Research Article

Monitoring of Heavy Metals Content in Soil Collected from City Centre and Industrial Areas of Misurata, Libya

M. A. Elbagermi, H. G. M. Edwards, and A. I. Alajtal

1 Department of Chemistry, Faculty of Science, University of Misurata, P.O. Box 1338, Misurata, Libya
2 Raman Spectroscopy Group, University Analytical Centre, Division of Chemical and Forensic Sciences, University of Bradford, West Yorkshire, BD7 1DP, UK

Correspondence should be addressed to M. A. Elbagermi; m.elbagermi@yahoo.co.uk

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1. Introduction

Global industrialization and human social and agricultural activities have an effect on environmental pollution and the global ecosystem. The pollution of soil by heavy metals from automobile sources is a serious environmental issue. These metals are released during different operations of the road transport such as combustion, component wear, fluid leakage, and corrosion of metals. Lead, cadmium, copper, and zinc are the major metal pollutants of the roadside environments and are released from fuel burning, wear out of tires, leakage of oils, and corrosion of batteries, and metallic parts such as radiators [1]. Intake of heavy metals. In urban area, heavy metals in urban soil and urban road dusts can be accumulated in human body via direct inhalation, ingestion, and dermal contact absorption.

The most important sources of heavy metals in the environment are the anthropogenic activities such as mining, smelting procedures, steel and iron industry, chemical industry, traffic, and agriculture as well as domestic activities [2–12]. Chemical and metallurgical industries are the most important sources of heavy metals in soil [13–15]. Tracing an life and the environment [16].

The problem of environmental pollution due to toxic metals has begun to cause concern now in most of the major cities. Pollution of the environment with toxic metals has increased dramatically since the onset of the industrial revolution [17]. Soil pollution by heavy metals, such as cadmium, lead, chromium, and copper, and iron, is a problem of concern. Although heavy metals are naturally present in soil, contamination comes from local sources: mostly industry, agriculture, waste incineration, combustion of fossil fuels, and road traffic. Long-range transport of atmospheric pollutants adds to the metals in the natural environment. In recent years, it has been shown that lead levels in soil and vegetation have increased considerably due to traffic pollution, especially from the usage of leaded petrol and exhaust combustion [18].

Biomonitoring of heavy metal is still new in Libya and has its own advantages such as sample is available throughout...
Table 1: Heavy metal concentration μg g⁻¹ and pH in roadside dust.

| Soil location       | pH  | Pb   | Fe  | Zn   | Ni  | Cd  | Cr  | Cu |
|---------------------|-----|------|-----|------|-----|-----|-----|----|
| Benghazi Street     | 6.67| 2.1–5.6 | 42–48 | 65–96 | 32.5–39.1 | 39.1–49.5 | 36.7–46.8 | 41–60 |
| Mean                | 3.85| 45   | 80.5 | 34.6 | 46.9 | 45.3 | 53.6 |
| Tripoli Street      | 6.25| 2.25–2.92 | 30–46 | 73–107 | 33.5–42.8 | 39.8–51.2 | 45.3–52.4 | 35–59 |
| Mean                | 2.585| 38   | 90   | 38.7 | 45.3 | 51.3 | 48.6 |
| Airport Street      | 6.55| 2.8–3.7 | 20–29 | 48–116 | 26.4–30.8 | 25.1–33.8 | 30.4–39.8 | 21–45 |
| Mean                | 3.25| 24.5 | 82   | 29.8 | 27.5 | 34.5 | 31.9 |
| Sadon Swihli Street | 6.89| 2.5–6.5 | 45–53 | 65–136 | 36.4–45.2 | 40.1–46.7 | 33.8–43.9 | 42–66 |
| Mean                | 4.5 | 49   | 100.5 | 42.5 | 45.7 | 37.7 | 55.9 |
| Qasr Ahmed Street   | 6.90| 4.03–6.65 | 48–72 | 55–146 | 34.5–42.8 | 38.5–47.8 | 29.7–36.8 | 38–55 |
| Mean                | 5.34| 60   | 100.5 | 37.2 | 44.1 | 31.3 | 51.5 |
| Aljazera Street     | 7.30| 1.2–3.3 | 22–28 | 42–93 | 13.8–28.4 | 12.5–34.8 | 16.7–25.9 | 23–41 |
| Mean                | 2.25| 25   | 67.5 | 22.5 | 29.1 | 19.7 | 32.1 |

2. Materials and Methods

All chemicals and reagents were of analytical grade and were purchased from: (Sigma-Aldrich, UK). All glassware was rinsed successively with detergent and distilled water three times prior to use.

