsius to degrade organic matter. The ashed sample was then transferred to 15 mL HDPE disposable centrifuge tube and digested overnight in 2N HCl at room temperature on a shaker table. After centrifugation, a subsample of the supernatant was diluted (1:100) with Milli-Q water and analyzed on a Perkin Elmer ICP-OES for a suite of metals, specifically lead (Pb), manganese (Mn), barium (Ba), chromium (Cr), copper (Cu), and zinc (Zn). Typical sample reproducibility, calculated from multiple measurements of the same soil ashed, digested, and analyzed was 5% for all elements. Cadmium was also included in the initial analysis, but unacceptably high levels of detection and poor sample reproducibility precluded its effective use in this study.

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
Dripline						
	7	583	33	11	5	31
	3,153	587	250	18	16	1,512
	1,513	765	214	33	44	910
	15	694	92	15	12	167
	15	672	101	16	13	182
	9	605	59	14	9	44
	7	419	48	13	11	63
	366	396	72	12	8	277
	370	396	83	14	9	323
	2,752	831	296	23	47	1,096
	2,547	797	251	23	39	960
	87	766	73	30	21	463
	840	449	173	16	12	625
	8	439	43	13	11	60
	33	321	90	19	8	128
	21	546	72	12	5	52
	56	735	108	19	14	85
	25	575	93	16	9	136
	340	789	147	36	20	209
	13	406	74	17	11	70
	616	873	134	26	20	981
	284	525	168	25	71	367
	14	483	72	17	13	87
	135	663	129	26	16	163
	82	505	65	15	11	124
	79	586	56	14	10	313
	1,121	792	191	19	19	370
	672	601	298	22	30	817
	949	485	182	29	32	752
	31	893	95	22	17	108
	4,847	769	341	38	23	2,678
	325	542	93	23	14	273
	262	890	138	26	28	312
	728	406	181	18	10	667
	22	437	83	15	8	68
	96	737	114	21	14	248
	434	645	87	20	15	361
	69	425	198	49	41	197
	19	777	98	15	14	65

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
793	662	303	23	31	1,087
1,903	819	581	28	34	1,565
68	505	70	16	7	136
39	518	82	24	24	99
816	456	176	18	10	390
31	544	64	30	42	77
20	526	79	16	9	30
52	562	98	16	14	186
28	480	58	12	6	63
59	337	86	16	9	105
53	479	72	14	8	90
80	347	63	14	9	283
3,433	560	181	22	11	2,133
60	283	56	14	6	88
68	1,359	132	25	20	185
23	320	66	16	11	67
58	521	61	11	6	60
6	591	86	16	364	73
55	594	94	17	8	89
427	326	136	12	10	276
1,200	435	87	17	54	502
296	511	93	21	40	254
5,739	374	78	19	7	1,222
407	698	102	20	9	332
995	457	113	16	8	427
111	581	171	29	27	165
150	567	139	27	33	349
140	580	202	28	27	342
174	520	192	32	49	343
268	452	150	31	82	278
183	474	139	28	45	286
158	581	126	26	36	195
112	555	136	27	37	270
1,510	651	620	33	56	1,630
439	602	215	28	99	1,000
602	447	266	33	322	739
288	501	132	22	30	479
217	601	151	28	34	289
1,970	525	600	36	52	1,760
224	522	137	31	67	379

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
77	506	125	22	65	320
118	468	114	24	32	180
299	645	146	28	39	387
407	661	183	33	45	323
149	788	136	27	30	195
387	503	213	31	156	791
157	648	118	31	38	266
53	630	103	24	23	97
240	899	192	28	42	278
230	909	167	24	43	445
169	823	153	24	70	247
168	1,220	156	25	24	156
761	715	143	49	73	1,120
3,710	1,070	1,110	28	37	1,930
521	1,150	206	37	38	1,040
2,120	497	547	249	84	827
842	530	273	52	39	713
22	607	126	26	22	101
23	620	144	34	24	89
17	599	110	24	43	85
196	840	163	22	31	250
397	733	142	25	28	387
5,100	737	810	51	51	3,250
597	880	238	25	31	585
30	628	122	25	19	181
57	726	128	30	32	218
70	777	128	24	29	133
82	603	109	26	32	181
360	843	218	32	61	733
890	866	200	22	36	512
15	505	88	26	24	87
14	637	124	25	30	94
309	479	104	28	35	1,041
842	882	220	50	61	547
31	734	120	13	28	72
208	590	138	16	10	156
429	446	60	15	17	969
3,007	665	69	16	19	797
422	346	93	15	8	492
3,895	513	81	13	22	1,495

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
914	496	77	13	10	942
1,243	290	172	19	221	956
6,496	1,082	256	34	224	3,534
1,281	607	140	17	27	1,560
1,507	398	240	18	15	810
597	784	120	24	118	1,071
708	636	151	18	12	353
101	650	110	18	140	151
54	873	98	35	8	251
1,143	541	145	19	25	1,011
7,102	720	191	33	24	3,557
139	460	116	18	12	120
8,816	210	70	13	6	1,860
6,461	255	115	15	18	1,288
352	537	80	23	17	214
53	592	50	13	15	86
32	522	72	17	10	60
868	777	144	24	28	425
57	512	98	19	15	81
178	649	162	31	25	196
205	483	120	22	20	495
500	973	161	27	33	386
1,143	541	145	19	25	1,011
7,102	720	191	33	24	3,557
139	460	116	18	12	120
195	488	75	14	9	136
512	556	125	19	14	367
219	676	111	14	18	525
616	699	133	20	16	442
282	802	102	22	12	307
1,152	857	132	23	76	2,191
360	767	119	18	11	420
584	1,199	136	17	47	3,814
282	887	129	17	22	203
654	757	89	18	20	416
100	569	86	17	13	217
139	647	67	3	4	32
145	641	67	4	4	32
147	363	61	4	3	27
638	370	102	6	11	1,044

