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Human Population Effects on Metal Levels in Worcester, Massachusetts, USA

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In this study, heavy metal concentrations in catch-basin cleanings and street sweepings in Worcester, Massachusetts, USA were determined. Based on the results, population *vs.* metal levels were graphed using selected population and metal concentrations in cities situated in the developed countries. It was found that urban population is important for metal levels, specifically cadmium and lead, in streets. However, no effect of city population on street copper was found. Therefore, urban street dust management, specifically in the large urban areas, should be performed carefully due to the fact that metal contaminated street dust causes serious health problems.

Key Words: Urbanization, Worcester, Massachusetts, Heavy metals, Street dust.

INTRODUCTION

While urbanization causes an increase in living standards, pollutant emissions from various sources cause very diverse environmental problems all around the globe. It is known that urbanized areas might be heavily contaminated locations especially when environment is not a concern by the land users and urban management. Vehicles cause chromium and copper contamination in and around the roads[1, 2] since chromium plated wheels are popular among some car owners and copper is used in brake parts in automobiles[3]. Heating systems contribute significant environmental loads into urban areas. Industries emit significant amounts of environmental contaminants from their stacks. Therefore, such emissions settle down into urban areas and might cause serious health effects, specifically in children and elderly people.

In this study, heavy metal contamination in the street sweepings and catch-basin cleanings in Worcester, Massachusetts, is examined and compared to other studies conducted in the cities in the developed countries. Worcester is a mid-size

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urban centre (population 170,000) and ranked as one of the top 100 US cities in terms of population density, located in central Massachusetts. Heavy metals, namely cadmium, copper and lead, in Worcester were found to be comparable with the metal levels in selected cities in the developed countries with respect to urban populations.

EXPERIMENTAL

A total of 15 raw catch-basin samples were taken from various catch-basins with the help of Department of Public Works in Worcester, Massachusetts. The samples were taken from industrial, commercial, residential and business districts with different traffic volumes. The samples were first analyzed for copper and lead (in addition to numerous parameters in Alpha Analytical Laboratory, which is a certified laboratory situated in Marlborough, Massachusetts). Then, a detailed metal analysis (only for lead and copper) investigation was performed at WPI (Worcester Polytechnic Institute Environmental Engineering Laboratory) using a Perkin-Elmer® Analyst-300 (situated at WPI Environmental Engineering Laboratory) atomic absorption spectrometer that was operated under flame mode. A detailed sampling and analysis report was compiled by Mathisen *et al.*[4] and explained by Özdilek and Mathisen[5].

At least five different standards, which were supplied as liquid solutions and made by Ultra® Scientific and Spex® CertiPrep, Inc., were read prior to starting total heavy metal concentration analysis. For quality control/quality assurance (QC/QA) purpose, a blank (e-pure) and an SRM 2711 (obtained from National Institute of Standards and Technology) reference soil, which had total lead concentration of 1,162 mg kg^{-1} and total copper concentration of 114 mg kg^{-1}, were also analyzed both following reading of standards and prior to completing all readings. For each metal a 99.5% minimum correlation coefficient was achieved prior to starting readings. With the samples to be analyzed, a clean sand sample, which has already been mentioned above, was also analyzed for comparison purpose.

Heavy metal levels in the developed countries were obtained from literature to draw a comparison on population and metal levels in city streets.

RESULTS AND DISCUSSION

Table-1 summarizes total heavy metal levels in Worcester streets. While cadmium was detected in only nine samples, other metals were detected in all samples examined. A high correlation (80%) between chromium and diesel range organics was also found in Worcester streets[4].

A 10-fold difference between minimum and maximum chromium concentrations and a 30-fold difference between minimum and maximum lead concentrations are important findings. In addition to minimum and maximum concentration comparisons, in a clean sand sample 2.9 mg kg^{-1} arsenic, 4.8 mg kg^{-1} chromium and 12 mg kg^{-1} barium were also detected. Based on these results, the mean metal

concentrations in Worcester exceed clean sand metal levels by more than three times for arsenic and barium and by approximately six times in chromium. It could be seen that serious chromium and lead contamination in some parts of the city, in this case commercial, industrial and dense residential zones in Worcester, occur in spite of the fact that Table-1 does not give details on sample collection places.

TABLE-1
METAL LEVELS IN WORCESTER STREETS

Property	Metal (mg kg^{-1})					
	Arsenic	Barium	Cadmium	Chromium	Copper	Lead
Mean	10.30	39.90	1.030	28.50	39.1	178
Median	9.80	42.00	0.920	27.00	27.9	150
Standard deviation	4.14	18.10	0.447	15.70	19.6	141
Standard error	1.07	4.83	0.149	4.05	17.5	36.4
Minimum-maximum	3.8-18	12-71	0.32-1.80	7.3-75	23-65	18-540

Furthermore, with respect to urban population both lead and cadmium in street dust were found to be increasing in selected urban areas in three developed countries (USA, United Kingdom and Spain). This indicates that crowded urban areas have metal contaminated streets as illustrated in Fig. 1. The reason of this

