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Determine The Contamination of Heavy Metals in Rural Soils from Benghazi-Libya

Heiam Hamed [1*], Rasha Najem [2], M. Ben Hkoma [3]

[1] Environmental Science and Engineering, The Libyan Academy Benghazi Branch

[2] Department of Modern Architecture Technology, The Higher Institute of Engineering Technologies

[3] The Libyan Centre for Studies and Research in Environmental Science and Technology, Libya

Corresponding Author*: *hamn47@yahoo.com*

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Abstract:

This study analyzed the concentrations of cadmium and iron in soil samples collected from various locations, focusing on identifying the range and distribution of these heavy metals in the environment. The cadmium concentrations ranged from 0.012 to 0.044 mg/L, with the highest concentration found near a road (sample 19). The majority of samples showed cadmium levels between 0.014 and 0.022 mg/L. Iron concentrations ranged from 13.916 to 20.230 mg/L, with sample 18 exhibiting the highest concentration. Elevated iron concentrations were observed in several samples, particularly those with values above 19 mg/L. The highest levels of cadmium and iron were funded in samples located near roads or potentially contaminated areas, suggesting the influence of anthropogenic activities such as traffic, industrial operations, and the use of phosphate-based fertilizers.

Key words: Heavy metals, Soil contamination, Rural soils, Environmental pollution and Benghazi.

تقييم مستويات تلوث المعادن الثقيلة في التربة الريفية بمدينة بنغازي – ليبيا

هيام حمد[1] ، رشا نجم[2] ، مصطفى بن حكومة[3]

[1] قسم علوم وهندسة بيئة، اكاديمية الليبية بنغازي

[2] قسم العمارة الحديثة، المعهد العالي للتقنيات الهندسية بنغازي

[3] المركز الليبي لدراسات وبحوث علوم وتكنولوجيا البيئة، ليبيا

الملخص

حللت هذه الدراسة تركيزات الكادميوم والحديد في عينات تربة جُمعت من مواقع مختلفة، مع التركيز على تحديد مدى وتوزيع هذه المعادن الثقيلة في البيئة. تراوحت تركيزات الكادميوم بين 0.012 و0.044 ملغم/لتر، حيث تم تسجيل أعلى تركيز بالقرب من أحد الطرق (العينة رقم 19). وأظهرت معظم العينات مستويات كادميوم تتراوح بين 0.014 و0.022 ملغم/لتر. أما تركيزات الحديد، فقد تراوحت بين 13.916 و20.230 ملغم/لتر، مع تسجيل أعلى تركيز في العينة رقم 18. وُجدت تركيزات مرتفعة من الحديد في عدة عينات، خاصة تلك التي تجاوزت قيمها 19 ملغم/لتر. لوحظت أعلى مستويات الكادميوم والحديد في العينات الواقعة بالقرب من الطرق أو المناطق التي يُحتمل تلوثها، مما يشير إلى تأثير الأنشطة البشرية مثل حركة المرور والعمليات الصناعية واستخدام الأسمدة الفوسفاتية.

الكلمات المفتاحية: المعادن الثقيلة، تلوث التربة، التربة الريفية، التلوث البيئي، بنغازي.

Introduction

Human activities, including both social and agricultural practices, play a major role in contributing to environmental pollution and disrupting global ecosystems. One significant concern is soil contamination by heavy metals originating from vehicular sources. These pollutants are introduced into the environment through various mechanisms associated with road transportation, such as fuel combustion, fluid leaks, mechanical wear, and metal corrosion. The main metallic contaminants commonly detected in roadside areas include cadmium, copper, zinc, and lead. These elements are primarily introduced into the environment through processes such as fuel combustion, oil spills, tire degradation, and the corrosion of automotive parts like batteries and radiators (1).

Environmental contamination by toxic metals has emerged as an increasingly serious issue, particularly in large urban centers. Since the onset of the industrial revolution, the release of these hazardous elements into the environment has risen substantially, raising significant concerns about their long-term ecological and health impacts (2).

Soil is one of the most critically affected mediums by various pollutants due to human activities (3).

The primary sources of heavy metal pollution in the environment are human activities, including the combustion of fossil fuels, mining operations, wastewater discharges from manufacturing industries, and waste disposal (4).

Metals such as iron, copper, manganese, and zinc are essential as they play important roles in biological systems, whereas lead and cadmium are non-essential metals and are toxic even in small quantities (5)

Soil contamination with heavy metals such as cadmium, lead, chromium, copper, and iron represents a major environmental challenge. Although these elements are naturally present in soils, their concentrations can rise to harmful levels due to anthropogenic sources. Key contributors include industrial processes, agricultural activities, waste incineration, fossil fuel combustion, and vehicular emissions. Moreover, the long-distance atmospheric transport of pollutants further adds to the accumulation of these metals in the environment. Recent studies have shown that lead levels in soil and vegetation have significantly increased due to traffic pollution, particularly from the use of leaded gasoline and exhaust emissions (6).

