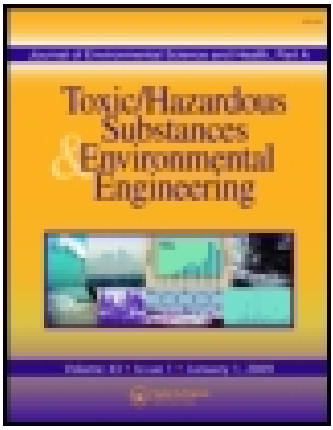

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A multielemental analysis of colombo roadside dust

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A MULTIELEMENTAL ANALYSIS OF COLOMBO ROADSIDE DUST

Keywords: metals, street dust, EDXRF, Br, Pb, Zr, Ti.

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ABSTRACT

Colombo street dust is analyzed for a variety of elements. It is shown that traffic is the main source for Pb and Br. Ti and Zr levels are high but natural. Most other elements are in the range of reported normal natural background levels.

INTRODUCTION

The metropolitan region of Colombo, Sri Lanka, is estimated to have more than 3.5 million inhabitants (1979: 1.8 millions [1, 2]).

Colombo's main streets are highly congested with all kinds of vehicles. A crude assumption is that at least 20% of all registered motor vehicles (1984: 410,000 [3]) ply in and around Colombo.

Sri Lanka imports crude oil mainly from the Middle East, the refinery is situated 15 km from Colombo city center.

Local gasoline contains upto 1 g Pb / l.

MATERIALS AND METHODS

15 road dust samples were collected in March 1989, after 3 months of dry weather. The prevailing wind direction during that period had been north-east (from inland).

The samples were taken from road surfaces and curb edges and stored in glass bottles. Each sample represents a mixture of three subsamples taken 1 meter apart from each other.

Samples 1, 5, 6, and 10 are from heavily trafficked main roads of the city center; 2, 3, 4, 7, and 9 from less frequented center streets; 8 and 11 from residential areas with little traffic; and 12, 13, 14, and 15 from outskirt roads leading to the industrial areas (see also Figure 1).

Sample preparation and analysis:

0.4 g of the air-dry fraction of <100 μm (dry sieved) were mixed with 0.1 g of "Hoechst-Wachs C"

