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Metallic Contaminants in Street Soils of Moncton, New Brunswick, Canada

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In recent years, a good deal of attention has been focused toward the analysis of metal contents of street dusts and soils. Elements of major concern from health hazards view point are Pb, Zn, Cd, Ni and Cu, since these are known for their toxic effects toward living organisms. Some of these elements result from automobile exhausts while others result from industrial operations. Several studies conducted in the recent past (PAGE & GANJE 1970, DAY et al. 1975, SMITH 1976, ARCHER & BARRATT 1976, FARMER & LYON 1977, DUGGAN & WILLIAMS 1977, HO 1979) have shown that elevated Pb concentrations in street soils of industrialized and/or populated cities result from increased automobile circulation. In addition the elements Zn, Ni, Cu and Cd also result from the industrial operations and the daily usage of the industrial products (e.g. wearing off the rubber tires on motor vehicles). GISH & CHRISTENSEN (1973) in their study have shown that Zn and Cd levels are also related to increased traffic density in a metropolitan area.

In our study we have attempted to evaluate similarly metallic and saline contamination in the street soils of the city of Moncton. It is a small and relatively non-industrialized town (pop. 80,000) situated in eastern Canada. The elements Pb, Cd, Zn, Mn, Fe, Cu, Na and Ca in street soils have been determined by atomic absorption and flame photometric procedures. The objective was to compare such data with those of the larger industrial towns, where such contaminants have been encountered and documented.

MATERIALS AND METHODS

Sampling of street soils was done in the summer months of 1979 and altogether 22 sampling sites were chosen to cover the avenues and boulevards of high automobile circulation and some side streets with limited traffic density.

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Soil samples were collected by scratching one square foot zone of a clear and vegetation free area. The street soil to 2.5-cm depth was procured and transfered to clean plastic bag and sealed until analysis. Samples from the beginning of the asphalted road surface until about 7 meters distance were collected from any particular site. However, only one sample was collected from the side streets, where traffic circulation was known to be very small.

In the laboratory, samples were homogenized using a mortar and pestle and screened through 40-mesh sieve. The sieved fraction was dried in an oven at 125°C for 4 h before analysis.

ANALYSIS OF Na^+ AND Ca^{2+}. These contaminants essentially result from the usage of winter salts on the streets. One g of dried soil sample was treated with 10 mL of 1.0M CH_3COONH_4 and thoroughly agitated on a mechanical shaker for about 10 min. The system was subsequently filtered into a 100-mL flask and soil washed twice with 25-30 mL of double distilled water and volume completed to mark. The Na^+ and Ca^{2+} contents of the filterate were analysed using flame photometer. Actual analysis in each case was completed by using a standard calibration curve for Na^+ or Ca^{2+} prepared in the same amount of 1M CH_3COONH_4 to partially neutralize the matrix effects.

HEAVY METALS ANALYSIS. A 10 g dried soil sample was taken and digested with 20 mL of 1:1 (1N HCl and 1N HNO_3) by placing the sample in a pyrex beaker at 70-75°C for at least 2 h. Once again filteration and washings were combined to obtain 100 mL final volume. The concentration of each element was determined using an atomic absorption spectrophotometer in acetylene-air mode. The analytical data in this case were obtained from a calibration curve for each element of interest in a similar acidity solution. The Fisher Certified AA Standards were employed for the preparation of calibration curves.

RESULTS AND DISCUSSION

The analytical procedures employed here have been tested earlier and recommended for such studies.

TRIPP & NADEAU (1974) have already shown that ammonium acetate is an effective extractant for Na^+ and Ca^{2+} from soils. They found 2 min of agitation and extraction for these elements to be adequate for flame photometric work.

OLIVER & KINRADE (1972) found the (1:1) HCl, HNO_3 mixture to be useful for the quantitative extraction of Pb, Zn, Cu, Co, Ni, Fe, Mn, Hg and Cr from river sediments. Our procedure is an adaption of their method with slight modifications in terms of digestion period.

