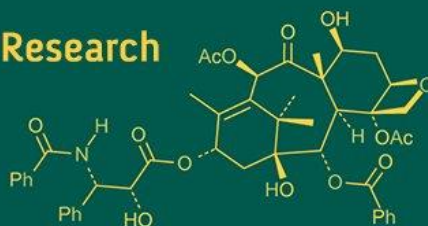
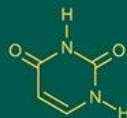


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Determination of percent of contamination by lead and cadmium in soil samples of Najaf City

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Abstract

In this study, atomic absorption spectrometry (AAS) was employed to assess soil contamination by heavy metals, specifically lead (Pb) and cadmium (Cd), at different locations within Najaf city. Soil samples were collected, prepared, and analyzed for elemental determination. The results indicated that the concentrations of Pb and Cd decreased with increasing distance from metallurgical activities. However, their levels were consistently higher than those detected in control soil samples collected from areas distant from traffic and industrial influence. For most analyzed metals, the highest concentrations at all soil depths were recorded in sites located within the influence zones of industrial activities, particularly those associated with ferrous processing operations.

Keywords: Atomic absorption spectrometry (AAS), Soil pollution, Heavy metals, Lead (Pb), Cadmium (Cd), Industrial contamination, Najaf, Environmental monitoring, Ferrous industry, Contaminated soils

Introduction

The contamination of the environment ^[1, 2]

Environmental pollution refers to the introduction or accumulation of substances in natural surroundings that, due to their chemical characteristics or elevated concentrations, interfere with ecological balance and result in harmful effects on both ecosystems and human health. Pollution is commonly categorized into several forms, including air, water, soil, noise, thermal, and radioactive pollution.

In recent decades, the level of environmental contamination has risen markedly, with particular concern directed toward soil and groundwater systems. This escalation has highlighted the urgent need for reliable and precise analytical methods to detect and quantify pollutants, especially toxic heavy metals. These elements are of significant concern because of their persistence in the environment, toxic nature, and tendency to bioaccumulate within biological systems.

Soil Contamination and Formation

Soil originates from the gradual breakdown of parent material (bedrock) through a combination of physical and chemical weathering processes. Mechanical weathering involves factors such as temperature fluctuations, wind erosion, water movement, and glacial activity, while chemical weathering includes reactions facilitated by environmental agents and biological activity such as lichens. Under favorable climatic conditions, approximately 1 cm of soil can develop over a period of about 15 years.

Soil structure is organized into distinct layers, commonly referred to as horizons:

O horizon: Composed mainly of recently deposited and partially decomposed organic matter such as leaves, twigs, animal residues, and microorganisms. It is typically dark in color (brown to black).

A horizon (topsoil): Contains a mixture of humus and mineral particles, making it darker and more rich than underlying layers. This layer plays a critical role in supporting plant growth.

O and A horizons: These upper layers are biologically active, hosting diverse organisms including bacteria, fungi, earthworms, and insects. Together, they contribute to nutrient cycling and the formation of a complex soil food web, enhancing soil fertility.

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B horizon (subsoil): Characterized by lower organic content and reduced biological activity compared to the topsoil layers.

C horizon: Consists of partially weathered parent material with no significant organic matter. Its composition influences soil properties such as pH, water infiltration, and retention capacity.

R horizon: Represents the underlying unweathered bedrock, forming the base of the soil profile.

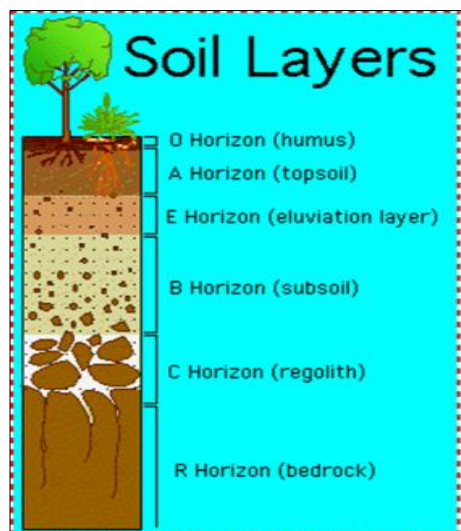


Fig 1: The soil layers

Soil contamination or soil pollution as part of land degradation is caused by the presence of xenobiotic (substances that are foreign to the body or to an ecological system) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (such as naphthalene), solvents, pesticides, lead, and other heavy metals. Contamination is correlated with the degree of industrialization and intensity of chemical usage.

