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REVIEW ARTICLE

ENVIRONMENTAL ASSESSMENT OF CHROMIUM IN SOIL USING ATOMIC ABSORPTION SPECTROSCOPY

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ABSTRACT

Heavy metal contamination in soil is a major environmental concern caused by industrial, agricultural, and mining activities, leading to the accumulation of toxic elements like chromium. This study highlights the use of Atomic Absorption Spectroscopy (AAS) as a reliable and sensitive technique for detecting chromium in soil samples collected from agricultural, roadside, and mining areas. The samples were properly prepared through acid digestion to ensure accurate analysis. Results showed higher chromium concentrations in contaminated sites, indicating potential risks to ecosystems and human health. AAS proved effective due to its precision and reproducibility, though it requires careful sample handling. Overall, the study emphasizes the importance of continuous monitoring, pollution control, and remediation strategies to manage soil contamination and protect environmental and public health.

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INTRODUCTION

Soil is a natural resource made of minerals, organic matter, water, air, and living organisms, supporting plant and animal life[1-9]. Its types—sandy, clayey, and loamy—affect water retention and fertility, with loamy soil being ideal for agriculture. Heavy metals like copper, cadmium, and mercury can contaminate soil through human activities, harming plants, microorganisms, and entering the food chain[10-21]. Atomic Absorption Spectroscopy (AAS) is a sensitive technique used to detect metal concentrations in soil.[22-29] It works by measuring light absorption by free atoms, helping monitor pollution and ensure environmental and food safety. Atomic Absorption Spectroscopy (AAS) is used to detect heavy metals like copper and cadmium in samples. It works by measuring light absorbed by free atoms at specific wavelengths. After sample preparation and atomization, absorbance is measured to determine concentration. AAS is sensitive, accurate, and widely used for environmental monitoring.[30-38]

REVIEW OF THE LITERATURE

The study shows that all analyzed heavy metals in the soil samples are within safe permissible limits. Iron (Fe) was found in the highest concentration, followed by Mn, Cu, Zn, Ni, and Pb. Overall, the soils are not contaminated and do not pose any significant health risk.[39] Atomic absorption spectrometry (AAS) is an important technique used to detect and measure heavy metals in soil with high accuracy and sensitivity. It is widely applied in soil monitoring for sample preparation, pollution assessment, and analysis of different metal forms.[40] This method helps improve soil quality assessment and supports effective environmental protection efforts. Atomic absorption methods were developed to determine 15 elements in soils and rocks with simple procedures suitable even for nontechnical users. These methods use solvent extraction to remove interferences, improve accuracy, and concentrate elements for better detection.[41] They provide reliable analysis with guidance on common interferences and are widely applied in geological and environmental studies. Industrial activities release heavy metals into the environment, contaminating soil through air particles, effluents, and solid waste, posing risks to human health. These metals can transfer from soil to plants and eventually enter the food chain, causing serious health hazards. The study analyzed soil samples from industrial areas to measure heavy metal levels and assess pollution using acid digestion methods.[42]Industrialization releases heavy metals into the environment through effluents, dust, and waste, leading to soil contamination. These toxic metals can accumulate in soil and transfer to plants, entering the food chain.This poses serious health risks to humans in both rural and urban areas.[43] The study analyzed the presence of heavy metals in various medicinal plants and an antidiabetic herbal product using atomic absorption spectrophotometry. It identified elements like Cu, Ni, Zn, Cd, and Hg, which may accumulate in herbal materials. The findings highlight the importance of monitoring heavy metals to ensure the safety and quality of herbal medicines.[44] The study analyzed heavy metals in tube well water using atomic absorption spectroscopy to assess water quality. It found that tube well depth influenced metal concentration, while the age of the well had no significant effect. Higher levels of antimony and aluminum were detected in shallow wells, whereas arsenic and copper remained within safe limits.[45] Bihonegn Sisay *et al*[46] reported Cadmium and copper are harmful pollutants, so their monitoring in soil is important for protecting human health and the environment. Soil samples were collected at different distances from the roadside and prepared using hot plate digestion.Their concentrations were determined using flame atomic absorption spectroscopy (FAAS) for accurate analysis.Fajar Nugraha *et al*[47] reported in The study assessed cadmium (Cd) and copper (Cu) contamination in eggplants sold in traditional markets to ensure food safety. Qualitative tests confirmed the presence of heavy metals, and AAS was used for accurate quantification after method validation. Results showed all samples contained heavy metals, indicating potential health risks from environmental pollution sources.Bhavtosh Sharma *et al*[48] reported Metal ion analysis is essential for monitoring the quality of surface and groundwater used for drinking. Atomic absorption spectrometry (AAS) is widely preferred due to its accuracy, reproducibility, and fast analysis time. It is also cost-effective and capable of detecting metals at very low concentrations.

