Tons of Heavy Metals in Mill Creek Sediments

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Heavy metals may accumulate in the sediment of rivers or creeks. Precipitation results in urban runoff; rain or snow carries heavy metal particles from highways to creeks such as the Mill Creek. Some of the particles are deposited along the banks in sediments (Sansalone 1996). Metal industries dumped their waste products into the Mill Creek, and waste deposits are exposed to erosion by the creek. In addition, every time the sewers overflow, a mixture of raw sewage and storm water goes directly into the Mill Creek.

My objectives for this summer research were to: 1.)   determine how much heavy metal pollution has accumulated in the Mill Creek sediments, and 2.) whether there is a change over time in the amount of pollution in the Mill Creek.

Acknowledgments

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Mill Creek

The Maketewa (Indian name for Mill Creek) was first inhabited by white men in the late 1700's. The creek proved to be useful for grist and saw mills. The Mill Creek soon became overwhelmed with industries.   Paper, woolen, flour, and cotton mills, starch factories, slaughterhouses, distilleries, and tanneries all used the Mill Creek as their main source of power and water, and for disposal of their waste. With the added industry came the added population. Great deforestation occurred especially in the 1880's, which led to many floods and high rates of erosion (Hedeen 1994).

Methodology

In order to analyze soil for pollution, I needed samples. My samples were collected from the Mill Creek bank behind the Valley Supply Company on June 3 and July 10 (figure la). I sampled 160 centimeters of a stratigraphic section, separating the outcrop into layers by looking at color changes and lithology changes. The layers consisted of clay/silt separated by thin sand lenses. All (13) layers were sampled; two or three samples per layer, for a total of thirty-six samples. Each of the samples in a single

layer was approximately thirty cm apart laterally. I used a shovel, trowel, and knife to extract the samples, and then placed them into plastic ziploc bags.

I soon realized that I needed reference samples in order to compare polluted Mill Creek sediment with non-polluted Mill Creek sediment. So on August 18, I collected three samples from lake clay at a construction site at Mitchell Ave and I-75. Another reference sample was collected from the Mill Creek near Tylersville Road, and my last sample was from a small tributary to the Mill Creek near Rial to (figure Ib).

From the Mill Creek at Tylersville Road, I removed the sample from a depth of about ten centimeters. There is a possibility that the sediment was not completely natural since a housing development was recently constructed and the creek had moved. There
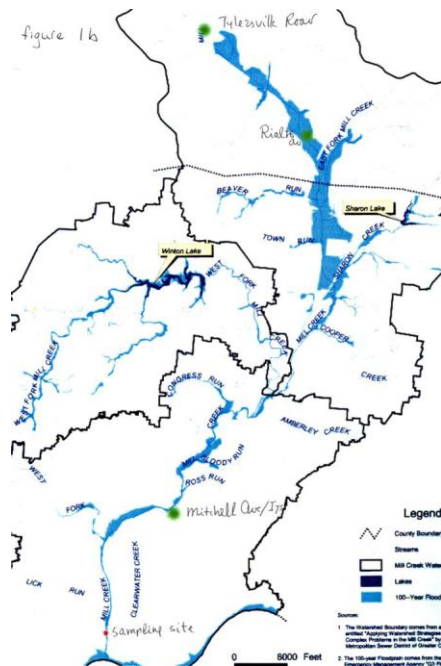
was also construction at Rialto. The floodplain was being raised for development. I took the sample from the surface of a small tributary to the creek.

I then moved into the laboratory. I let each sample dry overnight in a heated oven. For samples numbered 1-5, I used a tungsten mill to obtain a fine powder for the x-ray florescence spectrometry (XRF). For samples 6-9, I used a ceramic mortar and pestle for grinding, and used the fraction that passed through the #140 sieve for XRF analysis. The coarser fractions appeared to be only aggregates because the sediment could easily be ground between my fingers.

However, I did leave one of the samples (6c) in its size fractions and ran each through the XRF (figure 4). For samples 10-14 and the reference samples, I grounded the entire sample in a steel ball mill.

I was extremely careful throughout my research to prevent cross-contamination by thoroughly washing or wiping clean each apparatus between each sample. I used XRF for all data analysis, with the results presented in figures 2-5.