The heavy metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. The heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed to a small extent they enter our bodies via food, drinking water and air as trace elements, some heavy metals (e.g. Copper, selenium, zinc) are essential to maintain the metabolism of the human body, however, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain.

Heavy metals are widespread pollutants of great environmental concern as they are non-degradable, toxic and persistent. Different natural and artificial sources of pollution can pollute the soil and sediments with heavy metals.

The most important sources of heavy metals in the environment are the following: the stationary incinerators for urban residues, the metallurgical industry, chemical

industry, the construction industry, the mines, traffic, agriculture as well as domestic activities.

Chemical and metallurgical industries are the most important sources of heavy metals in soils. The presence of heavy metals in soil can affect the quality of food, groundwater, micro-organisms activity, plant growth. Heavy metals and some trace elements are biologically toxic and can affect and threaten the health of human being owing to their accumulation and persistence in the compartments of the food chain.

The Soil contamination by Cadmium (Cd)

Cadmium is a heavy metal with a strong effect on crop quality. Moreover, it is a very mobile element in the environment. Plants can easily uptake cadmium and transfer it to other organs^[1, 3]. Experiments on the effect of cadmium on contents of macro elements in plants are scarce and therefore the mechanism of its effect has not yet been fully explained. Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies (liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed). The most health effects of Cd, see figure (1-2), can be summarized as:

- Diarrhea, stomach pains, and severe vomiting.
- Bone fracture.
- Reproductive failure and possibly even infertility.
- Damage to the central nervous system.
- Damage to the immune system.
- Psychological disorders.
- Possibly DNA damage or cancer development.

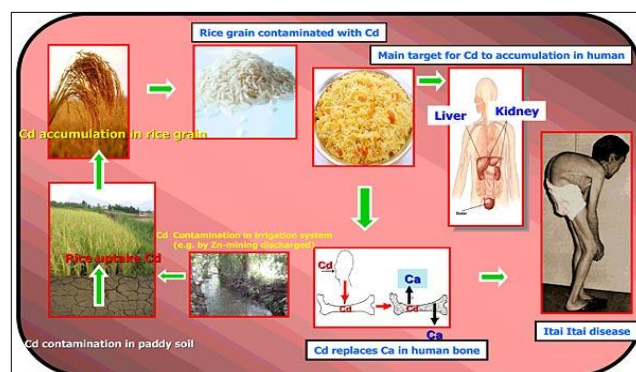


Fig 2: Cadmium contamination in paddy soil.

The Soil contamination by Lead (Pb)

Lead is naturally present in all soils at low concentrations. However, some soils have become contaminated due to historical use of lead-containing materials, such as lead-based paints and leaded gasoline. Although the use of these materials has been significantly reduced or eliminated since 1978, residual lead persists in the environment, remaining in soils for long periods.

Common sources of lead-contaminated soils include areas surrounding older buildings where lead-based paints were applied, sites adjacent to heavily trafficked roads and highways, and former orchard lands where lead arsenate pesticides were historically used. In undisturbed soils, lead concentrations are typically highest in the surface layer. In contrast, in disturbed soils (e.g., due to construction or excavation), lead may be distributed throughout the upper 6–12 inches of soil.

Lead exposure can also occur through contaminated food and beverages, including fruits, vegetables, meat, grains, seafood, soft drinks, and wine. In addition, cigarette smoke may contain trace amounts of lead. The health effects of lead exposure (Figure 1–3) include:

1. Disruption of hemoglobin synthesis leading to anemia
2. Increased blood pressure
3. Kidney damage
4. Miscarriages
5. Nervous system dysfunction
6. Brain damage
7. Reduced male fertility due to sperm damage
8. Impaired cognitive development in children
9. Behavioral disorders in children, including aggression, impulsivity, and hyperactivity
10. Transplacental transfer of lead from mother to fetus, which can cause severe damage to the developing nervous system and brain of unborn children