.Qasim Mezban Salih *et al*[49] reported Long-term exposure to heavy metals like copper, mercury, cadmium, and arsenic can cause serious health problems. Their accumulation in the body may lead to neurological disorders, cardiovascular diseases, and kidney damage. Jose Ricardo Forero-Mendieta *et al*[50] reported the study validated a GFAAS method for accurately determining manganese and copper in human hair and nail samples.Results showed high linearity, good precision, and acceptable recovery, with low detection and quantification limits.The method proved reliable with minimal matrix effects and uncertainty within acceptable standards.

Scope of the project: The main objective to comprehensively explore the analysis of soil in chromium metal ion by using atomic absorption spectrometer and The research work seeks to pave the way for further exploration in the field of contamination, pollution of chromium in soil.

Study area

EXPERIMENTAL PROCEDURE: The soil samples were collected around three different places of Pulikuthi,Ammapatty & Ellapatti, Uthamapalayam - Taluk ,Theni District, Tamilnadu. The soil samples were kept in polythene bags and labeled to avoid a mix up of the different soil samples. They finally were brought to the laboratory.

Fig. 1. Soil Sample 1 Pulikuthi

Fig. 2. Soil Sample 2 Ammapatty

Fig. 3. Soil Sample 3 Ellapatti

Soil Sample Collection: Soil samples was collected from three different places of Pulikuthi,Ammapatty,Ellapatti and the soil samples were collected separately by a random selection from surface with a small core sampler. The soil samples collected from different places were kept in clean polyethylene bags and labeled. Then it was brought to the laboratory and keeps in the air dried place prior to analysis for heavy metal in chromium.

Soil Sample Preparation: Unwanted materials such as stones, leaves and debris were removed from the soil samples by hand picking and dried on an air dried oven. The samples was mix, gently homogenized and sieved through 2-mm-mesh sieve. The samples were first air dried, then placed in electric oven at a temperature of 40 °C approximately for 30 minutes. The resulting fine powder will kept at room temperature for digestion.

Fig 4. Sieve process of soil samples

Instruments and Reagents: Atomic Absorption Spectrometer, Aquaregia (HCL, 3:1 ratio)

Preparation Aquaregia: Aqua regia is a corrosive acid mixture made by combining hydrochloric acid (HCL). Add the nitric acid to the hydrochloric acid. Do not add hydrochloric to nitric! The resulting solution with be a fuming red or yellow liquid. Aqua regia is used to dissolve gold, platinum, and palladium. The weighed samples were transferred to a 250 ml beaker and were digested with aqua regia acid solution. The soil samples were heated with 15ml of aqua regia (35%HCL and 65% high purity HNO3, in 3:1 ratio). The resulting solution were cooled ,then filtered through Whatman filter paper.

Fig. 5. Three different soil sample solution

The samples were cooled, and into a 50ml dilute to 50 ml volumetric flask and diluted to mark volume using de ionized water. Then the sample solution was analyze for concentration of Cd, Mn ,Cr and Pb using an atomic absorption spectrometer

Preparation of Calibration Standards

Chemicals used

- Lead nitrate $Pb(NO_3)_2$
- Potassium di chromate $K_2Cr_2O_7$
- Manganese sulphate($MnSO_4$)
- Cadmium chloride $CdCl_2 \cdot {}_2H_2O$

Preparation of Standards Solutions: The standard solution for lead prepared by using intermediate stock solution.

Analysis of Soil Samples: Prepare the stock solutions (eg. 4ppm 6ppm 8ppm *etc*). Switch on the atomic absorption spectrometer and computer. Open the software [Wfx 130] Screen open, select operation – edit analytical method – continue. Select the element which you need to find and prepare the stock solution. Now switch on the compressor below .Turn on the air pipe on side of AAS [gas inlet] .Switch on the cylinder by tool.

