Assessment of Heavy Metal Contamination in Dust in Vilnius Schools: Source Identification, Pollution Levels, and Potential Health Risks for Children

Murat Huseyin Unsal [1,*], Gytautas Ignatavičius [1], Arunas Valiulis [2,3], Nina Prokopciuk [2], Roberta Valskienė [4] and Vaidotas Valskys [1,5]

1 Institute of Biosciences, Life Sciences Center, Vilnius University, Saul˙etekio Ave. 7, 10257 Vilnius, Lithuania; gytautas.ignatavicius@gf.vu.lt (G.I.); vaidotas.valskys@gmc.vu.lt (V.V.)
2 Clinic of Children's Diseases, Institute of Clinical Medicine, Medical Faculty, Vilnius University, Antakalnio St. 57, 10207 Vilnius, Lithuania
3 Department of Public Health, Institute of Health Sciences, Medical Faculty, Vilnius University, M. K. C˘iurlionio St. 21, 03101 Vilnius, Lithuania
4 Nature Research Centre, Laboratory of Ecotoxicology, Akademijos St. 2, 08412 Vilnius, Lithuania; roberta.valskiene@gamtc.lt
5 Nature Research Centre, Laboratory of Climate and Water Research, Akademijos St. 2, 08412 Vilnius, Lithuania

* Correspondence: murat.unsal@gmc.stud.vu.lt

Table S1: Mean concentration of sampled schools in mg/kg

mg/kg	As	Cu	Zn	Zr	Sr	Rb	Pb	Cr	V	Sc	Fe
S1	13.11	66.93	1873.24	62.95	56.70	14.21	116.48	164.35	33.19	176.10	3707.10
S2	33.93	91.33	16131.34	61.91	128.65	9.66	415.47	192.09	150.86	202.56	8549.42
S3	8.34	80.72	632.33	61.20	143.53	14.07	63.30	76.56	26.17	207.88	8767.57
S4	4.55	199.18	598.57	38.37	52.04	10.25	72.44	108.41	49.77	174.32	2504.30
S5	8.24	70.31	1186.70	25.13	58.97	9.61	39.57	158.74	29.55	226.99	5574.71
S6	7.29	81.37	420.50	32.68	53.76	13.06	65.56	221.18	29.41	207.08	3781.25
S7	15.42	51.28	839.02	32.10	52.80	13.00	82.94	145.07	29.93	190.16	5268.82
S8	12.68	55.68	2464.17	44.09	68.22	12.62	90.84	135.88	37.05	231.05	3079.35
S9	13.32	68.52	871.25	57.65	161.86	15.01	107.50	121.79	33.70	336.43	7588.79
S10	5.03	82.83	611.95	42.86	27.85	14.00	5.30	90.99	37.26	126.04	3357.46
S11	6.64	159.60	1522.27	37.82	127.58	11.04	86.20	61.78	25.70	227.53	7724.22
S12	15.64	64.46	1595.86	31.88	68.24	9.53	151.13	146.11	34.59	196.80	6438.40
S13	6.61	58.87	497.30	27.92	29.51	7.76	16.41	132.96	32.78	132.76	1621.90
S14	69.96	88.26	4323.60	27.65	124.73	16.12	564.25	175.00	<BDL	220.03	25649.29
S15	5.49	121.60	470.05	20.03	66.24	10.16	22.38	99.16	<BDL	270.63	3530.75
S16	7.70	53.51	219.50	37.51	470.53	9.22	40.59	<BDL	68.05	811.54	2122.49
S17	5.25	121.13	352.42	18.97	71.38	10.34	<BDL	118.75	<BDL	307.46	3225.05
S18	<BDL	93.04	514.97	34.45	92.09	14.58	20.36	60.82	<BDL	306.15	3860.89
S19	5.65	95.16	235.32	32.85	56.53	8.58	<BDL	131.14	48.06	372.64	3022.12
S20	13.83	55.36	2228.31	33.83	57.17	13.42	66.23	198.55	46.68	176.58	3780.50
S21	5.84	73.20	409.87	27.41	76.72	14.65	<BDL	104.99	<BDL	155.36	2942.69
S22	<BDL	56.05	332.52	29.78	38.38	8.18	<BDL	143.30	<BDL	118.25	1569.18
S23	<BDL	395.37	6252.00	42.53	162.70	16.77	67.91	120.13	125.67	204.97	4463.36
S24	<BDL	87.28	599.02	24.76	72.72	12.53	46.88	87.28	42.01	193.58	10063.49

BDL = Below Detection Limit

Table S2: Dust concentrations found in similar research.