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	408	554	140	5	61	276
	1,227	839	128	17	44	803
	148	761	103	13	11	190
	332	745	148	15	28	478
	465	758	113	12	17	541
	1,045	730	103	13	17	809
	1,154	739	187	17	18	691
	349	720	118	13	19	192
	231	847	93	14	17	207
	685	878	169	20	35	344
	1,796	894	105	25	31	1,349
	189	909	135	18	75	207
	1,324	746	166	22	19	1,318
	298	937	126	16	19	489
	322	626	98	13	19	281
	903	778	135	20	51	966
	174	977	90	14	12	110
	538	519	133	27	1,469	1,147
	34	417	42	8	5	57
	14	326	48	9	3	86
	10	132	31	9	2	65
	99	749	55	12	12	122
	1,738	930	193	21	63	772
	23	665	58	12	4	49
	6,253	555	85	26	43	2,707
	1,173	647	195	13	35	813
	516	1,086	116	19	19	519
	2,219	1,086	265	24	32	1,230
Yard						
	272	347	77	15	11	121
	100	245	86	16	13	134
	97	276	66	12	6	130
	80	100	58	10	6	95
	20	312	63	7	3	34
	32	619	122	13	23	67
	30	366	80	8	5	43
	26	956	55	14	6	63
	24	525	47	16	8	72
	23	695	50	21	8	55

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	88	428	92	18	16	158
	470	444	223	19	19	529
	150	408	142	20	17	253
	21	512	101	10	10	65
	6	361	50	12	12	54
	9	282	92	17	13	69
	27	547	68	18	9	72
	25	492	72	20	12	76
	32	523	72	22	13	81
	26	550	66	18	9	73
	37	290	58	11	4	52
	58	391	73	16	9	150
	63	409	93	20	13	181
	55	480	92	18	11	160
	2,064	748	131	18	18	639
	1,366	889	111	18	10	624
	1,148	474	77	12	4	466
	432	846	243	21	44	379
	240	948	176	20	25	227
	384	1,050	203	21	23	272
	93	1,130	170	31	41	282
	143	1,170	174	28	27	350
	137	948	201	33	43	285
	242	882	254	33	62	691
	84	840	173	32	23	167
	52	868	125	34	21	625
	29	833	118	29	20	530
	29	879	131	32	26	258
	40	612	138	26	34	314
	237	1,010	185	25	35	286
	193	897	170	30	37	286
	478	878	199	23	31	596
	42	726	75	19	14	78
	26	755	74	16	7	61
	35	617	77	23	14	84
	44	678	165	21	13	33
	44	657	92	19	9	95
	23	541	80	17	8	89
	20	668	97	19	8	95
	4	696	125	24	11	76

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
4	374	77	27	16	263
7	575	104	32	19	238
7	568	102	23	12	124
39	450	92	21	16	177
6	420	44	14	9	49
7	490	48	15	7	48
7	559	56	13	8	51
21	240	54	8	3	35
17	207	38	13	3	139
20	414	65	12	8	148
20	287	48	7	2	56
46	406	64	12	6	122
204	585	88	15	9	137
161	458	70	14	13	129
127	469	74	16	9	156
203	586	73	13	11	193
35	375	69	13	5	68
33	323	53	11	5	83
43	380	68	14	6	68
345	867	88	13	13	263
212	1,121	112	13	11	194
329	1,153	121	16	14	272
21	908	139	35	19	96
16	564	100	48	35	387
18	594	108	27	31	269
21	667	111	27	19	147
63	517	110	29	32	234
35	489	89	20	14	87
37	460	82	22	15	83
121	391	139	33	47	188
52	274	58	11	6	63
13	393	67	13	7	58
24	563	73	13	11	100
21	660	73	13	7	64
17	749	93	35	29	97
24	892	114	67	35	118
31	1,416	124	45	72	123
10	293	54	13	8	25
21	712	93	20	13	44
20	578	97	20	11	44

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
357	511	82	13	13	241
242	378	65	12	11	153
9	890	75	13	7	54
13	676	114	18	11	81
15	706	91	15	9	73
15	463	89	18	10	76
13	440	90	21	13	83
25	578	72	18	5	51
17	422	72	9	2	50
23	565	78	9	2	54
15	1,352	175	51	52	80
17	1,005	137	19	11	83
17	950	170	27	16	77
224	569	85	15	15	250
14	381	72	21	32	81
125	869	119	36	42	143
427	531	157	31	47	446
760	491	156	21	25	823
285	505	122	21	20	798
103	377	61	11	6	83
118	258	61	10	16	180
215	291	61	10	4	131
393	435	111	18	16	303
130	471	65	12	8	114
845	440	157	26	27	621
155	247	75	13	8	140
55	393	61	11	5	65
185	395	76	12	6	156
56	395	86	17	8	83
75	579	105	16	7	90
188	575	123	29	29	188
469	1,104	215	28	30	261
275	1,103	159	29	26	210
171	1,052	119	20	23	142
60	281	52	6	4	83
335	357	91	10	8	176
621	403	166	12	11	421
276	449	118	13	9	259
296	511	93	21	40	254
238	406	170	13	8	210