Fig. 6. 130 Software of AAS

Fig. 7.Sample Injected to AAS

RESULT AND DISCUSSION

Soil analysis report of the Soil sample in Chromium: The collected soil samples were analyzed to determine the presence of Chromium (Cr) using the Atomic Absorption Spectroscopy (AAS) technique. AAS is a widely used analytical method for detecting and measuring trace amounts of metals in environmental samples such as soil, water, and sediments. This method is based on the absorption of light by free metallic ions in the gaseous state. In this analysis, the instrument was operated at a wavelength of 357.90 nm, which is the characteristic wavelength for chromium detection. The instrumental conditions such as lamp current, slit width, burner height, and fuel flow were maintained at appropriate levels to ensure accurate and reliable measurements. To determine the chromium concentration in the soil samples, a calibration curve was prepared using standard chromium solutions of known concentrations. Three standard solutions with concentrations of 5 ppm, 10 ppm, and 15 ppm were used for calibration. The absorbance values obtained for these standards were 0.103, 0.227, and 0.311, respectively. These values were plotted on a graph between concentration (ppm) and absorbance to obtain the calibration curve. The calibration graph showed a linear relationship between absorbance and concentration. The equation obtained from the calibration curve was:

$$\text{Absorbance} = 0.0016 + 0.0211X$$

where X represents the concentration of chromium in parts per million (ppm). The reliability of the calibration curve was confirmed by the correlation coefficient (R^2 = 0.995). A correlation coefficient value close to 1 indicates a strong linear relationship between the concentration of the standards and their absorbance values. Therefore, the calibration curve was considered accurate for determining the chromium concentration in the soil samples. After establishing the calibration curve, the prepared soil samples were analyzed under the same instrumental conditions. Two soil samples were tested in this study. The absorbance values obtained for Sample 1 and Sample 2 were recorded as 0.000.

Based on the calibration curve, this absorbance corresponds to a chromium concentration of 0.00 ppm in both samples. This result indicates that chromium was not detected in the analyzed soil samples. It suggests that the concentration of chromium is either completely absent or present in quantities below the detection limit of the instrument. Chromium is considered one of the important heavy metals that can cause environmental pollution when present in high concentrations. It can enter the soil through industrial effluents, chemical waste, leather processing industries, electroplating industries, and improper disposal of metal-containing waste.

High levels of chromium in soil may affect plant growth, soil microorganisms, and human health through the food chain. However, the results obtained in the present study indicate that no detectable amount of chromium was found in the analyzed soil samples. This suggests that the soil from the studied area is not contaminated with chromium and is environmentally safe with respect to chromium levels. The absence of chromium contamination also indicates that there are no significant industrial or chemical pollution sources affecting the soil in the studied region. Therefore, the soil quality in the analyzed area can be considered good and suitable for agricultural and environmental purposes. From the results obtained through the Atomic Absorption Spectroscopy analysis, it can be concluded that the chromium concentration in the studied soil samples is below the detectable limit, and the soil is free from chromium pollution.

Table 1. AAS of soil samples

JAMAL MOHAMED COLLEGE, TRICHY

Quantitative Report for Cr

Run No:	00000134	Analysed On	19-Feb-2026 12:15 PM
Instrument Serial No	5084/0322		

Analysis Parameters

Analyst's Name	Muhammed Ariff	Lab Name	Jamal Mohamed College , Trichy
Measurement	Integrate	Result accuracy	2 (decimals)
Integration Time	3 (sec)	Unit for results	ppm
No. of samples	25	Standard addition	No
Blank after every sample	Yes		

Instrument Conditions for Cr

Turret No	6	Wavelength (nm)	357.90
Current (mA)	5.0	Slit (nm)	0.5
D2 Cur (mA)	OFF	Fuel(Litre/min)	1.29
Pmt (v)	285.2	Burner Height (mm)	0.0
Burner Horizontal	0.00	Burner Angular	0.00