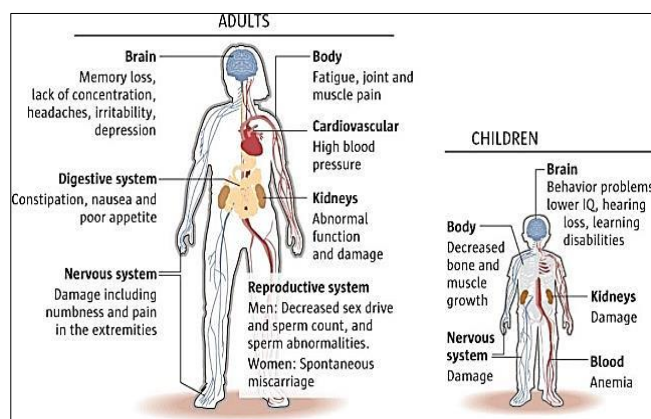


Fig 3: Symptoms of Lead Poisoning

The analysis of heavy metals ^[14-16]

The determination of total heavy metal concentrations, such as Cd, Cr, Mn, Co, Ni, Zn, Pb, and U, in sediments and soils is commonly performed to assess the degree of contamination in both aquatic and terrestrial environments. Analytical procedures for elemental determination in soil and sediment samples typically require partial or complete digestion of the sample matrix. However, the recovery efficiency and precision of pseudo-total and total digestion methods are influenced by several factors, including the mineralogical composition and origin of the sample, the digestion procedure employed, and the specific elements of interest. In addition, the accurate determination of certain elements in soils can be challenging, often necessitating the development of specialized methods for comprehensive multi-element analysis.

Consequently, there is growing interest in alternative or complementary solid sampling techniques that enable direct analysis of solid matrices. Soils, in particular, present a heterogeneous matrix with variable mineral composition, which contributes to analytical complexity. Therefore, sample digestion remains an essential step for the determination of total elemental concentrations in soils and sediments. An effective digestion method should ensure safe sample dissolution and achieve recoveries of at least approximately 90% for target elements.

A variety of digestion techniques are commonly employed, including open-vessel digestion using hot plates, block digestion systems, and closed-vessel microwave-assisted

digestion, all of which are widely used for the preparation of solid samples prior to elemental analysis.

Chemicals and Apparatus, Used Chemicals

All employed chemicals in this project were of analytical grade reagents unless otherwise stated. Table (2-1) sums up the main chemicals used throughout this research work as standard stock solutions. Other standard solutions were prepared by subsequent dilution of the stock solution.

Table 1: The main chemical used throughout this research work.

Seq.	Name	Formula	Molecular weight g/mol	Purity%	Company
1	Hydrochloric acid	HCl	36.458	35.00	BDH
2	Nitric acid	HNO ₃	63.01	98.00	BDH
3	Lead nitrate	Pb(NO ₃) ₂	331.200	99.00	BDH
4	Cadmium Chloride	CdCl ₂ .H ₂ O	201.31	98.00	BDH
5	EDTA	C ₁₀ H ₁₆ N ₂ O ₈	292.24	97.98	BDH

Apparatus

- An instrumental laboratory Atomic Absorption Spectrophotometers, Shimadzu model AA-6300 (Italy), furnished with a lead/cadmium hollow-cathode lamp and air-acetylene flame was used for all measurements.
- pH-measurements were carried out using WTW, listed 8f93 (Germany).
- Sensitive analytical balance with four decimal places, Denver Instrument, Germany.
- Heater, Ardeas 51, Germany.
- Oven, Heravs, Germany.

Sample Preparation ^[17]

Topsoil (0~20 cm) samples were collected from five provinces in Najaf city. Soil samples were air-dried and passed through a 2.0 mm sieve, homogenized and stored at 4°C until use. An incubation experiment was conducted with 0.5 g of each soil in plastic pot to simulate metal pollution. Heavy metals Pb and Cd were added as salts (CdCl₂ and Pb(NO₃)₂) in aqueous solution and then mixed with soils thoroughly.

The amounts of metals added to soils were 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 and 1.5 mg kg⁻¹ of Pb, and Cd (metal/soil), respectively. These soils were incubated for 2 days, and air-dried for analysis. And extra parts without the addition of heavy metals were simultaneously prepared as blank sample.