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	261	477	111	13	7	205
	561	623	83	18	66	197
	419	538	115	12	11	255
	251	400	124	13	11	216
	52	363	138	19	33	125
	437	636	167	27	37	897
	226	553	106	24	28	297
	60	784	130	23	28	114
	145	762	176	28	47	260
	743	540	387	33	82	780
	208	394	113	19	30	179
	319	533	216	27	65	330
	684	566	282	25	69	527
	482	572	300	23	37	425
	59	335	39	10	12	116
	75	344	36	10	17	127
	123	287	38	8	5	141
	84	318	39	10	11	130
	163	240	42	8	7	150
	50	227	28	9	3	102
	68	347	38	10	14	130
	68	345	36	10	12	118
	979	529	209	16	40	1,043
	223	367	75	18	13	275
	715	516	198	21	15	994
	173	364	75	16	9	163
	341	594	97	19	17	255
	446	648	127	17	9	312
	2,258	642	179	21	17	892
	1,862	780	268	17	22	646
	232	412	63	14	7	155
	430	505	111	20	36	363
	135	463	69	18	11	140
	140	571	82	17	11	224
	272	397	105	16	15	229
	248	424	91	16	16	247
	199	397	85	17	13	246
	236	394	135	18	22	357
	995	381	115	27	97	1,085
	335	533	102	21	64	543

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
567	583	80	17	11	224
1,796	428	152	22	14	450
181	615	67	13	10	116
145	563	77	15	9	136
145	568	64	12	10	109
295	772	92	20	13	291
125	542	64	15	9	133
301	446	97	15	10	187
284	570	86	16	13	202
1,548	611	149	36	436	922
689	681	143	32	26	517
448	503	119	24	24	370
640	599	153	34	29	506
762	591	148	31	26	848
209	570	142	33	28	378
972	509	216	29	34	721
354	527	150	28	28	368
300	543	125	27	25	396
1,659	568	265	32	32	1,421
629	568	160	26	25	553
791	498	260	20	48	708
826	526	269	21	45	701
255	453	143	21	40	378
739	550	182	31	40	536
24	568	54	12	11	76
10	676	56	12	8	67
9	684	64	14	10	72
11	691	52	13	7	58
9	655	49	12	6	53
9	695	45	11	6	50
11	896	65	12	8	66
6	1,138	112	19	15	101
21	609	53	11	10	73
214	695	96	15	25	195
239	883	120	18	25	183
499	508	112	15	87	350
6,619	794	226	46	24	2,516
1,838	558	256	22	17	1,199
5,325	778	278	44	33	3,483
507	890	198	28	23	444

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
325	816	160	22	80	302
542	866	175	20	28	450
413	711	156	17	18	279
303	885	147	25	32	284
275	799	150	24	29	249
329	1,012	155	25	25	264
374	1,067	162	23	44	244
214	841	166	26	25	234
159	847	131	22	20	153
371	834	190	14	13	189
622	521	87	12	8	303
87	820	103	11	11	98
568	751	181	19	57	395
866	655	153	22	33	466
398	678	131	16	29	374
1,430	529	220	25	54	1,562
2,341	641	190	44	82	946
499	685	212	28	18	461
395	758	165	19	11	204
920	855	170	20	36	481
1,283	659	209	52	65	1,504
558	795	104	16	20	840
195	412	61	11	10	131
394	535	115	18	19	306
378	583	128	16	18	119
400	493	151	20	16	267
400	964	125	15	45	425
264	579	111	17	27	340
389	526	116	18	41	412
307	751	129	18	13	375
318	609	132	17	10	165
345	615	129	19	13	215
11	691	60	13	8	69
367	464	149	22	32	419
570	544	220	50	107	986
185	401	71	16	18	255
743	471	145	19	26	694
69	446	40	15	17	109
367	653	142	24	43	441
563	513	224	28	72	672

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
289	919	134	22	22	318
219	909	156	21	67	332
523	1,013	163	45	236	902
228	595	120	20	19	186
322	562	135	19	22	248
284	495	128	19	24	239
264	612	137	17	16	192
1,061	543	127	26	35	1,574
407	794	109	31	41	1,019
110	680	149	25	30	538
403	772	143	44	69	1,617
113	781	106	17	9	130
161	509	100	20	15	152
438	450	155	20	20	643
1,181	595	207	40	58	1,231
52	388	39	8	3	95
14	359	36	7	3	65
20	395	29	5	2	59
203	283	87	10	7	304
206	242	74	10	10	347
115	258	48	8	5	182
100	284	45	9	4	183
5	430	41	8	3	56
18	219	29	8	4	50
671	674	239	26	46	702
1,639	621	114	18	20	591
735	801	88	17	9	300
165	703	78	14	8	98
36	853	67	15	5	60
247	567	66	14	10	130
1,233	543	106	15	20	752
275	566	87	19	15	278
482	541	177	17	11	265
32	626	61	14	4	60
158	666	79	28	20	153
849	534	88	18	20	457
553	653	110	14	12	221
3,949	559	177	15	13	892
909	632	108	15	17	335
2,200	530	93	15	12	599