Locations	Cr	Cu	Zn	Pb	Fe	As	References
Malaysia, Indoor dust	16.88	30.19	148.71	31.24	4225.33	-	[2]
Iraq, Indoor dust	65.68	54.28	43.90	51.46	-	-	[3]
Nigeria, Indoor dust	41.80	12.70	121.00	27.60	13.70	2.04	[13]
Hong Kong, Indoor and Outdoor dust	-	247.38	2293.56	199.96	-	-	[14]
Ghana, Indoor dust	381.30	-	-	4.82	-	-	[15]
Istanbul, Outdoor dust	254.00	513.00	1970.00	192.00	-	-	[18]
Istanbul, Outdoor dust	89.00	200.00	984.00	30.00	-	-	
Warsaw, Outdoor dust	90.00	109.00	1070.00	124.00	-	-	
New Zealand, Indoor dust	-	-	21700.00	724.00	-	-	
South Africa, Outdoor dust:							[76]
School A	87.90	38.00	148.70	12.45	-	2.90	
School B	37.13	60.97	107.35	15.86	-	0.78	
School C	57.45	7.78	45.10	8.08	-	1.66	
School D	82.40	28.66	315.10	52.68	-	1.60	
School E	45.60	44.91	9.53	16.49	-	2.07	
School F	34.90	116.80	37.50	24.43	-	0.99	
School G	24.35	66.85	37.90	62.85	-	1.82	
School H	27.15	416.65	41.10	184.20	-	0.96	
Greece, Outdoor dust	87.00	-	1505.00	133.00	-	-	[77]
Sydney, Indoor dust	90.00	-	1876.00	299.00	-	17.60	
Ottawa, Indoor dust	86.70	206.00	717.00	406.00	-	7.30	[19]
Canada, Indoor dust	117.00	279.00	833.00	210.00	-	13.10	
USA, Indoor dust	-	-	876.00	109.00	-	6.30	
Sydney, Indoor dust	65.00	-	372.00	76.00	2790.00	-	
China, Indoor and Outdoor dust	149.20	70.80	461.50	180.90	-	13.20	[21]
Hermosillo, Outdoor dust	-	26.34	387.98	36.15	-	-	[40]
Iran, indoor dust:							[20]
Cold Season	67.00	158.00	513.00	56.00	-	-	
Warm Season	97.00	127.60	666.70	292.00	-	-	
Tokyo and Hiroshima	67.80	304.00	920.00	57.90	-	-	

Table S3 Potential pollution sources for HCA, PCA and PMF factors

Analysis Method	Identified Elements	Potential Pollution Sources
HCA	Cluster 1: Sr and Sc Cluster 2: As, Pb, Cr, and Fe	Urban road dust (vehicular non-exhaust emissions, road

	Cluster 3: Cu, Zn, Zr, Rb, and V	pavement/furniture), power plants, roads, highways, train stations, wind dispersion, local sediment
PCA	Cluster 1: Sr and Sc Cluster 2: As, Pb, Cr, and Fe Cluster 3: Cu, Zn, Zr, Rb, and V	Similar patterns across all elements suggest common sources as HCA
PMF Factor 1	Zn, V, Pb, Cr, Cu, As	Electronics, construction, vehicular exhaust and tires debris, road dust, fossil fuel burning, industrial gases, zinc-coated materials in schools
PMF Factor 2	Fe, Cu	Cars (brake pads, discs, exhaust system), industrial activities, fossil fuel combustion, waste disposal, road dust, train station emissions, copper-brass automotive radiators, car lubricants
PMF Factor 3	Cr, Zr, Rb, Cu, As, Sc, V	Coal and oil combustion, rainwater migration through soil, road dust emissions, wear and tear of asbestos linings and cement dust, Cr-coated metals, waste disposal sites, manufacturing and utilization of zirconium-based products, rubidium-based compounds
PMF Factor 4	Pb, As, Fe	Coal-fired power generation, wood preservatives, waste disposal, road dust, construction activities, atmospheric pollution, phosphate fertilizers, lead-based paint on aging school structures, degradation of building materials
PMF Factor 5	Sr, Sc, Rb, V	Production and disposal of electronic devices (particularly fluorescent lamps), domestic heating, automotive traffic, alloy production with metals