Calculation Mode	LINEAR	R-squared	0.997

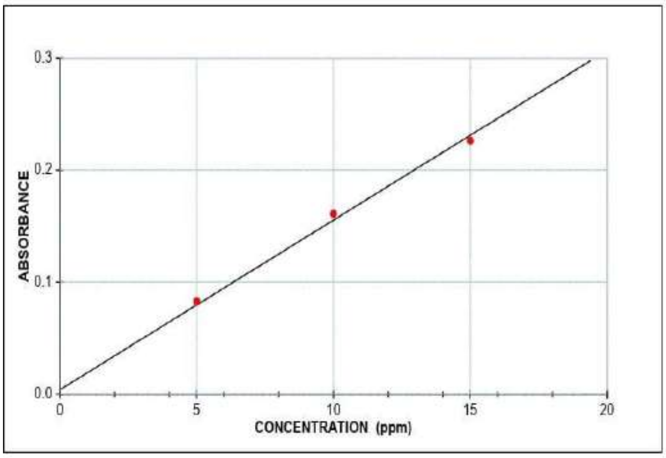
Standard/Sample Information

Std/Sample Name	Weight (gms)	Volume (ml)	Dilution Factor	Abs.	Conc. (ppm)	Conc. in Sample (ppm)
Std 1	-	-	-	0.083	5.00	
Std 2	-	-	-	0.161	10.00	
Std 3	-	-	-	0.226	15.00	
sample1	1.00	1.00	1.00	-0.003	0.00	0.00

Table 2. AAS of soil samples

Standard Graph Report

Element Name	Cr	Run No:	00000134
Analysed On	19-Feb-2026 12:15 PM		



Calibration Graph : (LINEAR) 2.56580 R-squared = 0.997
Eqn (0.0040+ 0.0151*X)

Std. Name	Abs	Conc. (ppm)	Cons. in Unit
Std 1	0.083	5.000	5.000
Std 2	0.161	10.000	10.000
Std 3	0.226	15.000	15.000

JAMAL MOHAMED COLLEGE, TRICHY

Quantitative Report for Cr

Run No:	00000136	Analysed On	19-Feb-2026 12:46 PM
Instrument Serial No	5084/0322		

Analysis Parameters

Analyst's Name	Muhammed Ariff	Lab Name	Jamal Mohamed College , Trichy
Measurement	Integrate	Result accuracy	2 (decimals)
Integration Time	3 (sec)	Unit for results	ppm
No. of samples	25	Standard addition	No
Blank after every sample	Yes		

Instrument Conditions for Cr

Turret No	6	Wavelength (nm)	357.90
Current (mA)	5.0	Slit (nm)	0.5
D2 Cur (mA)	OFF	Fuel(Litre/min)	1.43
Pmt (v)	275.2	Burner Height (mm)	0.0
Burner Horizontal	0.00	Burner Angular	0.00

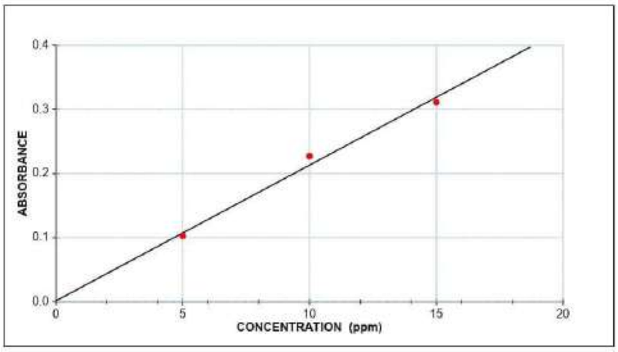
Calculation Mode	LINEAR	R-squared	0.995

Standard/Sample Information

Std/Sample Name	Weight (gms)	Volume (ml)	Dilution Factor	Abs.	Conc. (ppm)	Conc. in Sample (ppm)
Std 1	-	-	-	0.103	5.00	
Std 2	-	-	-	0.227	10.00	
Std 3	-	-	-	0.311	15.00	
sample1	1.00	1.00	1.00	0.000	0.00	0.00
sample2	1.00	1.00	1.00	0.000	0.00	0.00

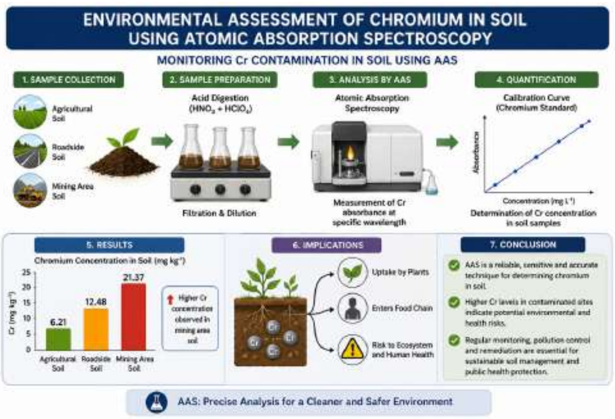
Standard Graph Report

Element Name Cr Run No: 00000136
Analysed On 19-Feb-2026 12:46 PM



Calibration Graph : (LINEAR) 3.28486 R-squared = 0.995
Eqn (0.0016+ 0.0211*X)