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	320	855	225	26	82	332
	228	667	160	24	56	215
	209	774	142	23	53	263
	388	909	192	24	78	314
	278	716	155	22	59	248
	192	721	149	27	71	247
	425	952	152	19	25	309
	922	819	191	19	19	554
	892	1,105	182	22	22	463
	109	873	110	21	16	149
	756	757	175	23	22	915
	158	941	116	20	12	159
	106	891	97	21	16	226
	239	1,062	119	26	20	211
	292	981	126	21	15	265
	182	952	116	32	19	186
	137	804	114	19	17	180
	104	954	109	22	12	166
	105	974	110	21	13	151
	191	932	124	20	15	172
	158	952	126	25	20	193
	135	1,027	108	22	15	147
	126	977	109	22	12	149
	127	934	101	19	11	135
	178	871	109	21	11	148
	165	895	123	20	15	156
	166	1,020	108	19	13	146
	3,168	817	268	18	15	1,321
	765	664	208	26	152	1,193
	272	679	176	27	39	292
	236	573	102	16	9	372
	124	537	59	20	18	100
	78	449	86	25	19	150
	864	1,015	110	25	35	621
	41	581	71	21	20	96
	292	628	88	21	21	294
	276	764	113	31	30	352
	64	629	64	21	22	118
	193	842	131	17	11	194
	266	899	115	12	8	149

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
61	1,050	151	42	23	103
100	1,070	163	37	31	158
223	1,010	214	35	45	346
248	970	185	27	32	287
526	1,090	314	41	58	480
612	1,090	405	42	87	698
263	1,040	258	32	33	312
214	1,120	235	35	32	270
199	1,110	228	40	56	264
172	1,020	170	51	34	192
537	1,080	328	46	53	396
276	942	226	38	56	280
110	1,110	179	32	30	166
357	1,160	261	41	48	334
542	1,120	370	53	70	466
87	1,050	172	37	29	133
305	1,210	255	52	42	298
2,570	1,280	338	46	45	294
415	1,110	198	40	94	279
170	960	168	28	79	277
228	980	175	35	54	330
429	1,180	225	32	32	588
161	953	169	28	34	243
227	942	191	35	50	277
255	961	181	27	33	333
276	1,050	251	36	54	576
312	1,120	241	36	50	335
358	903	273	37	73	368
162	886	176	38	35	264
296	961	218	38	39	308
242	859	186	29	53	310
213	1,190	204	50	40	246
49	1,140	159	36	32	118
501	1,030	298	33	43	414
498	1,120	277	35	37	546
563	1,150	266	31	41	694
299	1,120	230	33	45	369
648	1,040	361	30	39	583
363	1,110	253	30	37	293
807	997	800	44	80	794

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	334	1,130	203	28	29	264
	1,550	1,170	521	33	47	873
	189	1,160	201	48	46	243
	368	824	196	27	40	311
	728	1,190	377	32	27	791
	409	946	215	32	48	365
	149	593	132	45	30	143
	949	834	221	27	38	480
	666	1,120	377	37	61	682
	544	938	269	36	43	457
	2,180	981	455	28	42	1,570
	494	957	278	35	56	384
	560	1,120	288	33	38	439
	168	1,240	182	35	24	159
	265	1,100	223	37	58	268
	423	1,170	261	32	31	399
	353	1,260	219	52	35	326
	533	1,040	262	34	54	457
	1,380	997	398	31	53	681
	201	1,260	182	26	21	167
	269	868	201	38	38	274
	656	1,220	245	31	33	378
	798	1,100	303	29	28	396
	263	955	185	27	42	315
	283	1,030	195	28	44	351
	773	924	308	27	42	824
	108	1,100	175	30	27	177
	1,350	982	623	26	140	809
	113	873	246	31	32	188
	957	698	1,200	38	48	895
	267	1,080	277	32	48	421
	324	1,100	229	29	33	310
	75	641	127	18	18	99
	498	998	285	30	54	472
	228	902	191	24	24	283
	240	689	136	23	25	189
	269	1,070	193	29	36	265
	293	757	165	24	32	296
	644	604	182	21	30	205
	241	802	189	26	35	291

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
499	899	227	28	39	451
715	906	284	28	64	571
228	666	157	24	51	243
203	1,010	161	24	32	425
200	1,080	179	27	31	235
216	1,050	169	26	32	980
347	682	188	25	49	468
317	564	172	36	51	295
147	259	85	25	44	186
362	855	242	25	43	314
567	754	360	34	51	415
439	842	248	34	42	356
140	1,160	205	29	29	308
985	1,000	479	27	38	579
282	1,130	224	29	30	281
668	1,140	617	39	100	811
252	712	209	27	26	260
160	763	162	26	27	206
1,010	938	348	38	75	733
667	831	216	29	35	404
324	1,050	178	29	34	159
155	1,120	179	30	28	181
> 5000	967	1,140	66	146	3,660
602	1,380	226	33	37	507
210	842	149	27	33	238
248	858	148	28	36	185
121	828	143	27	37	157
156	614	110	18	23	135
109	548	98	17	24	118
124	612	98	18	25	123
29	383	72	13	8	64
423	520	96	18	29	104
47	945	108	25	16	88
206	678	80	14	9	138
95	929	129	23	14	109
94	768	121	21	15	135
173	1,213	154	26	22	208
234	918	164	28	36	253
166	1,126	149	26	19	306
193	1,265	166	25	23	223