Data on the metallic contaminants in the street soils of Moncton are summarized in Table 1. Variations of these contaminants with distance are recorded in Table 2. No definite trend is evident from the analytical data in Table 1, except that Fe has the highest concentration, while Cd has the lowest value. Nonetheless all the heavy elements Zn, Cd, Cu, Pb, Fe, Mn and lighter elements Na and Ca have been detected in the street soils of Moncton.

Some trends, however, do emerge from data in Table 2. One observes a decrease in Pb concentration as distance from asphalted surface increases. Similar trend holds in the case of Cu and Zn as well. The elements Fe and Mn on the other hand do not appear to be affected by distance since their concentrations remain more or less consistent. It is therefore presumed that Fe and Mn do not vary with environmental variations and the concentrations recorded are their natural occurrences. The other metallic contaminants Pb, Zn, Cu and Cd show decreased concentrations and this pattern obviously relates to the environmental emissions from unnatural sources. Earlier observations by other authors have clearly demonstrated that emissions from automobiles and industrial operations deposit metallic contaminants in the immediate vicinity of the discharge point. This study shows a similar behavior and the contaminations arising from Pb, Zn, Cu and Cd can therefore be attributed to automobile traffic circulation in Moncton like other big metropolitan areas.

The distribution trends of Na and Ca on the other hand are very inconsistent to offer a reasonable interpretation. These elements occur naturally and in addition are added onto the streets to circumvent winter snow problems. Since snow clearing operations by mechanical means can easily alter their distribution pattern and perhaps for this reason no trend can be established within a short interval of about 7 meters. Obviously sampling over an extended distance of several hundred meters from the asphalted surface shall be necessary to establish their concentration profile.

TABLE 1. Analytical data for metallic contaminants on street soils
|mg/g soil (end of asphalted surface - 0 m)|

Road/Street	Pb	Cd	Cu	Zn	Mn	Fe	Na	Ca	Remarks
Elmwood	0.48	0.0013	0.033	0.116	0.27	3.27	0.19	1.83	H.T.
Main Street	1.50	0.0013	0.049	0.265	0.27	3.35	0.87	0.89	H.T.
Causeway	0.43	0.0014	0.043	0.113	0.26	3.30	0.13	0.64	H.T.
Mountain Road	0.55	0.0013	0.052	0.229	0.28	3.26	2.91	1.28	H.T.
High Street	0.42	0.0011	0.057	0.166	0.28	3.38	0.12	0.56	H.T.
Church Street	0.65	0.0012	0.044	0.162	0.29	3.36	0.69	0.93	H.T.
Killam Drive	0.52	0.0013	0.048	0.137	0.29	3.36	0.85	1.18	H.T.
John Street	0.56	0.0012	0.162	0.176	0.26	3.32	0.26	1.43	H.T.
Lewisville Road	0.18	0.0011	0.033	0.099	0.33	3.40	0.25	1.42	H.T.
Botsford	0.45	0.0011	0.047	0.118	0.26	3.27	0.21	0.64	M.T.
Steadman/George	0.43	0.0012	0.028	0.117	0.22	3.32	0.19	0.66	M.T.
Champlain Street	0.46	0.0009	0.039	0.151	0.32	3.23	0.16	1.23	M.T.
Connought/Morton	0.41	0.0008	0.029	0.103	0.37	3.36	5.72	2.29	M.T.
Archibald	0.60	0.0012	0.036	0.135	0.27	3.32	5.61	1.60	M.T.
Mount Royal	0.25	0.0011	0.047	0.118	0.26	3.27	0.21	0.64	M.T.
McLaughlin	1.39	0.0014	0.051	0.279	0.27	3.35	0.12	0.70	M.T.
St. George	0.37	0.0009	0.029	0.075	0.26	3.23	0.21	1.12	M.T.
Edinburgh	0.19	0.0010	0.033	0.076	0.29	3.27	0.42	1.07	L.T.
Mill Road	0.04	0.0004	0.006	0.031	0.14	3.04	0.19	0.96	L.T.
Edinburgh/Gulf	0.22	0.0008	0.029	0.053	0.25	3.17	0.31	0.86	L.T.
Pacific	0.44	0.0014	0.051	0.133	0.35	3.40	0.12	1.60	L.T.