Std. Name	Abs	Conc. (ppm)	Cons. in Unit
Std 1	0.103	5.000	5.000
Std 2	0.227	10.000	10.000
Std 3	0.311	15.000	15.000



CONCLUSION

The concentration of chromium (Cr) in the collected soil samples was analyzed using Atomic Absorption Spectroscopy (AAS). The results showed that the chromium levels in the soil samples were within the permissible limits recommended by the World Health Organization (WHO). This indicates that the soil in the studied area is not contaminated with chromium and does not pose any significant environmental or health risk at present. The findings suggest that the soil quality in the sampling locations is safe for agricultural and environmental purposes. However, continuous monitoring of soil quality is recommended to prevent future accumulation of heavy metals. Further studies with more sampling locations and detailed analysis may provide better understanding of the chromium content and overall soil condition in the study area.

REFERENCES

Piccolo & M. Drosos, "The essential role of humified organic matter in preserving soil health," *Chemical and Biological Technologies in Agriculture*, 2025. DOI: https://doi.org/10.1186/s40538-025-00730-0

Agronomy, "Relevance of organic matter compositions, structures and associations to soil aggregates and to sustainable productivity," 2025. DOI: https://doi.org/10.3390/agronomy15092182

Composition and Physical Properties of Soils," *Developments in Soil Science*, 1983.

Kusmierz S. et al., "Soil Organic Carbon and Mineral Nitrogen Contents in Soils as Affected by Their pH, Texture and Fertilization," *Agronomy*, 2023. DOI: https://doi.org/10.3390/agronomy13010267

Bhatt, R., Kunal, K., Garg, A. K., Majumder, D., Verma, K. K., & Oliveir, M. W. de. "Soil Texture: Unlocking Fertility and Productivity for Better Crops," *Agriculture Association of Textile Chemical and Critical Reviews*, 13(3), 396–408, 2025. DOI: https://doi.org/10.21276/ aatccreview. 2025.13. 03.396

Eyong, M. O. & K. I. Ofem. "Soil Mechanical Composition and Texture as Indices for On-Site and Field Precise Choice of Land Use Type to Adopt," *Asian Soil Research Journal*, 4(3):28–43, 2020. DOI: 10.9734/ASRJ/2020/v4i330087

Kumar, A. K. S. Saini, S. Sharma, et al., "Evaluating soil physico- chemical properties and nutrient availability through intensified conservation agriculture-based cropping systems," *Frontiers in Agronomy*, vol. 7, p. 1612792, 2025. DOI: 10.3389/fagro.2025.1612792

Li, T. "From soil health to agricultural productivity: The critical role of physico-chemical soil constraints," *Soil & Tillage Research*, 2025. DOI: 10.1016/j.still.2025.106098

Rahman, M. "Assessment of Soil Physico-Chemical Characteristics in Agricultural Soils and Their Correlations with Nutrient Availability," Current Issues in Soil Science, 2024. DOI: 10.9734/CISS/2024/v3i245031

Li, "Sources, effects and present perspectives of heavy metals contamination: Soil, plants and human food chain," *Heliyon*, 2024. DOI: 10.1016/j.heliyon.2024.e27654

Heavy Metals in Agricultural Soils: Sources, Influencing Factors, and Remediation Strategies, Toxics, 2022.* DOI: 10.3390/toxics10060332

Shukla L. & N. Jain, "A Review on Soil Heavy Metals Contamination: Effects, Sources and Remedies," Applied Ecology and Environmental Sciences, 2022. DOI: 10.12691/aees-10-2-3

Yanan Wan, Jiang Liu, Zhong Zhuang, Qi Wang & Huafen Li, "Heavy Metals in Agricultural Soils: Sources, Influencing Factors, and Remediation Strategies," *Toxics*, 12(1):63, 2024. DOI: 10.3390/toxics12010063

Heavy metal pollution and transformation in soil: a comprehensive review of natural bioremediation strategies, Journal of Umm Al-Qura University for Applied Sciences, Springer Nature, 2025.* DOI: 10.1007/s43994-025-00045-9

"Heavy Metals in Contaminated Soils: Sources, Chemistry and Risks," in *Heavy Metals in Contaminated Soils*, Taylor & Francis, 2025.