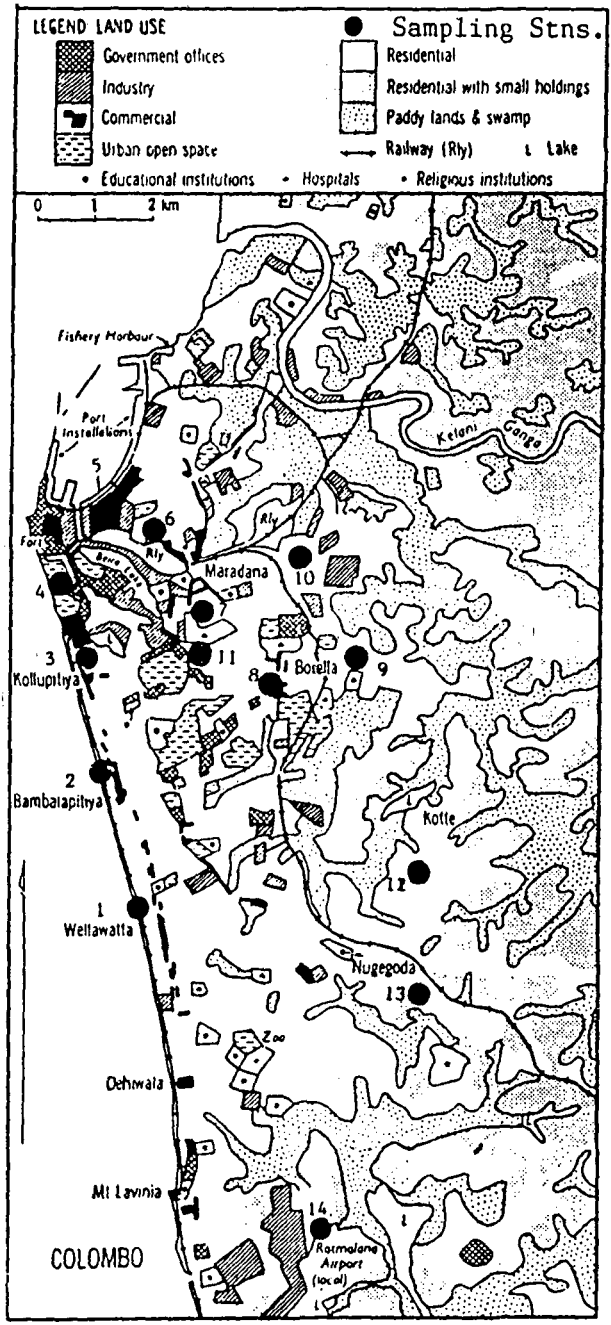

Fig:1 Colombo Urban Land Use (4)

(used as a binder) and pressed to pellets. 2 pellets were prepared of each sample.

The samples were analyzed by means of Energy Dispersive X-Ray Fluorescence Spectrometry (EDXRF) at 12 mA, using a Sn secondary target; measuring time was 1000 s. For technical details of EDXRF, see e.g. [5].

The results were determined by "Matrix 3", a matrix correction program implemented by S. Uffelmann ([6], and pers. comm.).

RESULTS AND DISCUSSION

The detected elements and their concentrations in Colombo street dust are listed in Table 1.

For statistical analysis, Cr and As values below the detection limits were recalculated as 3/4 of the respective detection limit in order to keep a uniform pool.

Correlations are shown in Table 2.

The concentrations of Pb and Br are above the natural background levels of <40 and around 10 mg/kg, resp. At a highly significant correlation of .8, and good agreement with the respective traffic density, it is concluded that both elements are mostly if not solely traffic-induced: Typical Br-Pb ratios of industrial emissions are reported to be <0.037 [7], while gasoline (if leaded it has to contain scavengers,

TABLE 1
Concentrations of elements in Colombo street dust (mg/kg)

Probe	K	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Zn	As	Br	Pb	Rb	Sr	Zr	Nb	Br/Pb
sril01	9124	23070	11540	<108	483	43570	36	31	445	17	120	641	44	251	783	27	.19
sril02	10350	17000	5898	< 95	304	41330	<19	152	526	12	62	278	54	204	413	15	.22
sril03	9330	16870	8788	230	281	48710	<22	22	289	22	23	242	48	181	655	22	.10
sril04	14465	35780	10010	190	595	52550	26	70	867	21	23	199	81	325	864	25	.12
sril05	18740	24420	10130	<104	652	52880	56	95	942	26	65	380	100	282	1019	23	.17
sril06	10270	19320	9077	147	496	52660	35	73	800	30	63	653	72	221	1042	23	.10
sril07	12330	19830	10200	173	455	38320	33	35	297	15	18	138	78	195	926	29	.13
sril08	8341	15970	14460	180	413	40970	<19	35	310	18	47	270	48	172	1509	33	.17
sril09	7138	17520	7017	138	380	56520	<21	66	267	<10	44	292	52	206	857	17	.15
sril10	14190	28910	9997	273	610	78760	43	250	1715	22	25	323	90	296	1019	24	.08
sril11	8453	28620	12200	407	762	13040	<36	71	480	28	20	161	52	234	1382	22	.12
sril12	13490	39550	9770	207	605	60350	<22	60	682	14	21	186	76	263	777	21	.11
sril13	11880	29380	15730	< 97	689	62570	<22	97	698	30	16	226	71	296	1504	40	.07
sril14	11320	16380	8735	< 87	461	49510	<26	40	1011	11	52	201	80	155	768	21	.26
sril15	5318	33710	6079	144	378	45740	<18	49	640	23	26	207	34	297	734	20	.13

often Br compounds) usually has an ethyl ratio of around 0.4 upto 0.6 (ibid.).

The mean Br/Pb ratio here is 0.14. As Br is volatile the original ratio as exhausted by cars can be detected in airborne samples but usually not in aged sedimented dust, although this does not hold for extremely dry and dusty conditions [8].

The third element the concentrations of which do most probably represent not only background levels is Zn. Normal soils contain 10-300 mg/kg (c.f. [10]), while the Colombo dust ranges from <300 to 1700 mg/kg.