Results

Figure 2 is useful to show how much more lead, zinc, and copper there is compared to what is in sediment naturally. The x-axis represents the average value for each metal of the polluted samples. The y-axis represents the average value for each metal for the reference or base samples. The Ix line represents non-polluted sediment. The 2x line shows pollution by heavy metals twice the base level value, and so on.

Figure 3 gives a clearer view of the amount of pollution. The x-axis represents the metals of each layer averaged and divided by the reference amounts. The y-axis is the depth in centimeters. Lead, zinc, and copper totals are astonishing when compared to the other metals measured.

Most laboratories use bulk samples (do not separate by layers) for analysis (Tan 1996). Figures 4 and 5 show the differences among each sample at each depth. Figure 4 also raises the question of grain size analysis. Scatter plots show that many of the metals have no pattern, which asks the question of are layers, and the samples themselves, homogeneous? Figure 5 shows the clearest variance of lead abundance for each sample versus depth.

Interpretation and Discussion

I calculated that one kilometer of sediment on the Mill Creek bank between the Western Hills viaduct and the 8th Street viaduct contains about nine tons of pollution of lead, zinc, and copper. I estimated the bank to be three meters high and five meters wide. I used the averages of those three metals minus the reference averages in order to obtain pollution. Nine tons of pollution is a ridiculously large number. How could man overlook the pollution for so long? That total is almost worth opening up a mine in the area to pay for the clean up, if it weren't for the hazardous waste site just a few meters away.

Most professional laboratories homogenize their sample in the field and the lab. Many use only one or two samples to represent an entire field. All laboratories use only the fine-grain fraction for analysis. My research shows that even at the same depth the amount of metal in a sample can vary greatly. Angle et al. (1998) also found that results could vary greatly from sample to sample. The testing for lead in samples using only one to two grams of the sample, "representative samples," resulted in wide ranges of the total lead. Possible causes for the variances were homogenization procedures in the field and lab, extraction procedure, soil matrix, or uneven lead in soil.

By looking at figures 3 and 5 the wide variances of lead for each depth is evident. The samples I measured range as much as 4 times greater to 37 times greater than the average of the references. This variance could mean the difference between the soil being labeled hazardous and it not.

This pollution has accumulated extremely quickly. I found pieces of colored plastic less than a meter deep, and clear plastic about a meter and a half deep. So there is a fast rate of sedimentation since plastic, especially colored, is not more than thirty years old.

The rate of pollution is decreasing today. The top layer of soil had the least amount of lead, zinc, and copper. Lead has low solubility, degradation, and there is little evidence of leaching (Alloway 1995). So lead is not moving to anywhere else. There is a slight problem with my conclusion, though. The top layer at the polluted Mill Creek site is mostly sand-size particles. Sand is not measured in laboratories for heavy metals because quartz grains have little ability to absorb metals (Alloway 1995). So there is a possibility that the top layer samples are not of good quality for my measurements.

Future Research

Research is never finished. Upon completing this research several questions came to mind that I either didn't have the time or the means to answer. Where did all this pollution come from? How was it deposited? Is the Mill Creek one of the sites with the fastest sedimentation rate known to geologists? What is the rest of the stratigraphic section like? Does a pattern develop? Why do my samples vary laterally?

There is not a single number for the maximum amount of lead allowed in soil. The EPA varies from 500 PPM for residential to 10,000 PPM for industrial areas (Angle et al. 1998). This total even varies from state to state. My average for lead is 256 PPM, which is higher than what is in my reference samples, but that number is well below the need for any action. However, two of my samples were above 500 PPM. Should the soil be labeled hazardous or should those two numbers be thrown out? Are bulk samples representative of the whole area in question?

Conclusion

Heavy metals have accumulated in the sediment of the Mill Creek. Heavy metals do not deteriorate with time; this soil must be treated. The practice of taking bulk representative samples may not give reliable answers. My samples varied quite significantly, and the average number is not a fair representation for the whole vertical section. This is important because sediments that are not polluted according to EPA standards, might be polluted when sampled a meter away.