The purpose of this study was to investigate the concentrations of cadmium and iron in soil samples collected from various locations, to assess the levels of these heavy metals and their potential environmental impact. This research aimed to identify any areas with elevated concentrations of these metals, which are often associated with industrial activities, and to compare the results with existing studies to better understand the soil contamination in the region.

Significance of the Study

This study is significant as it provides valuable insights into the presence and distribution of heavy metals specifically cadmium (Cd) and iron (Fe) in soils from various locations, highlighting areas that may be affected by environmental pollution. Understanding the concentrations of these metals is crucial due to their potential toxicity, persistence in the environment, and impact on human health and agricultural productivity. By identifying hotspots of contamination and comparing findings with previous studies, this research contributes to the broader understanding of soil quality in the region and may help inform environmental policies, land management practices, and future monitoring programs aimed at reducing heavy metal accumulation in soils.

Objectives

- To determine the concentrations of cadmium (Cd) and iron (Fe) in soil samples collected from the study area.
- To identify spatial variations in Cd and Fe levels among different soil samples

Previous Studies

Several studies have highlighted the varying concentrations of cadmium and iron in soils, particularly in areas affected by industrial and agricultural activities. Khan et al. (7) reported that agricultural soils near industrial zones contained cadmium concentrations reaching up to 0.05 mg/L, which is considered relatively high and comparable to the highest values observed in this study. Similarly, Gao et al. (8) found that cadmium levels in soils ranged from 0.01 to 0.05 mg/L, which aligns with the range recorded in the current samples. Regarding iron, Müller et al. (9) documented iron concentrations between 15 and 25 mg/L in industrially contaminated soils, consistent with the higher levels found in some of the analyzed samples.

Zhou et al. (10) also reported iron concentrations ranging from 20 to 30 mg/L in soils impacted by industrial activity, supporting the possibility that certain samples in this study were influenced by similar sources. A Libyan study conducted in 2023 found elevated concentrations of cadmium, iron, lead, and cobalt in soils near oil fields in Zueitina and Ajdabiya, likely due to industrial and petroleum-related emissions, which mirrors the elevated levels observed in several samples of this study.

Additionally, recent research has indicated that phosphate-based fertilizers are a significant source of cadmium in soils, especially under acidic conditions, increasing its bioavailability and posing a potential threat to the food chain (11).

Materials And Methods

1. Study Area

The samples of the study were collected in 2024 from 20 sites in the Sidi Khalifa area. The precise location of each sample was recorded using a Global Positioning System (GPS), as shown on the Figure 1.

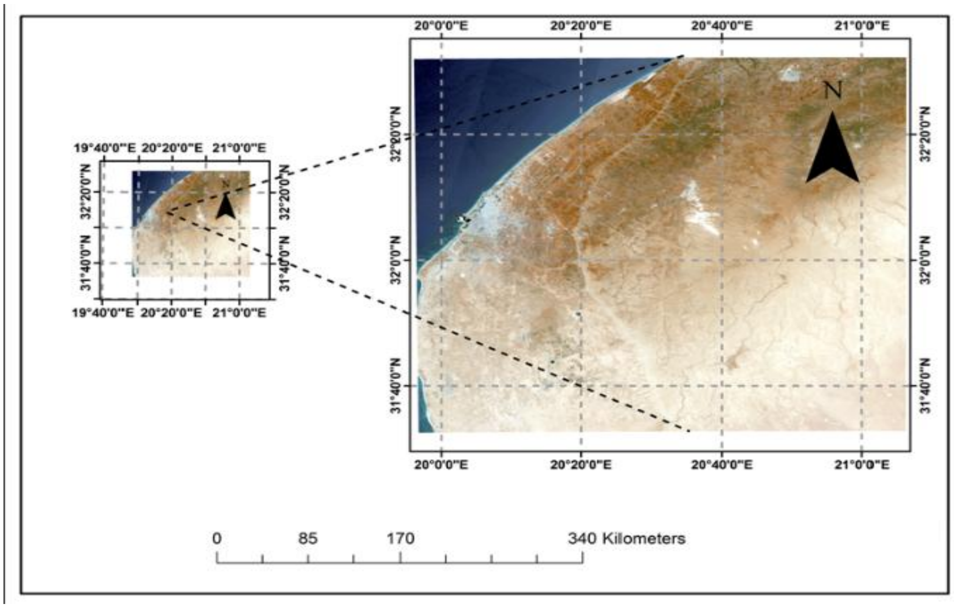

Figure 1: location of study

2. Sample Preparation

Surface soil samples were collected using shovels and placed in polyethylene bags from each site. The samples were labeled at each site and transported to the laboratory. The soils were dried at room temperature and passed through a 2-mm sieve. The samples were then stored in a dry place until the required analysis could be conducted.