TABLE 2
Correlations of elements in Colombo street dust
(signif.: *=<.01; **=<.001)

Correlations:	K	CA	TI	CR	MN	FE
K	1.0000	.2620	.1870	-.1256	.5130	.4131
CA	.2620	1.0000	.1077	.2970	.5956*	.2178
TI	.1870	.1077	1.0000	.1505	.5820	-.0576
CR	-.1256	.2970	.1505	1.0000	.3512	-.3123
MN	.5130	.5956*	.5820	.3512	1.0000	.0288
FE	.4131	.2178	-.0576	-.3123	.0288	1.0000
NI	.6249	-.2296	.0180	-.3005	.5707	.3141
CU	.2914	.0790	-.1668	-.2574	.1814	.0802
ZN	.5741	.3597	-.0488	-.3407	.4474	.3461
AS	.1672	.3061	.4452	.2788	.5416	-.0392
BR	-.0476	-.3994	-.0804	-.5215	-.2179	-.0871
PB	-.0065	-.2566	.0018	-.3195	-.0667	.1636
RB	.9240**	.1927	.1402	-.0906	.5292	.4810
SR	.3744	.8366**	.1155	.0677	.5689	.3840
ZR	.0348	.0804	.8582**	.3038	.6087*	-.1098
NB	.1469	.0823	.8949**	-.0909	.3768	.1097
GA	.1161	.3527	.1881	.6640*	.5665	-.2755
Y	.3902	.2249	.4238	.2393	.7692**	.0475

(continued)

Apart from steel industry, common sources of Zn pollution are traffic (motor oil additives; rubber tyres contain 1.5% Zn), chemical industries (e.g. paints and dyes for textiles and ceramics), and coal combustion.

The Pb/Zn ratio from traffic is around 1:0.03 [11], so that car traffic, at a given ratio of roughly 1:2, can hardly be the main source here.

With the steel industry as the dominant factor, one would expect closer relations with other common alloy constituents such as Fe, Mn, or Cr.

Figure 2 maps the surrounding industries; many of them are Zn consuming. With respect to their large variety

TABLE 2 (ext.)
Correlations of elements in Colombo street dust
(signif.: *=<.01; **=<.001)

Correlations:	NI	CU	ZN	AS	BR	PB
K	.6249	.2914	.5741	.1672	-.0476	-.0065
CA	-.2296	.0790	.3597	.3061	-.3994	-.2566
TI	.0180	-.1668	-.0488	.4452	-.0804	.0018
CR	-.3005	-.2574	-.3407	.2788	-.5215	-.3195
MN	.5707	.1814	.4474	.5416	-.2179	-.0667
FE	.3141	.0802	.3461	-.0392	-.0871	.1636
NI	1.0000	.5390	.3517	.3668	.2223	.1558
CU	.5390	1.0000	.2978	.1098	.0311	.0091
ZN	.3517	.2978	1.0000	.2829	.0679	.0979
AS	.3668	.1098	.2829	1.0000	-.1826	.2208
BR	.2223	.0311	.0679	-.1826	1.0000	.8047**
PB	.1558	.0091	.0979	.2208	.8047**	1.0000
RB	.5142	.2340	.6522*	.1342	-.1578	-.0393
SR	.1016	.2860	.4142	.4776	-.1751	.0340
ZR	.5264	-.0904	-.0407	.5514	-.2426	-.0514
NB	-.4782	-.2086	-.0493	.4306	-.1363	-.0075
GA	-.4761	.2269	.0095	.1226	-.1905	-.1577
Y	.7921	.0802	.4172	.6583*	.0415	.2671

Correlations:	RB	SR	ZR	NB	GA	Y
K	.9240**	.3744	.0348	.1469	.1161	.3902
CA	.1927	.8366**	.0804	.0823	.3527	.2249
TI	.1402	.1155	.8582**	.8949**	.1881	.4238
CR	-.0906	.0677	.3038	-.0909	.6640*	.2393
MN	.5292	.5689	.6087*	.3768	.5665	.7692**
FE	.4810	.3840	-.1098	.1097	-.2755	.0475
NI	.5142	.1016	.5264	-.4782	-.4761	.7921
CU	.2340	.2860	-.0904	-.2086	.2269	.0802
ZN	.6522*	.4142	-.0407	-.0493	.0095	.4172
AS	.1342	.4776	.5514	.4306	.1226	.6583*
BR	-.1578	-.1751	-.2426	-.1363	-.1905	.0415
PB	-.0393	.0340	-.0514	-.0075	-.1577	.2671
RB	1.0000	.2749	.1079	.1279	.1222	.4680
SR	.2749	1.0000	.1146	.1742	.2832	.4719
ZR	.1079	.1146	1.0000	.7420**	.2697	.5683
NB	.1279	.1742	.7420**	1.0000	-.1101	.3226
GA	.1222	.2832	.2697	-.1101	1.0000	.3969
Y	.4680	.4719	.5683	.3226	.3969	1.0000