2.1. Data Collection and Analysis. Samples were collected during October 2011 and May 2012. 15 Soil samples (three replicates) were collected at surface level (0–10 cm in depth) from various locations to cover industrial, commercial, and residential areas. The procedure of metals determination in soil and dust samples was followed according to the reported method [20]. The soil dust samples were grounded and sieved. The sieved samples were dried at 70°C/24 hrs. One gram of soil was treated with 10 mL concentrated nitric acid heated up to dryness and then cooled. This procedure was repeated with another 10 mL concentrated nitric acid followed by 10 mL of 12 N HCl. The digested soil and dust samples were then warmed in 20 mL of 2 N HCl to re-dissolve the metal salts. Extracts were filtered using Whatman filter paper no. 40, and the volume was then adjusted to 25 mL with 1.5% HNO₃. Heavy metal concentrations of each fraction were inductively coupled plasma atomic emission spectroscopy (ICP-AES) assurance that was guaranteed through double determinations and use of blanks for correction of background and other sources of error. Soil pH was determined with a glass electrode with water-soil slurry (1:10).

3. Results and Discussion

Levels of heavy metals in soil and dust samples supplied from different areas of Misurata City are given in Table 1. The results of heavy metal analysis are given below with the subheadings.

The limit of detection (LOD) of the analytical method for each metal was calculated as triple the standard deviation of a series of measurements of a solution, the concentration of which is distinctly detectable above. These values were 0.001, 0.002, 0.001, 0.003, 0.001, and 0.002 mg/kg for Pb, Fe, Cd, Zn, Cu, and Ni, respectively. Also the limit of quantification (LOQ) of the element was determined; these were 0.003, 0.003, 0.003, 0.003, 0.01, 0.003, and 0.007 mg/kg for Pb, Fe, Cd, Zn, Cu, Cr, and Ni, respectively.

Lead. In the present study, the lead content of the roadside dust ranged from 1.2 to 6.65 μg g⁻¹ (Table 1 and Figure 1). Maximum lead content was measured as 6.65 μg g⁻¹ in road dust samples of Qasr Ahmed street this area contains (Libyan Iron and Steel Company (LISCO) Port of Misurata and central petroleum station). The lead level in the Sadon Swihli Street ranges from 2.5 to 6.5 μg g⁻¹. The reason for the high Pb content at Taorghae Street is the heavy traffic in the area and industrial area. The lead content in the Aljazera Street was lower than in other areas.

Iron. The highest Fe value as a mean was at Qasr Ahmed Street and Sadon Swihli Street samples 60 μg g⁻¹ and 49 μg g⁻¹, respectively whereas the lowest Fe concentration was at Airport Street 24.5 μg g⁻¹, Figure 2.

Zinc. The amount of zinc in the roadside dust ranged from 42 to 146 μg g⁻¹ with the mean value of 94 μg g⁻¹. The highest Zn value was at Qasr Ahmed street (146 μg g⁻¹), while the lowest value was at Aljazera Street (42 μg g⁻¹). The highest value as a mean was at Qasr Ahmed street and Sadon Swihli Street samples (100.5 μg g⁻¹). Alloway [21] and Mcgrath and Loveland [22] reported the mean zinc concentration of
410 µg g⁻¹ in soil collected from the urban roadside soil in Bradford. The industrial area showed the highest mean value of 146 µg g⁻¹, and the seaside had the lowest concentration of 42 µg g⁻¹.

The mobility of the metal depends on the soil pH and also depends on the organic matter and granulometric composition of the soil. Acidic pH makes easier the solubilisation of the Zn compounds.

Nickel. The nickel content for the Sadon Swihli Street (36.4–45.2 µg g⁻¹) was the highest of all the sampling places, whereas the lowest value was at Aljazera street (13.8 µg g⁻¹). The concentration of nickel at Qasr Ahmed Street, Tripoli Street, and Benghazi Street were 34.5–42.8, 33.5–42.8, and 32.5–39.1 µg g⁻¹, respectively. Also, the mobility of the metal depends on soil pH and also depends on the organic matter and granulometric.