Measurement of Heavy Metals by AAS

Soil samples were digested using a standard procedure. Briefly, 1.0 g of soil was transferred into a 50 mL round-bottom flask and treated with 10 mL of aqua regia (HCl:HNO₃ = 1:3). The mixture was left at room temperature overnight, after which a water condenser was attached and the solution was heated to boiling for 2 hours. Subsequently, 10 mL of distilled water was added through the condenser, and the mixture was filtered using Whatman No. 42 filter paper. The residue was rinsed twice with 5 mL of distilled water, and the filtrate was diluted to a final volume of 50 mL. All solutions were prepared using 18.3 MΩ deionized water.

The same procedure was applied to prepare blank and control samples, and all results were blank-corrected. The

concentrations of cadmium (Cd) and lead (Pb) in the digested solutions were determined using atomic absorption spectrophotometry (AAS).

Results and Discussion

Lead is a highly toxic element that poses significant risks to both human health and the environment. The highest concentrations of lead (Table 3-2 and Figure 3-4) were detected in samples collected from areas with high population density. A particularly concerning finding is that lead levels in all analyzed samples exceeded the maximum permissible limits set by the World Health Organization (WHO) [20].

This contamination may be attributed to historical pollution sources, particularly vehicular emissions, as well as lead deposition resulting from the abrasion of lead-based ammunition and subsequent weathering processes in shooting range soils.

Table 2: Pb(ppm) to the soil samples from different positions in Najaf city

Number of samples	The position	AAS method Ppm (Pb)
1	Al-Sadrien square	4.32
2	Al-Najaf court	3.01
3	Al-Kufa court	3.24
4	AllAissa territories	0.99
5	NearAl-sahla mosque	2.23

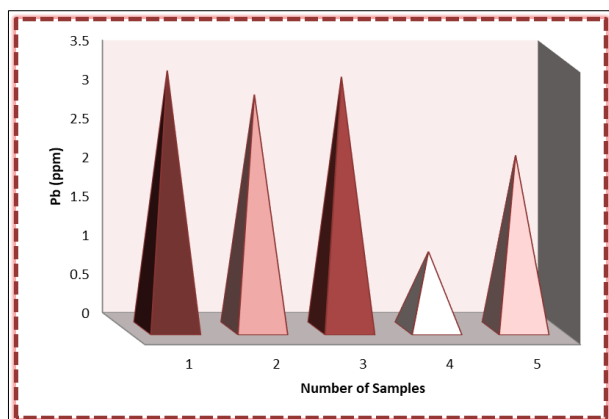


Fig 4: Pb(ppm) to the soil samples from different positions in Najaf city.

A similar observation was recorded for The value of obtained could be compared with reported for soil samples from high traffic area, as shown in table [21]. However, Cd was non essential element of human health with high biological toxicity which mainly accumulates in surface soil [22] (its concentration should be monitored).

Table 3: Cd(ppm) to the soil samples from different positions in Najaf city

Number of samples	The position	AAS method Ppm (Cd)
1	Al-Sadrien square	2.28
2	Al-Najaf court	2.05
3	Al-Kufa court	2.19
4	All Aissa territories	0.54
5	Near Al-Sahla mosque	1.67

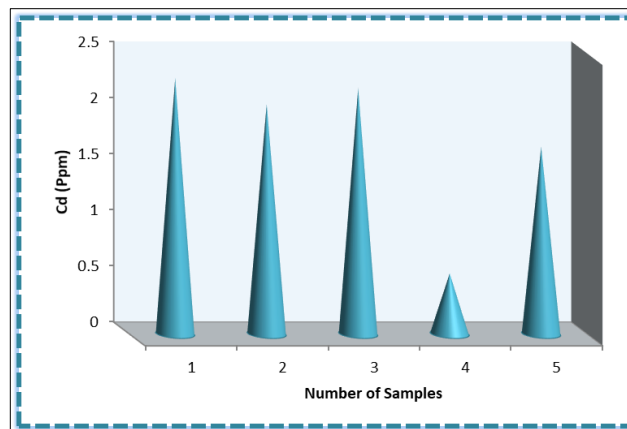


Fig 5: Cd (ppm) to the soil samples from different positions in Najaf city

In atomic absorption spectrometry (AAS), careful consideration must be given to potential interferences arising from substances present in the sample, regardless of the target analyte. One effective approach to minimize such interferences is the use of matrix modifiers.

In flame AAS, the presence of compounds such as carbonates, phosphates, iodides, or fluorides at concentrations exceeding ten times those of lead (Pb) and cadmium (Cd) may result in negative interference. This effect can be effectively reduced by the addition of approximately 0.1 M EDTA.