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
117	657	132	25	21	130
73	911	136	23	15	119
169	1,194	161	28	23	211
138	1,137	108	20	19	202
10	665	55	14	10	45
17	1,079	88	12	11	70
9	564	52	14	11	60
75	513	162	29	21	258
183	458	115	23	13	143
141	491	137	40	17	218
97	801	114	24	21	139
108	851	96	20	19	129
102	833	109	22	18	159
169	778	124	22	22	210
139	911	117	18	20	168
289	733	149	23	24	331
231	881	146	25	22	247
286	868	164	30	31	436
193	898	139	24	21	226
60	1,435	137	29	18	306
42	1,543	124	24	15	117
63	1,810	173	32	27	152
48	982	118	27	19	145
514	1,060	330	31	71	749
312	941	249	27	49	472
600	1,060	329	32	88	940
329	1,020	197	29	49	551
246	1,000	185	27	46	443
398	864	192	25	42	447
1,360	1,090	277	36	101	2,070
313	934	283	32	70	570
421	776	234	24	93	525
20	311	138	19	34	99
16	320	141	19	37	96
86	856	189	41	31	197
142	728	109	25	30	253
103	647	75	25	24	126
728	729	151	27	133	476
557	507	164	18	15	392
151	551	227	17	13	418

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
514	555	153	18	18	484
233	751	119	16	10	133
816	574	148	17	10	297
33	665	120	17	8	57
634	781	185	35	28	957
539	754	120	23	12	861
652	653	100	36	22	498
192	759	93	22	7	242
154	751	68	19	6	109
258	1,038	103	22	12	268
253	1,010	98	22	12	258
102	1,189	118	21	17	103
11	1,206	86	21	33	175
310	749	76	17	45	308
135	1,083	106	19	17	191
34	389	54	11	21	100
35	465	59	18	20	160
64	551	82	16	29	167
36	614	108	25	19	70
120	795	111	12	10	280
515	384	118	14	18	209
80	689	81	12	25	308
338	392	100	17	25	361
320	463	198	18	31	541
311	553	95	16	34	232
68	643	76	14	15	137
370	336	117	15	17	231
82	318	64	14	19	132
79	529	149	31	32	158
374	684	215	30	140	458
209	438	123	26	45	239
269	623	222	29	55	418
217	604	212	31	55	374
195	650	156	23	38	321
723	454	561	39	392	1,190
143	679	142	24	60	203
197	668	134	26	36	254
66	766	125	22	19	97
116	449	111	24	32	178
220	583	136	23	35	222

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
110	721	137	27	31	216
88	764	124	25	25	146
106	489	142	26	47	218
157	577	133	21	38	239
230	630	183	27	53	285
34	639	129	32	31	116
32	595	146	31	36	120
38	534	124	25	26	99
57	839	154	26	28	119
163	751	210	22	35	191
136	841	162	24	41	180
121	784	154	26	27	157
31	676	127	23	32	150
70	931	153	29	29	326
21	670	123	14	16	85
68	906	165	37	31	143
192	1,170	175	29	59	388
573	828	112	13	18	359
572	845	215	22	40	400
879	552	163	16	21	488
406	579	134	14	15	200
150	542	88	13	8	127
350	500	119	15	14	194
4,400	845	88	27	47	1,967
636	818	122	14	14	635
215	705	91	14	9	145
951	616	107	15	15	343
1,289	774	130	51	1,332	1,070
408	558	78	14	18	474
1,368	826	51	35	119	917
513	514	81	24	18	343
200	472	93	9	9	142
246	496	102	9	8	143
20	9	1	1	1	10
772	512	201	34	77	409
564	336	119	15	71	316
934	369	159	30	73	584
253	590	142	19	14	165
295	574	128	21	17	163
151	534	102	18	11	122

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
538	564	167	21	19	362
562	701	142	29	46	1,261
536	779	130	28	36	683
684	716	199	29	30	747
45	568	94	20	17	90
29	693	106	20	18	82
42	526	80	17	13	64
330	623	144	30	36	378
131	681	150	25	20	157
315	1,010	262	44	35	335
84	285	63	16	5	95
161	374	95	19	8	164
246	515	97	17	19	252
670	705	178	21	28	351
363	605	137	18	21	259
329	347	74	11	48	262
190	283	69	11	11	177
155	298	64	11	7	133
530	763	103	14	22	386
1,689	636	65	11	14	435
129	596	99	16	16	334
57	460	109	19	17	153
65	434	86	19	18	199
56	492	121	22	18	159
126	561	95	24	12	209
60	406	69	20	9	108
66	408	62	17	16	572
199	355	82	18	13	133
152	739	165	26	18	246
204	624	125	24	14	219
328	493	83	17	13	620
197	316	89	20	12	287
269	488	129	20	26	381
45	491	150	30	28	130
278	650	152	27	37	228
288	717	200	33	48	362
121	458	102	24	31	126
511	608	207	29	62	499
116	531	120	25	35	159
8	92	26	7	1	46

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
6	85	29	8	2	43
145	764	64	14	12	253
64	783	90	22	20	181
54	865	84	30	11	100
110	1,185	132	21	24	285
75	1,006	104	24	17	534
33	659	95	18	19	171
31	855	120	14	6	78
17	666	87	21	17	74
1,174	2,597	439	50	82	889
139	1,278	123	17	15	119
369	978	172	26	21	412
82	843	106	26	34	137
204	961	112	23	24	164
59	983	101	19	15	109
311	843	108	23	18	156
92	712	140	11	18	115
191	626	113	14	11	774
91	610	86	13	7	129
112	677	93	11	10	128
27	394	98	30	22	93
78	714	133	23	26	210
75	385	70	28	23	137
79	698	124	23	22	190
41	639	156	17	47	112
201	595	124	22	27	1,010
33	824	88	19	10	88
37	986	111	62	11	93
132	629	87	5	4	64
400	558	151	6	15	237
485	671	121	5	24	233
284	936	140	5	11	231
120	440	43	9	9	91
106	733	85	13	12	130
122	634	81	15	14	219
176	807	89	15	17	206
155	556	49	13	15	140
513	855	152	24	23	597
202	530	83	17	6	193