Cadmium. In the present study, the cadmium content of the roadside dust ranged from 27.5 to 48.8 µg g⁻¹ (Table 1 and Figure 3). Maximum cadmium content was measured as 51.2 µg g⁻¹ in roadside dust Tripoli street, and the lowest concentration was 12.5 8 µg g⁻¹ at Aljazera Street. Cadmium levels in roadside soil decrease as distancing from the main road. Also, as previously observed for Pb, the Cd levels in the heavy traffic areas (Tripoli Street, Benghazi Street, and Sadon Swihli Street) were greater than Cd levels along the residential street (Aljazera Street and Airport Street). This feature is attributed to the wear and tear of tires and the greater traffic density on the busy road compared to the residential street.

Chromium. The results of average Cr levels in roadside soil samples from different sites collected from Misurata Area are represented in Table 1. It is observed that the overall level of Cd lies between 45.3 and 52.4 µg g⁻¹ for Tripoli street, 36.7–46.8 µg g⁻¹ for Benghazi street, 30.4–39.8 µg g⁻¹ for Airport street, 33.8–43.9 µg g⁻¹ for Sadon swihli street, 29.7–36.8 µg g⁻¹ for Qasr ahmed street, and 16.7–25.9 µg g⁻¹ for Aljazera street. These results indicate that Cr levels among the sites of each road are significantly different. This indicates that the existence of Cr in roadside soil may be due to the tire erosion. The Cr levels in the heavy traffic areas and industrial areas were greater than Cr levels along the residential street.

Copper. The copper content in the roadside soil ranged from 21 to 60 µg g⁻¹ with the mean values of 31.9–55.9 µg g⁻¹ (Table 1 and Figure 3). Copper is usually present in soil within the range of 0–250 µg g⁻¹ [23].

Muller [24] reported the range of 1.2–1507.7 mg kg⁻¹ for copper in the soil of England and Wales with a median value of 18.1 mg kg⁻¹. Total copper content in most of the
and to detect very small anthropogenic influences [26, 27].

in the content of a given substance in the environment. The constant 1.5 allows us to analyze natural fluctuations in the environment and Bn is the geochemical background value in each area.

\[ I_{\text{geo}} = \log_2 \left( \frac{Cn}{1.5 \times Bn} \right), \]  

where \( Cn \) is the measured concentration of the element in the environment and Bn is the geochemical background value in soil. The constant 1.5 allows us to analyze natural fluctuations in the content of a given substance in the environment and to detect very small anthropogenic influences [26, 27]. According to Muller (1969) [24], the \( I_{\text{geo}} \) for each metal is calculated and classified as uncontaminated (\( I_{\text{geo}} \leq 0 \)); uncontaminated to moderately contaminated (\( 0 < I_{\text{geo}} \leq 1 \)); moderately contaminated (\( 1 < I_{\text{geo}} \leq 2 \)); moderately to heavily contaminated (\( 2 < I_{\text{geo}} \leq 3 \)); heavily contaminated (\( 3 < I_{\text{geo}} \leq 4 \)); heavily to extremely contaminated (\( 4 < I_{\text{geo}} \leq 5 \)); and extremely contaminated (\( I_{\text{geo}} \geq 5 \)). The \( I_{\text{geo}} \) values for the metals in urban soil, urban road dusts, and agricultural soil for each area are presented in Table 2, respectively.

In general, Cr and Ni appear to be the least contaminated elements in all the cities, while Pb, Fe, Zn, Cu, and Cd show the highest \( I_{\text{geo}} \) values for most areas (Table 2). In all the areas, ranges of \( I_{\text{geo}} \) values for the metals are very wide. The areas of Airport street, Qasar Ahmed street, and Aljazeera street appear to be the least contaminated areas with low \( I_{\text{geo}} \) values for Cr, Cu, Pb, Zn, Ni, and Cd, while Tripoli Street, Benghazi Street, and Sadon Swihli street, three heavy industrial and traffic areas, show the highest \( I_{\text{geo}} \) values for the metals.

The highest \( I_{\text{geo}} \) values for Pb (1.52) and Cd (2.23) are in Benghazi Street. The highest \( I_{\text{geo}} \) values for Cu (1.76) and Zn (3.56) are found in Sadon Swihli street, while the highest \( I_{\text{geo}} \) value for Fe (3.43) is found in Qasar Ahmed street. This indicates that the urban soil in these areas are significantly contaminated by the corresponding metals. In general, Tripoli Street and Benghazi Street have the highest \( I_{\text{geo}} \) values of heavy metals as they are crowded areas and were the centre of fierce fighting and are located in a frontline battle zone in the Misurata-Libyan war.