References

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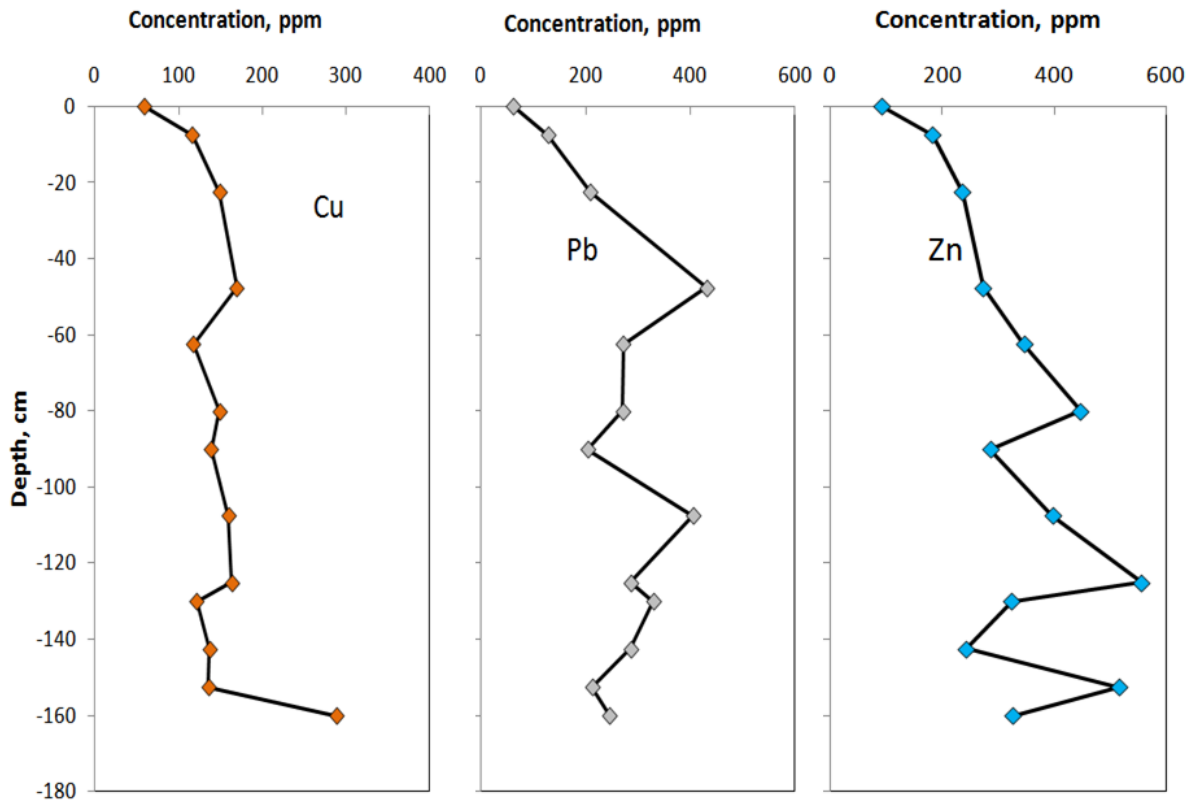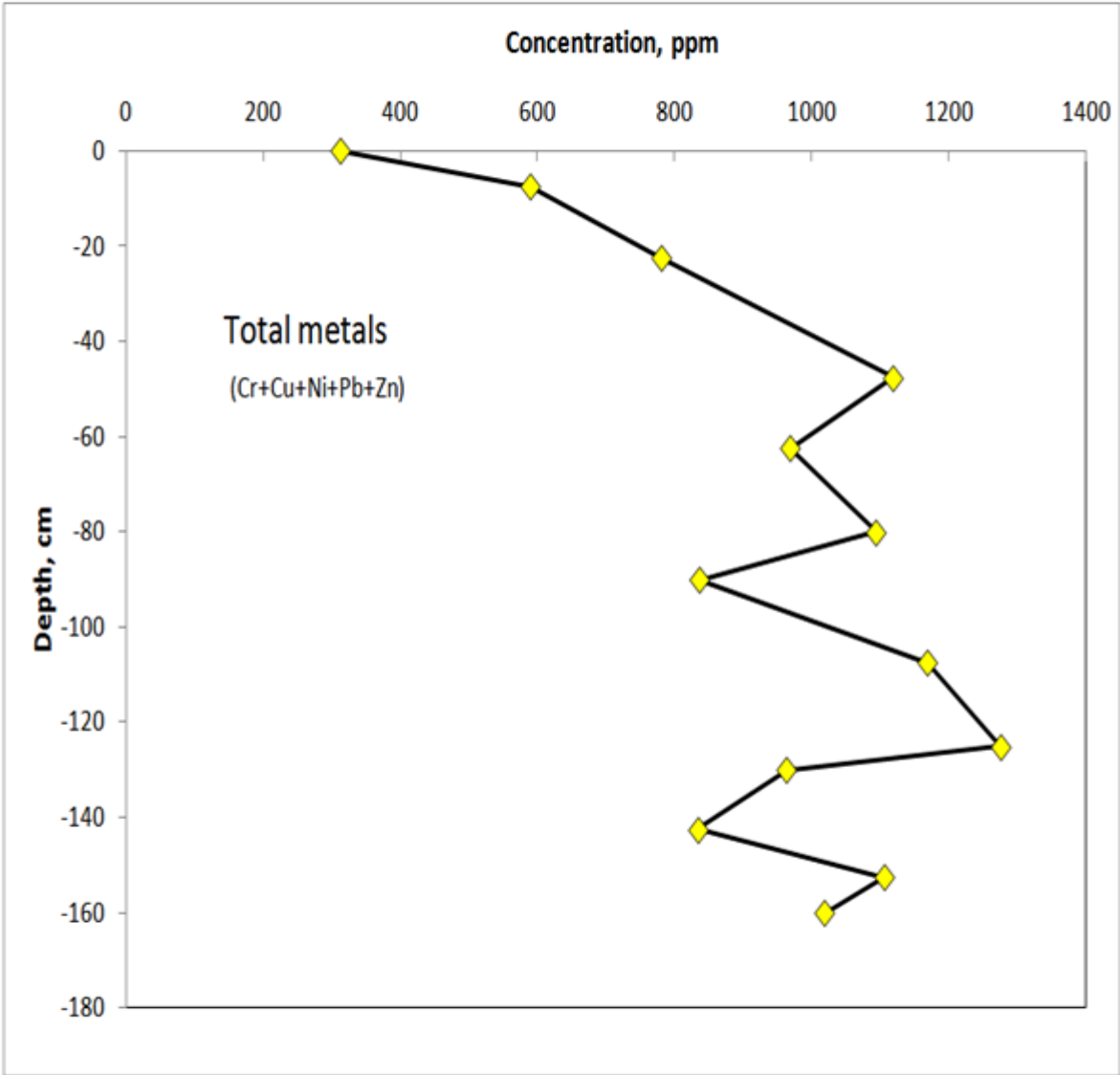
Mill Creek alluvium	Depth (cm)	Cr ppm	Cr Ratio to bkgrnd	Cu ppm	Cu Ratio to bkgrnd	Ni ppm	Ni Ratio to bkgrnd	Pb ppm	Pb Ratio to bkgrnd	Zn ppm	Zn Ratio to bkgrnd	Total metals Cu+Cr+Ni+Pb+Zn
Mill Creek Rd	0.0	52	1.06	59	2.79	49	0.93	62	4.51	91	1.62	313
	-7.5	86	1.75	116	5.47	77	1.47	128	9.31	183	3.24	590
	-22.5	99	2.01	149	7.01	89	1.70	209	15.19	236	4.18	781
	-47.5	141	2.88	169	7.98	105	1.99	431	31.31	272	4.83	1118
	-62.5	134	2.73	118	5.55	101	1.91	271	19.71	345	6.12	968
	-80.0	133	2.71	149	7.00	94	1.79	271	19.70	446	7.92	1093
	-90.0	120	2.45	139	6.55	87	1.65	204	14.83	286	5.07	836
	-107.5	125	2.55	159	7.50	82	1.56	405	29.46	397	7.04	1169
	-125.0	131	2.66	163	7.70	138	2.63	286	20.81	556	9.85	1274
	-130.0	110	2.25	121	5.72	79	1.49	328	23.88	324	5.75	963
	-142.5	84	1.71	137	6.44	86	1.63	286	20.77	242	4.29	834
	-152.5	112	2.29	135	6.38	130	2.47	212	15.44	515	9.14	1105
	-160.0	77	1.56	288	13.57	83	1.58	245	17.84	326	5.77	1019
	Average	108	2.20	146	6.90	92	1.75	257	18.67	325	5.76	928