3. Methods

Approximately 1.0 g of the dried soil sample was digested in 15 mL of a hydrochloric acid-nitric acid mixture (HCl: HNO_3, 3:1) for 4–5 hours using an electric heater at around 110°C. After digestion, the solution was allowed to cool, filtered through Whatman No. 42 filter paper, and transferred to a 50 mL flask. The filtrate was then diluted to the mark with deionized water. The soil samples were now ready for analysis using atomic absorption spectrophotometry (12). The atomic absorption method was used to measure the concentrations of lead and copper using a Philips PU 9100X atomic absorption spectrophotometer (AAS), equipped with a Slotted Tube Atom Trap (STAT) unit, under the following operating conditions:

Operating conditions	Cadmium	(Cd) Iron
Wavelength nm	228.8	248.33
Lamp current M A	8	30
Slit width nm	0.5	0.2
Flow Rate Fuel/Air Acetylene/L	1-1.3	1.5-5.0

4. Statistical Analysis

Parametric analysis of variance (ANOVA) was carried out to test for significant differences in the heavy metals concentration in terms of inter site comparison. If the significant value Were obtained $P<0.05$, Post Hoc Multiple Comparison Test were used to determine the sites of Significant differences using the computer SPSS 26

Data are presented as mean and, standard deviation of soil sample for each study sites. Sampling sites, metal type (Cadmium and Iron) specific differences were statistically tested by analysis of variance (ANOVA). Mean values were compared by Tukey's test and $p<0.05$ was considered as statistically significant.

Results

The analysis of cadmium (Cd) concentrations in the soil samples, as summarized in Table 1, reveals values ranging from 0.012 to 0.044 mg/L. The lowest concentration was detected in sample 1 (0.012 mg/L), while the highest concentration was recorded in sample 19 (0.044 mg/L). The majority of the samples exhibited cadmium levels between 0.014 and 0.022 mg/L, suggesting a relatively consistent distribution across the sampling area. However, elevated cadmium levels were observed in samples 11, 12, 13, 15, 18, and 19, each exceeding 0.04 mg/L.

Regarding iron (Fe) concentrations, the samples displayed a range from 13.916 to 20.230 mg/L. Sample 6 exhibited the lowest iron concentration (13.916 mg/L), whereas the highest was observed in sample 18 (20.230 mg/L). Several samples, particularly samples 11, 12, 13, 15, 16, 18, and 19, had iron concentrations exceeding 19 mg/L, indicating a trend of elevated iron levels in these specific areas.

Table 1: Shown the concentration of Havey metal

Soil Sample number	Cd mg/l Mean ± SD	Fe mg/l Mean ± SD
1	0.012±0.0009	16.908±0.029
2	0.022±0.0008	17.157±0.020
3	0.014±0.0008	17.059±0.014
4	0.016±0.0007	16.957±0.010
5	0.017±0.0003	16.829±0.021
6	0.016±0.0005	13.916±0.024
7	0.014±0.0005	16.938±0.028
8	0.017±0.0010	17.000±0.006
9	0.017±0.0006	16.589±0.004
10	0.031±0.0017	16.779±0.003
11	0.041±0.0019	19.920±0.023
12	0.040±0.0010	19.710±0.020
13	0.043±0.0020	19.970±0.014
14	0.022±0.0007	19.990±0.009
15	0.030±0.0018	20.130±0.019
16	0.015±0.0013	20.100±0.021
17	0.014±0.0006	19.890±0.010
18	0.041±0.0018	20.230±0.020
19	0.044±0.0013	20.170±0.008
20	0.022±0.0008	19.850±0.028

Discussion

The cadmium concentrations detected in the soil samples are generally within a low to moderate range. Nonetheless, the significantly higher concentration observed in sample 19 (0.044 mg/L) may be attributed to its proximity to a nearby road, suggesting a potential link between vehicular emissions or roadside contamination and increased cadmium levels. This aligns with findings by Khan et al. (7), who reported similar concentrations of cadmium (up to 0.05 mg/L) in agricultural soils located near industrial zones. Likewise, Gao et al. (8) observed cadmium concentrations ranging from 0.01 to 0.05 mg/L, which correspond closely with the data from this study, further reinforcing the hypothesis of anthropogenic influence.