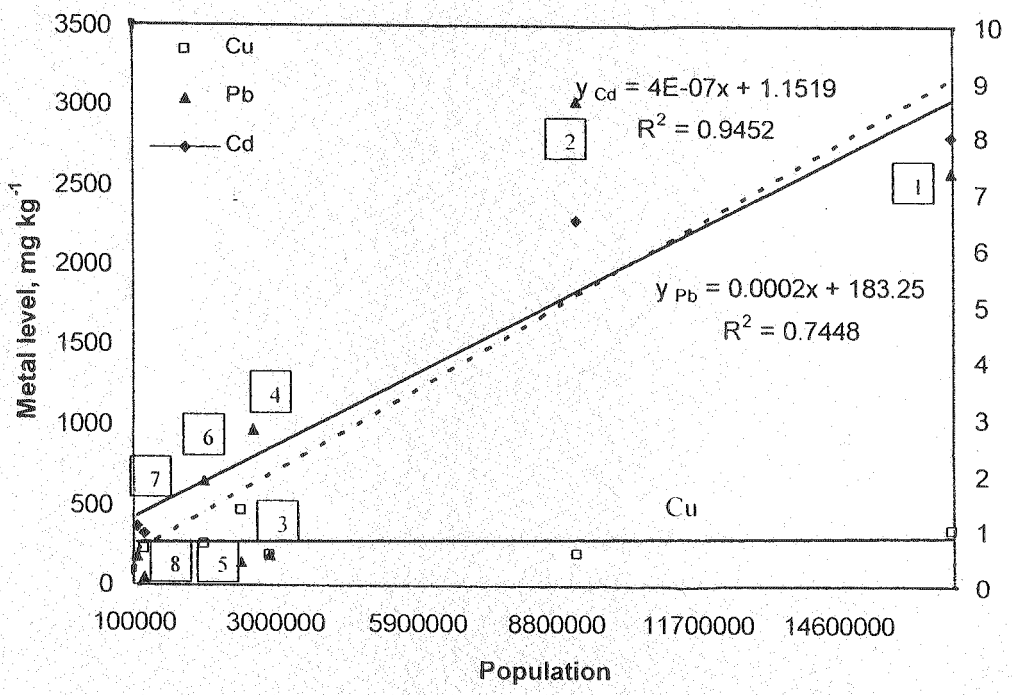

Fig. 1. Heavy metal concentrations in different cities in the developed countries (1. New York[6], 2. London[7], 3. Madrid[8], 4. Manchester[9], 5. Birmingham[10], 6. Cincinnati[11]; 7. Coventry[10], 8. Worcester (this study) (only cadmium (n = 4) belongs to the right-hand-side y-axis)

could be that city residents tend to have automobiles and tend to consume more while urbanization increases their living standards. Unlike cadmium and lead, copper was observed to be stagnant with respect to urban residents.

As a conclusion, street dust is a potential threat to human health and some of its heavy metals increase with urban population. Therefore, the problem should be carefully managed.

REFERENCES

1. U. Förstner, Land Contamination by Metals: Global Scope and Magnitude of Problem, in: H.E. Allen, C.P. Huang, G.W. Bailey and A.R. Bowers (Eds.), Metal Specification and Contamination of Soil, Lewis Publishers, Boca Raton, pp. 1–33 (1995).
2. S.E. Kesler, Mineral Resources, Economics and the Environment, Macmillan College Publishing Co., New York (1994).
3. J.F. Hauri (Jr.), Measurement and Manipulation of Copper Speciation and Toxicity in Urban Runoff Acid Mine Drainage and Contaminated Discharged Ground-water, Ph.D. Dissertation, University of California, Berkeley (2001).
4. P.M. Mathisen, P.J.R. Graves, J.A. Roberge and H.G. Özdilek, Reuse of Street Sweepings and Catch-basin Cleanings in Worcester, Massachusetts, Chelsea Center for Recycling and Economic Development, Technical Report 37, p. 39 (1999).
5. H.G Özdilek and P.P. Mathisen, Proceedings of the First International Conference on Environmental Research and Assessment, Bucharest, Romania, pp. 279–290 (2003).
6. J.E. Fergusson and D.E. Ryan, *Sci. Total Environ.*, **34**, 101 (1984).
7. R.M. Harrison, D.P.H. Laxen and S.J. Wilson, *Environ. Sci. Tech.*, **15**, 1376 (1981).
8. E. de Miguel, J.F. Llamas, E. Chacon, T. Berg, S. Larssen and O. Royset, *Atm. Environ.*, **31**, 2733 (1997).
9. J.P. Day, M. Hart and M.S. Robinson, *Nature*, **253**, 343 (1975).
10. S. Charlesworth, M. Everett, R. McCarthy, A. Ordones and E. de Miguel, *Environ. Int.*, **29**, 563 (2003).
11. S. Tong. *Environ. Geochem. Health*, **20**, 123 (1998).

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