Background samples

		Cr ppm		Cu ppm		Ni ppm		Pb ppm		Zn ppm		Total metals Cu+Cr+Ni+Pb+Zn
Rialto Tributary	a	42		18		46		14		49		169
Tylersville glacial lake clay	b	44		17		45		16		55		176
glacial lake clay	c	41		21		54		12		48		176
glacial lake clay	d	62		25		60		14		68		228
	e	57		24		58		13		63		216
	Average background	49		21		53		14		56		193

Samples from creek bank at Mill Creek Rd	Depth (cm)	ppm Ba	ppm Cr	ppm Cu	% Fe2O	% MnO2	ppm Mo	ppm Nb	ppm Ni	ppm Pb	% TiO2	ppm Zn	ppm Zr
990603-53	0.00	195	37	46	2.34	0.06	2.14	6	37	74	0.20	83	176
990710-143	0.00	266	60	77	4.51	0.13	6.31	13	63	69	0.69	136	373
990710-14b	0.00	243	56	78	3.35	0.10	7.95	11	51	51	0.64	81	471
990710-140	0.00	179	56	35	5.41	0.08	4.14	7	44	55	0.39	65	311
990710-133	7.50	290	85	112	4.89	0.13	5.28	14	76	126	0.71	183	287
990710-13b	7.50	301	79	120	4.93	0.13	4.31	13	76	126	0.71	183	286
990710-130	7.50	272	93	117	4.74	0.13	4.37	13	79	132	0.68	181	296
990710-123	22.50	298	97	150	5.37	0.13	6.41	15	88	216	0.74	240	245
99071 0-12b	22.50	317	103	155	5.37	0.13	4.42	15	90	215	0.75	236	255
990710-120	22.50	316	96	141	5.32	0.13	6.22	15	90	196	0.74	231	260
99071 0-11 a	47.50	430	126	163	5.53	0.15	4.80	15	96	396	0.76	264	234
99071 0-1 1b	47.50	377	170	177	5.38	0.15	6.24	16	117	384	0.74	285	247
99071 0-1 1C	47.50	416	129	169	5.58	0.17	6.96	15	101	512	0.75	269	241
990710-103	62.50	309	118	112	4.80	0.12	6.81	16	91	288	0.75	304	332
990710-10b	62.50	320	152	128	4.85	0.12	6.27	18	114	275	0.74	395	284
990710-100	62.50	299	132	113	4.55	0.12	5.61	17	97	251	0.72	337	303
990710-93	80.00	342	116	132	6.13	0.13	3.93	15	90	187	0.77	394	225
990710-9b	80.00	358	130	143	6.14	0.13	5.32	16	93	212	0.77	430	225
99071 0-9C	80.00	379	153	171	5.30	0.12	5.24	16	100	413	0.72	516	232
990710-8a	90.00	340	105	134	5.84	0.14	4.47	14	77	192	0.71	284	255
99071 0-8b	90.00	329	107	131	5.38	0.14	4.14	13	85	180	0.71	272	253
990710-80	90.00	335	149	152	4.68	0.11	5.77	14	98	240	0.71	301	297
990710-7a	107.50	391	125	154	5.69	0.13	5.48	14	80	347	0.77	385	266
990710-7b	107.50	515	147	183	5.64	0.13	4.73	13	88	609	0.76	517	271
990710-70	107.50	382	104	141	5.67	0.12	5.31	14	77	260	0.74	289	267
990710-63*	125.00	348	94	140	5.26	0.14	4.93	14	74	273	0.73	328	309
	125.00	347	100	138	4.87	0.13	4.73	13	83	267	0.72	327	310
	125.00	330	104	138	4.79	0.13	5.35	14	79	271	0.73	330	311
990710-6b	125.00	374	101	146	5.52	0.15	5.27	15	81	312	0.78	330	276
990710-60(14-20)	125.00	518	149	154	6.89	0.13	6.37	14	166	227	0.76	685	275
990710-60(35-60)	125.00	635	174	191	5.00	0.13	8.10	13	227	300	0.75	892	294
99071 0-60 (120-pa	125.00	876	193	237	4.65	0.14	7.54	11	260	353	0.71	997	331
990603-1 a	130.00	403	106	108	5.53	0.12	4.16	15	76	255	0.75	286	273
990603-1 b	130.00	431	115	135	5.66	0.11	5.19	15	81	43	0.76	362	262
990603-2a	142.50	361	79	122	4.18	0.12	5.73	12	80	250	0.52	224	280
990603-2b	142.50	385	88	151	4.21	0.11	6.08	12	91	321	0.52	260	284
990603-33	152.50	406	92	106	5.18	0.13	5.14	14	89	162	0.68	297	286
990603-3b	152.50	622	132	164	4.87	0.13	5.52	13	170	262	0.67	734	300
990603-43	160.00	328	83	288	3.51	0.09	5.04	12	84	236	0.50	341	278
990603-4b	160.00	316	70		4.18	0.08	4.50	10	82	255	0.35	310	205