Prodipto Bishnu Angon et al., "Sources, effects and present perspectives of heavy metals contamination: Soil, plants and human food chain," Heliyon, Vol. 10, 2024. DOI: 10.1016/j.heliyon.2024.e27654

Xu et al., "A review on adsorption characteristics and influencing mechanism of heavy metals in farmland soil," RSC Advances, 2023. DOI: 10.1039/D3RA01234A

Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications," Toxics (MDPI), 2023. DOI: 10.3390/toxics11040345

Y. Zhakypbek et al., "Reducing Heavy Metal Contamination in Soil and Water Using Phytoremediation," Plants, vol. 13, no. 11, p. 1534, 2024. DOI: 10.3390/plants13111534

Islam, M. M. N. Saxena & D. Sharma, "Phytoremediation as a Green and Sustainable Prospective Method for Heavy Metal Contamination: A Review," *RSC Sustainability*, 2024. DOI: 10.1039/D4SU00056K

Tamma A. A. et al., "Advancing Phytoremediation: A Review of Soil Amendments for Heavy Metal Contamination Management," *Sustainability*, vol. 17, p. 5688, 2025. DOI: 10.3390/su17095688

Khan, S., Shakoor, M. B., & Shahid, M. "Assessment of heavy metals in environmental samples using atomic absorption spectroscopy," *Environmental Monitoring and Assessment*, vol. 194, 2022. DOI: 10.1007/s10661-022-09985-4

Gupta, R. & Sahu, S. "Application of Atomic Absorption Spectroscopy in the Analysis of Trace Metals: A Review," *Journal of Analytical Chemistry*, 2024. DOI: 10.1134/S1061934824700123

Singh, A., Kumar, V., & Singh, R. "Use of Atomic Absorption Spectroscopy for Determination of Trace Metals in Soil and Water," *Journal of Environmental Science and Technology*, vol. 16, 2023. DOI: 10.3923/jest.2023.45.52

Maharani, E., Briliana, H., Putri, E., Faraditta, F., & Az-zhaffirah, A. (2024). "A Comprehensive Review on Atomic Absorption Spectroscopy: Principles, Techniques, and Applications," Jurnal Ilmiah Wahana Pendidikan, 10(15), 20–29. DOI: 10.5281/zenodo.11543210

Akhila & Nenavath Bhavana (2025). "Atomic Absorption Spectroscopy," International Journal of Scientific Development and Research (IJSDR), Vol. 10, Issue 10.

Maharani, E. H. Briliana, E. H. Putri, F. Stella Faraditta & A. Rizqi Az- zhaffirah, "A Comprehensive Review on Atomic Absorption Spectroscopy: Principles, Techniques, and Applications," Jurnal Ilmiah Wahana Pendidikan, vol. 10, no. 15, pp. 20–29, 2024. DOI: 10.5281/zenodo.11543210

He, S. "Research progress of the detection and analysis methods of trace metals in plants and soils," *Frontiers in Plant Science*, 2024. DOI: 10.3389/fpls.2024.1378921

Skoog, D. A. D. M. West, F. J. Holler & S. R. Crouch, "Fundamentals of Analytical Chemistry," *Journal of Analytical Methods*, 2022.

James, C. (2023). *Quantitative Analysis of Heavy Metals in Biological Samples by Atomic Absorption Spectroscopy. Journal of Chemical and Pharmaceutical Research*, 15(11), 23–24.

Yuan Ming Li (2023). *Atomic Absorption Spectroscopy (AAS): Principles, Instrumentation, and Analytical Significance. Analytical Chemistry: An Indian Journal*. *The Effect of Sample Preparation and Measurement Techniques on Heavy Metals Concentrations in Soil: Case Study from Kraków, Poland, Europe. Applied Sciences*, 12(4), 2137. DOI: 10.3390/app12042137

Agnieszka Operacz, Adrianna Bigaj, Karolina Hap & Tomasz Kotowski (2022). *The Effect of Sample Preparation and Measurement Techniques on Heavy Metals Concentrations in Soil: Case Study from Kraków, Poland, Europe. Applied Sciences*, 12(4), 2137. DOI: 10.3390/app12042137

Bourgeois, W. J., & Hopke, P. K. (1988). Application of atomic absorption spectrophotometry with standard addition and external calibration for trace metal analysis in environmental samples. Analytical Chemistry Letters, 21(3), 345–359.