In graphite furnace AAS, chloride ions can react with Pb and Cd to form their respective chlorides. Due to the relatively low boiling points of these compounds, they tend to volatilize during the charring stage, leading to reduced sensitivity and poor reproducibility.

Conclusion

The experimental results demonstrate that the concentrations of heavy metals, particularly lead (Pb) and cadmium (Cd), decrease with increasing distance from metallurgical facilities. However, their levels remain higher than those recorded in control soil samples collected from areas distant from industrial and traffic-related activities.

For most of the analyzed metals, the highest concentrations across all soil depths were observed at sites located within the influence zones of industrial operations, especially those associated with ferrous processing. These elevated levels are primarily attributed to anthropogenic sources, including industrial emissions and environmental pollution. In particular, emissions such as sulfur dioxide and other industrial discharges contribute to the accumulation of heavy metals beyond natural background levels.

In several locations, metal concentrations were found to exceed the alert limits established by the World Health Organization (WHO), indicating potential environmental and public health risks. These findings highlight the need for continuous monitoring and the implementation of effective pollution control strategies.

References:

1. Stihl C, Radulescu C, Busuioc G, Popescu IV, Gheboianu A, Ene A. Rom J Phys. 2011;56:257.
2. State G, et al. Rom J Phys. 2011;56:240.

3. Florescu D, Ionete RE, Sandru C, Iordache A, Culea M. *Rom J Phys.* 2011;56:1001.
4. de Vries W, Romkens PF, Schutze G. Cadmium accumulation and environmental behavior. *Rev Environ Contam Toxicol.* 2007;191:91.
5. Popescu CG. *Rom Rep Phys.* 2011;63:471.
6. Lokeshwari H, Chandrappa GT. Impact of heavy metals on environment. *Curr Sci.* 2006;91(5):622-627.
7. Andrade SAL, Silveira APD, Jorge RA, de Abreu MF. Cadmium accumulation in sunflower plants influenced by arbuscular mycorrhiza. *Int J Phytoremediation.* 2008;10(1):1-13.
8. Das P, Samantaray S, Rout R. Studies on cadmium toxicity in plants: A review. *Environ Pollut.* 1998;98(1):29.
9. Frossard R. Contaminant uptake by plants. In: Schulin R, *et al.*, editors. *Soil Monitoring.* Basel: Birkhäuser Verlag; 1993. p. 7.
10. Kabata-Pendias A, Pendias H. Trace elements in soils and plants. 3rd ed. Boca Raton: CRC Press; 2001. p. 413.
11. Seregin IV, Ivanov VB. Physiological aspects of cadmium and lead toxic effects on higher plants. *Russ J Plant Physiol.* 2001;48:523-544.
12. Verma S, Dubey RS. Lead toxicity induces lipid peroxidation and alters antioxidant enzymes in rice plants. *Plant Sci.* 2003;164:645-655.
13. Kubravova I. *Spectrochim Acta B.* 1997;52:1469-1481.
14. Wu S, Zhao X, Feng X, Wittmeier A. *J Anal At Spectrom.* 1996;11:287-296.
15. Hseu Z, Chen Z, Tsai C, Tsui Cheng S, Liu C, Lin H. *Water Air Soil Pollut.* 2002;14:189-205.
16. Chen M, Ma LQ. *Soil Sci Soc Am J.* 2001;65:491-499.
17. World Health Organization. Guidelines for drinking-water quality. Vol 2. Geneva: WHO; 2006.
18. Chinese Standard GB/T 22105.1-2008. Soil quality—analysis of total mercury, arsenic and lead contents—atomic fluorescence spectrometry; 2008.
19. Chinese Ministry of Agriculture Standard NY/T 1613-2008. Soil quality—analysis of soil heavy metals—atomic absorption spectrometry with aqua regia digestion; 2008.
20. Fakayode SO, Olu-Owolabi BI. Heavy metal contamination of roadside topsoil in Osogbo, Nigeria: relationship to traffic density. *Environ Geol.* 2003;44:150-157.
21. Liang J, Chen C, Song Z, Han Y, Liang Z. Assessment of heavy metal pollution in soil and plants from Dunhua sewage irrigation area. *Int J Electrochem Sci.* 2011;6:5314-5324.