	Depth (cm)	ppm Ba	ppm Cr	ppm Cu	% Fe2O	% MnO2	ppm Mo	ppm Nb	ppm Ni	ppm Pb	% TiO2	ppm Zn	ppm Zr
averages at each depth	0.00	221	52	59	3.90	0.09	5.13	9	49	62	0.48	91	333
	-7.50	288	86	116	4.85	0.13	4.65	13	77	128	0.70	183	289
	-22.50	310	99	149	5.35	0.13	5.68	15	89	209	0.74	236	253
	-47.50	408	141	169	5.49	0.16	6.00	15	105	431	0.75	272	241
	-62.50	309	134	118	4.74	0.12	6.23	17	101	271	0.74	345	306
	-80.00	360	133	149	5.86	0.13	4.83	16	94	271	0.75	446	228
	-90.00	335	120	139	5.30	0.13	4.79	13	87	204	0.71	286	268
	-107.50	429	125	159	5.67	0.13	5.18	14	82	405	0.76	397	268
	-125.00	490	131	163	5.28	0.14	6.04	14	138	286	0.74	556	301
	-130.00	417	110	121	5.59	0.12	4.67	15	79	328	0.75	324	267
	-142.50	373	84	137	4.19	0.12	5.90	12	86	286	0.52	242	282
	-152.50	514	112	135	5.02	0.13	5.33	13	130	212	0.68	515	293
	-160.00	322	77	288	3.84	0.08	4.77	11	83	245	0.43	326	242
all depths	Average	367	108	146	5.01	0.12	5.32	14	92	257	0.67	325	275

Background samples

		ppm Ba	ppm Cr	ppm Cu	% Fe2O	% MnO2	ppm Mo	ppm Nb	ppm Ni	ppm Pb	% TiO2	ppm Zn	ppm Zr
Rialto Tributary	a	211.2	42.4	18.0	3.5	0.1	3.0	9.1	46.4	13.7	0.5	48.6	195.0
Tylersville	b	224.9	43.9	17.1	3.7	0.1	1.6	9.2	44.8	16.0	0.5	54.6	211.2
glacial lake clay	c	192.5	40.7	21.5	3.4	0.1	3.9	8.6	53.7	12.1	0.4	48.2	140.1
glacial lake clay	d	288.9	61.5	25.5	5.5	0.1	3.2	12.7	59.6	13.6	0.7	67.6	144.5
glacial lake clay	e	256.6	56.9	24.1	4.7	0.1	2.2	12.6	58.3	13.4	0.6	63.0	160.6
	Average bkgr:	234.8	49.1	21.2	4.2	0.1	2.8	10.4	52.5	13.8	0.5	56.4	170.3