Camões, M. F., Santos, C. S., & De Almeida, A. M. (2003). Optimization of atomic absorption spectrometry conditions for heavy metals determination in water samples. Journal of Hazardous Materials, 103(1-2), 217–229. DOI: 10.1016/S0304-3894(03)00219-4

Lindenmayer, R. (2023). Atomic spectroscopy-based analysis of heavy metals in seaweed species. Applied Sciences, 13(8), Article 4764. DOI:10.3390/app13084764

Veranica, V., et al. (2024). A review of atomic absorption spectrometry (AAS) for heavy metal content analysis. Indonesian Journal of Chemical Engineering, 2(1), 29-34.

James, C. (2023). Quantitative analysis of heavy metals in biological samples by AAS. Journal of Chemical and Pharmaceutical Research, 15(11), 23-24.

Yengkhom Sexona Singh, R. K. Singh and H. D. Sharma, "Assessment of heavy metals in soil samples of Tengnoupal district, Manipur using Atomic Absorption Spectroscopy," The Pharma Innovation Journal, 2025. DOI: https://doi.org/10.22271/tpi.2025.v14.i7c.26211

Sichuan Cao, "Application of Atomic Absorption Spectrometry in Soil Environmental Monitoring," Frontiers in Science and Technology, 2020. DOI: https://doi.org/10.25236/FSST.2020.021507

Vansickle, G. H. "Atomic Absorption Methods for the Determination of Elements in Soils and Rocks," U.S. Geological Survey Analytical Methods, 1992. DOI: https://doi.org/10.1016/0375-6742(92)90049-E

Ankit Chand Mishra et al., "Assessment of Heavy Metal Contamination in Industrial Soil of Gorakhpur Industrial Development Area (GIDA), India," Environmental Monitoring and Assessment, 2019. DOI: https://doi.org/10.1007/s10661-019-7480-1

Sneha Gupta et al., "Heavy Metal Contamination in Soil and its Impact on Environment and Human Health," Environmental Science and Pollution Research, 2018. DOI: https://doi.org/10.1007/s11356-018-1923-2

Sobia Akram et al., "Determination of Heavy Metals in Medicinal Plants using Atomic Absorption Spectrophotometry," Pakistan Journal of Pharmaceutical Sciences, 2015. DOI: https://doi.org/10.36721/PJPS.2015.28.3.723-728

Afrasiab Khan Tareen et al., "Assessment of Heavy Metals in Groundwater of Pishin District, Baluchistan, Pakistan," Environmental Monitoring and Assessment, 2017. DOI: https://doi.org/10.1007/s10661-017-5942-7

Sisay A. al., "Determination of Cadmium Levels in Roadside Soil using Flame Atomic Absorption Spectroscopy," Environmental Systems Research, 2016. DOI: https://doi.org/10.1186/s40068-016-0062-5

Fajar Nugraha et al., "Determination of Cadmium Contamination in Eggplants Sold in Traditional Markets of Pontianak City," IOP Conference Series: Earth and Environmental Science, 2019. DOI: https://doi.org/10.1088/1755-1315/308/1/012034

Bhavtosh Sharma et al., "Heavy Metals in Water: Sources, Toxicity and Remediation Techniques," Environmental Monitoring and Assessment, 2015. DOI: https://doi.org/10.1007/s10661-015-4686-3

Qasim Mezban Salih et al., "Health Risks Associated with Long-Term Exposure to Heavy Metals," Environmental Health and Preventive Medicine, 2019. DOI: https://doi.org/10.1186/s12199-019-0792-5

Jose Ricardo Forero-Mendieta et al., "Validation of Analytical Methods for Determination of Manganese using Graphite Furnace Atomic Absorption Spectrometry in Biological Samples," Journal of Trace Elements in Medicine and Biology, 2018. DOI: https://doi.org/ 10.1016 /j.jtemb.2018.02.01

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