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
51	460	68	15	10	78
197	550	91	21	17	137
45	333	57	14	8	87
381	1,065	172	27	29	430
320	1,089	158	28	29	345
628	1,048	172	29	44	415
186	729	112	16	15	161
398	585	140	26	42	371
1,051	619	203	29	209	920
180	731	119	16	19	175
164	925	126	18	16	159
214	676	131	22	27	366
212	824	147	20	16	479
128	822	118	17	9	977
412	611	193	21	35	459
74	844	102	16	7	96
57	790	88	13	6	82
110	681	84	12	8	177
155	806	111	15	10	198
370	848	143	21	137	952
185	870	179	23	36	230
117	725	118	13	13	210
66	602	94	11	7	115
107	742	117	14	16	223
463	856	116	19	33	361
187	809	118	13	8	190
65	600	99	16	10	107
457	828	96	12	10	372
229	919	146	40	18	335
235	869	121	75	44	287
243	800	144	80	59	298
179	620	113	19	12	240
210	717	131	20	14	199
140	718	133	18	10	154
177	884	135	16	14	265
262	782	150	19	18	513
355	812	163	18	42	763
261	765	117	30	16	290
215	753	127	22	12	241
259	769	114	34	15	274

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
698	1,073	155	16	36	654
520	1,011	145	18	27	458
514	1,141	151	18	28	474
530	1,200	170	21	26	348
1,490	883	159	26	37	1,047
187	862	165	24	28	232
2,260	941	154	22	39	1,235
1,708	805	155	25	31	910
1,847	896	137	24	33	1,050
131	563	109	15	13	263
137	579	109	16	15	294
141	611	101	15	14	271
156	742	71	4	6	48
147	769	104	4	8	54
146	463	74	4	4	35
150	591	76	3	3	34
134	714	91	4	6	53
796	580	85	5	10	494
1,244	621	119	6	22	501
827	519	130	6	20	452
980	463	160	10	25	653
225	981	131	23	21	344
174	874	120	25	13	313
245	805	124	19	13	256
55	626	85	11	6	64
86	664	89	14	18	106
906	670	91	18	31	786
344	855	104	13	13	204
637	1,456	197	30	36	442
239	940	152	21	37	274
387	1,153	106	13	8	119
109	342	54	8	25	156
422	345	67	16	67	303
524	416	110	22	107	321
1,181	606	172	36	197	616
1,083	593	92	34	166	410
528	729	131	13	19	432
315	695	124	12	18	372
3,154	664	95	19	22	1,678
198	682	68	7	11	97

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
175	555	83	9	9	134
740	583	105	16	14	397
4,278	591	106	16	11	904
64	654	56	7	4	41
164	648	129	17	15	139
318	810	78	9	9	176
205	637	108	12	13	202
27	526	66	9	5	45
767	644	109	15	21	367
1,397	694	105	14	13	585
485	609	137	15	12	324
308	632	106	12	17	190
439	704	124	12	11	247
547	961	124	27	56	281
739	825	159	21	23	399
305	786	163	18	11	360
248	902	127	20	19	192
381	705	134	20	21	335
1,706	732	133	17	18	458
1,324	849	202	20	19	452
511	913	122	22	33	295
1,778	670	60	30	71	1,238
864	882	119	29	60	939
1,144	835	144	27	36	664
750	797	135	24	35	404
397	1,210	127	24	25	332
174	1,219	133	18	16	189
126	1,080	101	19	13	159
328	1,257	133	21	17	327
1,478	944	96	33	98	412
826	1,082	214	16	31	368
238	930	109	12	17	556
369	824	158	15	16	1,565
833	1,112	157	23	129	673
468	869	114	17	36	240
922	2,321	156	34	52	847
458	923	126	16	34	370
492	778	166	20	43	1,454
1,702	830	138	23	40	719
220	1,263	167	21	27	176

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
1,166	766	190	16	19	407
698	917	138	14	20	228
885	737	130	15	13	300
570	538	81	18	52	281
174	715	125	14	12	175
628	763	150	15	20	270
256	764	180	17	24	273
373	575	129	15	30	340
701	764	173	20	36	651
1,616	945	159	28	40	775
155	567	73	12	14	196
263	621	96	16	21	213
45	384	70	12	8	70
2,150	738	81	56	32	1,478
131	637	60	15	15	97
76	865	93	17	12	473
60	605	73	19	11	113
234	973	151	18	18	240
678	876	181	28	46	512
417	838	139	20	26	374
489	816	155	17	20	382
203	748	113	12	16	183
571	879	121	18	34	469
2,602	881	125	25	72	1,453
806	848	125	22	72	702
799	1,074	117	27	120	1,144
1,647	1,147	184	37	166	809
204	898	140	24	27	948
499	973	117	26	29	918
574	1,126	91	28	46	761
477	1,025	114	21	30	377
148	876	112	19	18	215
411	740	112	18	25	190
218	869	116	18	15	207
86	888	107	13	9	115
194	914	102	16	11	191
141	1,020	95	13	9	110
213	628	85	11	13	153
1,008	748	125	18	18	581
872	1,139	119	14	18	303