### 4. Conclusion

Heavy metal contamination in the soil from the busy roadside verges in the study area was higher as compared to the background levels for lead, iron, zinc, nickel, cadmium, chromium, and copper in residential street. These concentrations, however, were below the critical maximum levels above which toxicity is possible. The highest concentrations were detected in the samples collected from the border zone of the verges, and there was a trend of gradual decrease in the metal contents with the increasing distance from the paved roads. Also, the heavy metals concentration in industrial area was higher as compared to the nonindustrial area.

Higher Pb concentrations were found in sites with a high traffic volume on main roads and in the entrances of petrol station. It seems reasonable to conclude that Pb and Cd in roadside soil levels are significantly higher on busy roads compared to residential roads. Pb and Cd concentration levels in roadside soil decline as distancing from the main roads. We, therefore, conclude that there is a correlation between the roadside soil concentration of heavy metal and the distance from the road. It can also be observed that the frequencies with which motor vehicles stop, start, and accelerate, especially at traffic lights, may help to explain differences in the Pb levels in roadside soil. It is clear that Pb levels vary from time to time and depend on the volume of traffic.

### References

[1] L. M. J. Dolan, H. Van Bohemen, P. Whelan et al., “Towards the sustainable development of modern road ecosystem,” in The Ecology of Transportation: Managing Mobility For the Environment, J. Davenport and J. L. Davenport, Eds., pp. 275–331, Springer, Amsterdam, The Netherlands, 2006.

[2] I. Suciu, C. Cosma, M. Todíca, S. D. Bolboacă, and L. Jäntsch, “Analysis of soil heavy metal pollution and pattern in central transylvania,” International Journal of Molecular Sciences, vol. 9, no. 4, pp. 434–453, 2008.

[3] E. I. B. Chopin and B. J. Alloway, “Distribution and mobility of trace elements in soils and vegetation around the mining and smelting areas of Tharsis, Riotinto and Huelva, Iberian Pyrite Belt, SW Spain,” Water, Air, and Soil Pollution, vol. 182, no. 1–4, pp. 245–261, 2007.

[4] C. Stühli, A. Buncata, I. V. Popescu et al., “Air pollution studies using PIXE and ICP methods,” Journal of Physics, vol. 41, no. 1, article 070, pp. 565–568, 2006.

[5] R. Garcia and E. Millán, “Assessment of Cd, Pb and Zn contamination in roadside soils and grasses from Gipuzkoa (Spain),” Chemosphere, vol. 37, no. 8, pp. 1615–1625, 1998.

[6] X. Li, C. S. Poon, and P. S. Liu, “Heavy metal contamination of urban soils and street dusts in Hong Kong,” Applied Geochemistry, vol. 16, no. 11-12, pp. 1361–1368, 2001.

[7] N. Sezgin, H. K. Ozcan, G. Demir, S. Nemlioglu, and C. Bayat, “Determination of heavy metal concentrations in street dusts in

### Table 2: Geoaccumulation index of heavy metals in soil in the areas of Misurata.

| Soil location       | Pb   | Fe   | Zn   | Ni   | Cd   | Cr   | Cu   |
|---------------------|------|------|------|------|------|------|------|
| Benghazi Street     | 1.52 | 1.21 | 0.39 | 0.61 | 2.23 | 0.13 | 1.02 |
| Tripoli Street      | 1.48 | 0.54 | 3.42 | 0.74 | 2.01 | 0.21 | 1.46 |
| Airport Street      | 0.5  | 0.45 | 0.41 | −0.38 | 0.75 | −0.24 | 0.34 |
| Sadon Swihli Street | 1.2  | 2.65 | 3.56 | 0.41 | 0.18 | 0.43 | 1.76 |
| Qasar Ahmed Street  | 0.7  | 3.43 | 3.54 | −0.27 | 0.98 | −0.8  | 0.32 |
| Aljazeera Street    | −0.56| −0.23| 0.76 | −0.76 | −0.35| −1.2  | −0.08|
Istanbul E-5 highway,” Environment International, vol. 29, no. 7, pp. 979–983, 2004.