H.T. - High traffic
M.T. - Medium traffic
L.T. - Low traffic

TABLE 2. Variation of metallic contaminants with distance

Road	Pb	Cd	Cu	Zn	Mn	Fe	Na	Ca	Remarks (approximate distance)
Edinburg	0.15	0.0010	0.028	0.080	0.32	3.26	0.30	0.90	3.5 m
	0.09	0.0080	0.025	0.063	0.36	3.32	0.28	1.51	7.0 m
Lewisville	0.29	0.0013	0.036	0.100	0.29	3.32	0.30	0.99	3.5 m
	0.19	0.0008	0.024	0.072	0.24	3.26	0.30	1.43	7.0 m
St. George	0.03	0.0007	0.013	0.030	0.26	3.14	0.40	1.09	3.5 m
	0.02	0.0006	0.014	0.038	0.23	3.21	0.21	0.93	7.0 m
Steadman/George	0.34	0.0009	0.031	0.107	0.29	3.26	0.09	0.84	3.5 m
	0.13	0.0011	0.017	0.063	0.33	3.19	0.14	0.48	7.0 m
Elmwood	0.24	0.0008	0.022	0.076	0.29	3.26	1.30	1.33	3.5 m
	0.06	0.0009	0.012	0.045	0.22	3.21	0.56	3.07	7.0 m
Edinburg/Gulf	0.13	0.0009	0.025	0.075	0.25	3.30	0.22	1.54	3.5 m
	0.07	0.0007	0.014	0.047	0.30	3.14	0.15	1.07	7.0 m
Main Street	0.30	0.0007	0.026	0.099	0.28	3.14	0.57	1.12	3.5 m
	0.05	0.0003	0.007	0.035	0.23	2.94	0.52	0.83	7.0 m
Mountain Road	0.40	0.0009	0.037	0.171	0.27	3.21	0.81	1.02	3.5 m
	0.35	0.0010	0.035	0.153	0.32	3.23	0.16	1.23	7.0 m
Champlain	0.31	0.0008	0.037	0.130	0.33	3.19	0.89	1.33	3.5 m
	0.14	0.0005	0.025	0.073	0.31	3.13	0.68	0.95	7.0 m

From the public health view point, it is the concentration of heavy metals that remains of paramount interest. A comparison has been made in Table 3 of Pb concentration in street soils of Moncton, with that found in the larger metropolitans.

TABLE 3. Comparative data on Pb concentration (mg/g dry soil)

Location	Pb (mean 0-8 meters)	Reference
Hong Kong	2.97	HO 1977
Birmingham (U.K.)	1.63	ARCHER & BARRATT 1976
Glasgow (U.K.)	0.96	FARMER & LYON 1977
London (U.K.)	1.20	DUGGAN & WILLIAMS 1977
Manchester (U.K.)	1.89	HARRISON 1979
Washington, D.C. (U.S.A.) (Vicinity)	0.54	LANGERWERFF & SPECHT 1970
Chicago (U.S.A.)	3.69	KHAN, COELLO & SALEEM 1973
Moncton (Canada)	0.28	This study

The principal source of this element has unquestionably been established to be due to the automobile exhaust emissions. The results of this study show that average value for Pb concentration for the city of Moncton is lower than compared to big cities such as Chicago, Washington, D.C. or Hong Kong. Once again the volume of the traffic density appears to be the determining factor for Pb distribution, e.g. the mean daily vehicle circulation (24 h average) at the busy sampling sites in Chicago (53,500), Washington (34,000) and Hong Kong (25,300) is much larger compared to Moncton (15,400) and this in turn tends to deposit increased quantities of Pb on the street soils of the larger metropolitans. The meterological factors such as direction of prevailing

wind and precipitation can influence distribution of metallic contaminants.

Such a study therefore simply reflects a trend relating to the distribution of metallic contaminants resulting from the environmental changes brought about by the increased automobile circulation or similar occurrences.

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