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	538	757	142	18	15	323
	248	762	104	16	22	185
	180	608	109	13	8	103
	5	352	72	10	8	29
	109	509	79	11	6	151
	295	736	138	13	15	194
	220	619	82	12	17	131
	91	522	45	11	7	146
	312	465	44	11	54	429
	26	488	63	15	21	192
	171	492	60	10	10	275
	281	444	54	16	84	581
	68	428	43	9	5	133
	357	465	42	11	9	465
	213	401	40	9	5	394
	209	534	39	7	6	398
	299	555	38	8	17	348
	276	763	63	15	15	189
	185	504	108	14	13	275
	359	580	134	17	24	337
	331	639	94	15	18	232
	179	726	64	12	20	151
	95	539	81	12	6	118
	162	504	91	11	5	155
	178	506	68	16	15	171
	104	528	64	10	4	147
	178	683	85	13	16	130
	82	601	86	12	10	115
	138	767	91	14	51	358
	107	709	109	12	9	138
	92	692	78	14	27	246
	121	667	105	16	15	151
	345	616	119	20	43	350
	321	585	115	18	25	406
	361	531	134	20	16	411
	269	530	101	16	29	231
	38	544	68	10	5	66
	100	614	81	13	7	127
	68	494	64	10	6	368
	68	735	49	8	5	89

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
81	628	80	12	7	132
74	487	58	11	8	127
115	546	88	16	9	323
97	426	64	14	16	356
224	426	93	14	31	383
104	300	34	8	11	181
601	791	321	33	97	796
175	895	194	24	44	209
366	1,130	199	33	44	305
35	662	71	15	14	112
50	530	66	12	8	161
25	437	63	14	14	100
26	440	62	15	16	77
22	551	87	18	11	83
31	625	97	17	11	99
16	506	81	16	9	72
215	426	127	16	25	270
187	488	94	16	16	206
151	446	92	13	18	183
33	269	41	9	3	44
66	307	49	12	4	57
37	422	52	11	6	80
38	518	72	16	16	778
31	690	53	10	6	41
34	704	64	12	6	44
24	330	60	14	16	53
17	371	86	13	26	86
32	395	117	28	22	106
15	190	20	6	7	34
14	284	40	10	11	32
6	469	59	13	11	53
7	480	59	14	12	57
14	587	87	18	21	76
17	573	92	26	26	111
15	539	81	21	24	82
19	613	80	20	24	78
12	530	83	21	20	75
26	804	80	20	9	42
15	602	60	15	6	36
17	708	72	17	6	33

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
16	337	80	18	8	59
19	357	81	20	11	57
42	354	57	16	8	73
29	357	55	14	10	64
34	424	62	17	8	71
11	825	75	21	18	77
13	430	56	48	29	84
16	392	41	13	13	52
26	402	110	20	13	69
74	636	95	19	12	236
31	833	76	21	17	105
31	765	75	22	17	111
29	816	80	19	13	52
14	485	93	22	21	72
26	490	105	22	26	81
17	594	127	24	29	78
89	516	75	15	9	89
82	669	83	14	8	79
45	645	71	16	7	79
90	852	101	18	8	112
37	878	89	15	5	65
34	571	59	14	7	62
60	579	66	11	6	67
28	357	34	9	5	67
28	498	44	9	4	82
15	296	40	14	5	78
12	508	93	19	24	78
11	691	121	25	20	81
13	634	122	20	38	87
6	359	45	12	10	51
9	537	72	11	8	48
42	260	66	14	6	80
623	700	147	18	32	267
18	249	53	12	7	47
19	294	60	14	8	226
18	184	80	15	8	72
29	222	122	29	27	120
26	1,020	126	20	18	108
29	253	124	29	27	139
40	488	63	15	8	87

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
40	444	67	17	8	82
35	359	60	15	8	72
180	763	131	22	17	184
134	509	107	20	12	155
127	548	84	16	11	140
123	541	93	16	13	156
107	703	96	15	10	181
38	855	122	16	11	70
92	915	127	27	21	255
61	752	96	17	21	116
18	755	103	16	6	33
15	723	99	15	5	35
37	1,174	140	24	11	27
1	341	80	17	9	43
3	588	94	13	10	77
4	533	91	12	9	86
4	431	68	10	4	34
4,717	620	293	75	59	2,596
248	609	128	34	23	298
840	653	216	51	37	761
49	1,024	103	11	8	68
24	975	107	12	7	75
35	878	112	15	9	100
71	366	88	19	9	99
96	491	100	23	10	128
44	380	59	13	6	67
38	219	59	13	6	62
44	279	59	13	5	67
44	376	51	13	5	64
41	289	52	11	4	58
45	381	57	14	6	78
39	229	50	12	5	66
34	419	59	14	5	71
45	317	72	19	7	91
58	304	73	17	7	98
63	315	77	17	7	92
159	576	162	16	12	216
2,785	235	147	12	8	632
467	233	111	16	9	748
540	174	108	9	5	1,342

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	506	456	108	21	20	253
	45	551	45	12	6	74
	116	489	95	19	11	200
	34	504	55	1,183	6	73
	1,183	815	150	19	37	420
	35	496	75	14	8	64
Street						
	7	456	67	14	12	54
	15	380	62	11	10	111
	259	378	78	29	23	256
	358	549	114	19	35	234
	18	649	53	11	8	47
	19	438	63	13	8	76
	69	491	69	14	17	121
	67	450	74	12	12	116
	43	622	64	12	10	72
	50	696	68	14	13	82
	24	388	54	16	13	86
	24	401	59	16	15	100
	13	236	62	12	6	54
	41	432	87	19	10	89
	68	882	106	21	11	124
	47	352	70	16	12	72
	660	756	264	24	29	384
	13	419	81	15	13	61
	292	1,090	158	23	33	313
	73	301	107	27	10	131
	18	624	94	18	11	81
	48	821	127	25	9	101
	33	607	129	24	20	112
	96	475	58	16	11	107
	201	868	94	20	14	135
	115	650	94	19	13	166
	192	521	77	19	20	157
	145	568	116	27	20	185
	32	685	54	15	9	61
	449	719	125	34	35	282
	518	936	168	24	24	360
	86	527	83	23	17	142