Elevated cadmium levels in samples 11 through 13 and 18 through 19 raise environmental concerns, particularly because cadmium is a toxic heavy metal with known health risks. Long-term accumulation in the soil, especially from sources like phosphate-based fertilizers and industrial discharge, can increase its bioavailability and potentially affect the food chain, particularly in acidic soils.

The distribution of iron concentrations also reflects patterns consistent with industrial impact. Samples with iron levels above 19 mg/L—especially those from 11 to 13 and 15 to 19—mirror the elevated cadmium zones, possibly suggesting a shared source of contamination or co-migration through similar geochemical pathways. The results align with the findings of Müller et al. (9), who reported iron levels between 15 and 25 mg/L in soils near industrial zones. Additionally, Zhou et al. (10) documented iron concentrations as high as 30 mg/L in industrially impacted soils, which supports the relatively high iron concentrations observed in this study.

The results are further corroborated by a 2023 Libyan study investigating soils near oil fields in Zueitina and Ajdabiya, which reported elevated levels of cadmium, iron, lead, and cobalt. (13) These similarities suggest that the high metal concentrations found in the current samples could stem from nearby industrial or oil-related activities.

Conclusion

This study provides important insights into the levels of cadmium and iron in soil samples from the region, revealing the presence of these heavy metals in varying concentrations. While the cadmium concentrations in most samples were relatively low, sample 19 exceeded typical environmental limits, suggesting the influence of nearby industrial or road activities. The iron concentrations, on the other hand, were generally high across the samples, with some samples showing values above 19 mg/L, aligning with findings from other industrially impacted areas. These results underscore the need for further monitoring of heavy metal contamination in soils, particularly in regions affected by industrial activities, to ensure environmental and public health safety. Further studies are recommended to evaluate the long-term impact of such contamination on ecosystems and human health.

References

1. Dolan, L. M. J., Van Bohemen, H., &Whelan, P. (2006). Toward the sustainable development of modern road ecosystems. In J. Davenport and J. L. Davenport (Eds.), The Ecology of Transportation: Managing Mobility for the Environment (pp. 275–331).
2. Nriagu, J. O. (1979). Global inventory of natural and anthropogenic emissions of trace metals to the atmosphere. Nature, 279(5712), 409–411.
3. Najib, N. W. A. Z., Mohammed, S. A., Ismail, S. H., &Ahmed, W. A., (2012). Assessment of heavy metals in soil due to human activities in Kangar Perlis, Malaysia. International Journal of Civil and Environmental Engineering (IJCEE), 12(06), 1-6. M. Young, The Technical Writers Handbook. Mill Valley CA: University Science, 1989, pp. 102-103.
4. Friberg, L., Nordberg, G. F., & Vouk, V. (1986). Handbook on the Toxicology of Metals (18th ed.). Elsevier.
5. Schroeder, H. A. (1973) The Trace Elements and Nutrition. Faber and Faber, London.
6. Cabrera, F., Clemente, L., Díaz Barrientos, E., López, R., & Murillo, J. M. (1999). Heavy metal pollution of soils affected by the Guadiamar toxic flood. Science of the Total Environment, 242(1–3), 117–129.
7. Khan, S., Zhang, L., & Liu, D. (2010). Cadmium Contamination in Agricultural Soil. Environmental Science & Technology, 44(3), 868-873.
8. Gao, Y., Wang, F., Li, X., & Zhang, Y. (2014). Analysis of Cadmium and Heavy Metals in Soil. Environmental Toxicology and Chemistry, 33(7), 1463-1470.
9. Müller, G., Schöne, F., & Güth, A. (2012). Iron Contamination in Industrial Soils. Environmental Pollution, 164, 89-95.
10. Zhou, D., Li, Z., & Cheng, H. (2015). Impact of Heavy Metals on Soil and Environment. Environmental Geochemistry and Health, 37(1), 93-104.

11. Zhang, Y., Li, M., & Wang, Q. (2024). Cadmium accumulation in agricultural soils due to long-term fertilizer use. Agronomy, 14(5), 978.
12. Jones. C. A., Jacobson. J., & Lorbeer. S. (2002). Metal concentration in three Montana soils following 20 years of fertilization and cropping. Communication in soil sciences and plant analysis". 33(9 and 10) 1401-1414.
13. Abobaker, R. A., & Gammoudi, F. S. (2023). Study of heavy metals concentration in soil and groundwater near oil fields in Libya. Scientific Journal for Damietta Faculty of Science, 7(1), 89–98.