[8] B. Viard, F. Pihan, S. Promeyer, and J. C. Pihan, “Integrated assessment of heavy metal (Pb, Zn, Cd) highway pollution: bioaccumulation in soil, graminaceae and land snails,” Chemosphere, vol. 55, no. 10, pp. 1349–1359, 2004.

[9] G. Nabulo, H. Oryem-Origa, and M. Diamond, “Assessment of lead, cadmium, and zinc contamination of roadside soils, surface films, and vegetables in Kampala City, Uganda,” Environmental Research, vol. 101, no. 1, pp. 42–52, 2006.

[10] S. R. Oliva and A. J. F. Espinosa, “Monitoring of heavy metals in topsoils, atmospheric particles and plant leaves to identify possible contamination sources,” Microchemical Journal, vol. 86, no. 1, pp. 131–139, 2007.

[11] M. Kampa and E. Castanas, “Human health effects of air pollution,” Environmental Pollution, vol. 151, no. 2, pp. 362–367, 2008.

[12] L. Guo-li, L. Da-xue, and L. Quan-ming, “Heavy metals contamination characteristics in soil of different mining activity zone Trans,” Transactions of Nonferrous Metals Society of China, vol. 18, no. 1, pp. 207–211, 2008.

[13] A. Pantelica, V. CercasoV, E. Steinnes, P. Bode, and B. Wolterbeek, in Proceedings of the 4th National Conference of Applied Physics (NCAP ’08), pp. 25–26, Galati, Romania, September 2008.

[14] W. de Vries, P. F. Römkens, and G. Schütze, “Critical soil concentrations of cadmium, lead, and mercury in view of health effects on humans and animals,” Reviews of Environmental Contamination and Toxicology, vol. 191, pp. 91–130, 2007.

[15] V. Cojocaru, A. Pantelică, E. Pincovschi, and I. I. Georgescu, “EDXRF versus INAA in a pollution control of soil,” Journal of Radioanalytical and Nuclear Chemistry, vol. 268, no. 1, pp. 71–78, 2006.

[16] Bangalore Metropolitan Rapid Transport Limited, Environmental Impact Analysis, 2006.

[17] J. O. Nriagu, “Global inventory of natural and anthropogenic emissions of trace metals to the atmosphere,” Nature, vol. 279, no. 5712, pp. 409–411, 1979.

[18] F. Cabrera, L. Clemente, E. Díaz Barrientos, R. López, and J. M. Murillo, “Heavy metal pollution of soils affected by the Guadiamar toxic flood,” Science of the Total Environment, vol. 242, no. 1-3, pp. 117–129, 1999.

[19] R. Wittig, General Aspects of Bio-Monitoring Heavy Metals by Plants, Plants as Bio-Monitors. Indicators for Heavy Metal in Terrestrial Environment, VCH Press, Weinheim, Germany, 1993.

[20] X. Chen, X. Xia, S. Wu, F. Wang, and X. Guo, “Mercury in urban soils with various types of land use in Beijing, China,” Environmental Pollution, vol. 158, no. 1, pp. 48–54, 2010.

[21] B. J. Alloway, Heavy Metals in Soils, Chapman & Hall, London, UK, 1995.

[22] S. P. McGrath and P. J. Loveland, The Soil Geochemical Atlas of England and Wales, Blackie Academic & Professional, London, UK, 1992.

[23] ICRCL, Interdepartmental Committee on the Redevelopment of Contaminated Land. Guidance on the Assessment and Redevelopment of Contaminated Land. Guidance Note. 59/83, Department of Environment, London, UK, 1987.

[24] G. Muller, “Index of geo-accumulation in sediments of the Rhine River,” Geo Journal, vol. 24, no. 2, pp. 108–118, 1969.

[25] Y. Ji, Y. Feng, J. Wu, T. Zhu, Z. Bai, and C. Du, “Using geo-accumulation index to study source profiles of soil dust in China,” Journal of Environmental Sciences, vol. 20, no. 5, pp. 571–578, 2008.

[26] CEPA, (Chinese Environmental Protection Administration, Elemental Background Values of Soils in China, Environmental Science Press of China, Beijing, China, 1990.

[27] CEPA, (Chinese Environmental Protection Administration, Environmental Quality Standard For Soils (GB15618-1995), Beijing, China, 1995.