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	825	678	212	29	33	604
	132	859	123	24	14	154
	150	481	102	25	13	169
	16	421	54	13	8	41
	22	573	69	16	8	42
	76	818	97	19	10	133
	21	718	105	16	6	29
	158	868	101	25	13	78
	32	578	78	16	6	43
	27	478	68	16	13	41
	36	909	103	11	9	81
	58	958	67	17	12	63
	20	525	73	17	11	31
	237	435	46	20	17	330
	33	414	55	12	5	59
	40	413	61	12	5	62
	206	872	155	17	13	172
	118	275	129	17	17	196
	53	209	32	9	3	47
	91	1,264	98	22	18	162
	33	137	38	9	4	33
	45	580	73	15	8	77
	184	319	85	8	7	181
	321	351	81	9	6	167
	226	428	103	16	29	169
	145	353	96	11	6	134
	19	338	67	8	3	39
	379	472	225	20	31	496
	391	405	90	12	12	255
	650	502	97	15	19	306
	87	874	120	15	7	122
	129	735	85	11	10	100
	23	1,040	199	34	29	124
	196	505	180	33	47	329
	35	620	127	26	24	99
	210	533	222	27	34	294
	451	373	134	24	51	542
	113	534	113	28	33	149
	350	676	236	28	105	520
	172	671	149	29	40	275

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
126	686	122	21	25	174
680	751	483	54	178	1,190
37	879	140	28	23	102
986	453	356	41	888	1,330
284	609	201	29	50	381
161	682	132	28	40	207
62	510	114	23	29	118
201	672	137	25	35	222
76	484	105	24	27	120
92	765	126	30	26	530
96	817	138	28	21	114
68	638	110	21	16	96
86	515	107	22	26	147
397	548	165	33	61	344
226	579	126	27	38	242
183	505	150	23	37	245
363	580	99	30	46	219
73	718	115	24	28	143
80	488	85	20	29	104
294	1,020	257	29	54	340
419	1,080	234	30	55	906
50	1,030	160	29	31	196
218	263	126	24	29	314
1,720	834	969	30	68	2,930
240	346	197	28	62	423
171	864	163	30	195	355
967	1,070	222	32	53	691
211	907	156	22	39	393
259	1,070	245	33	58	411
614	554	252	30	369	1,120
182	1,130	159	29	34	261
440	714	142	35	50	713
136	785	128	22	25	179
47	741	132	29	24	114
35	986	111	20	15	88
14	517	103	22	22	81
61	1,010	139	39	50	176
380	504	142	19	40	357
223	745	145	28	35	204
79	752	129	37	30	170

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	Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
	22	445	125	30	19	84
	60	723	131	19	18	118
	220	1,070	158	26	38	303
	127	827	130	24	23	152
	15	590	104	24	24	88
	33	493	119	12	9	79
	165	547	80	15	7	118
	90	428	71	13	8	94
	49	392	65	13	6	67
	713	596	201	12	9	205
	162	375	57	12	8	95
	470	633	109	14	16	289
	176	528	76	8	6	85
	198	383	70	7	20	104
	542	964	118	17	24	235
	233	419	109	16	19	312
	2,227	643	206	21	69	3,692
	208	883	91	12	12	115
	393	554	104	18	17	190
	129	601	75	17	11	120
	82	913	98	79	13	126
	123	569	93	16	13	147
	393	854	151	16	12	215
	70	620	80	46	9	106
	120	647	118	22	27	119
	30	738	93	22	15	77
	428	711	150	43	38	287
	21	508	59	15	9	93
	333	753	182	29	51	239
	211	603	72	24	18	128
	343	1,183	168	34	36	392
	352	426	93	25	17	237
	835	622	112	24	38	536
	268	488	100	16	18	188
	67	937	96	11	10	105
	245	828	102	15	15	162
	352	527	93	12	7	257
	227	802	123	17	15	271
	117	669	100	14	8	415
	255	578	136	15	11	396

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Pb ppm	Mn pm	Ba ppm	Cr ppm	Cu ppm	Zn ppm
152	1,040	102	12	15	122
2,654	978	186	28	42	1,423
238	1,001	110	12	13	138
172	922	101	14	14	405
89	573	65	3	3	31
156	720	94	4	5	42
158	569	69	4	5	55
911	619	151	5	22	509
159	987	102	15	12	189
95	826	105	13	9	96
635	908	116	13	24	875
511	743	106	16	19	308
258	614	94	11	14	149
1,133	892	91	19	65	1,165
266	899	126	15	16	240
159	528	85	11	19	150
57	877	79	9	14	115
1,433	975	145	21	53	902
110	617	107	13	6	103
36	1,118	109	17	7	87
211	550	84	11	18	172
944	767	115	20	37	1,159
96	814	94	15	13	186
45	606	118	16	11	94
640	924	137	20	42	289
230	995	106	34	25	417
36	608	72	14	19	135
65	183	43	9	5	155
102	102	36	11	16	295
25	439	39	7	4	101
16	123	33	10	3	70
43	493	57	14	9	63
142	991	75	18	7	106
166	500	63	19	13	219
31	488	40	13	7	65
303	387	72	14	9	173
135	702	76	14	13	121
158	1,358	137	30	23	134