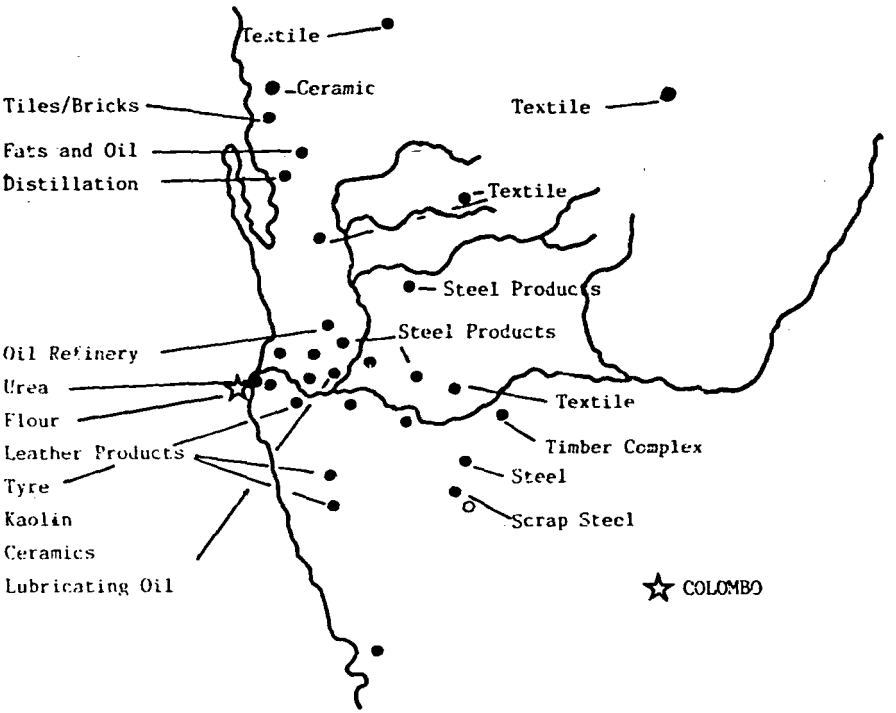

Fig: 2 Some Major Industries in and around Colombo (9)

of products, they are likely to emit a large variety of Zn compounds. It is therefore reasonable why there are no characteristic features hinting at certain emittants, although the wide range (267-1715 mg/kg) of Zn levels indicates additional site-dependent immissions: Mere background levels show a far more homogenous distribution as e.g. in the case of Ca, or Y (max.= 2-3 min.).

As the two maximum values are found at the train station (most Sri Lankan freight trains are coal-fired) and near a power plant, it is assumed that coal burning is a substantial contributor to the Zn pollution in the area.

The natural content of Ti in soil is 400 to 10,000 mg/kg [12], the concentrations in Colombo street dust are considerably higher. However, the coastal sands of SW Sri Lanka are rich in the Ti ores ilmenite and rutile, although the main mining district is in the north-east of the island. Our city samples do not reveal enough information to discriminate natural levels from an assumable man-made overlay from the processing plants. From steel and alloy production one would expect to find a closer relation with e.g. Fe, Mn, V in the dust (as is the case e.g. in sedimented Cairo street dust where such a multiple source apportionment has been carried out for 17 elements; [13]). Extended sampling should answer this question. There is a strong correlation of Ti with Zr, a common constituent of Ti ores. The mean concentration 950 mg/kg, is again somewhat higher than the reported background levels of 160-300 mg/kg in soil and earth crust (c.f. [14]).

Both Ti and Zr correlate with Nb, indicating that Nb also comes with the above described ores and/or manufacturing.

The Nb concentration in the earth crust is around 24 mg/kg, and so is the mean conc. in Colombo street dust

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