

Quantitative Analysis of Heavy Metals in Agricultural Soil

Dr. Rishabh Bhardwaj, Iram Khan, Ms. Meenal Maan

Department of Chemistry, Shri Ram College, Muzaffarnagar

Abstract— Heavy metal contamination in agricultural soils has become a major environmental concern due to its adverse effects on soil quality, crop productivity, and human health. The present study focuses on the quantitative analysis of heavy metals in agricultural soil samples collected from selected locations. Metals such as lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), zinc (Zn), and copper (Cu) were analyzed using standard analytical techniques. Soil samples were collected, air-dried, sieved, and subjected to acid digestion followed by analysis using Atomic Absorption Spectroscopy (AAS). The results indicated variation in heavy metal concentrations across different sampling sites, reflecting the influence of anthropogenic activities such as fertilizer use, wastewater irrigation, and industrial emissions. Some metals were found near or above permissible limits, indicating localized contamination. Statistical analysis revealed correlations among metals, suggesting common sources. The study highlights potential environmental and health risks associated with heavy metal accumulation and emphasizes the need for sustainable soil management and regular monitoring.

Keywords— Heavy metals, Agricultural soil, AAS, Soil contamination, Environmental pollution, Food safety.

I. INTRODUCTION

Agricultural soil plays a crucial role in food production and environmental sustainability. However, increasing industrialization, urbanization, and intensive agricultural practices have led to the accumulation of heavy metals in soils. Heavy metals such as Pb, Cd, Cr, Ni, Zn, and Cu are persistent, non-biodegradable, and toxic at higher concentrations.

These metals enter the soil through natural processes as well as anthropogenic activities including industrial discharge, agrochemicals, wastewater irrigation, and vehicular emissions. Once present in soil, they accumulate and may enter the food chain through plant uptake, posing serious risks to human health.

Quantitative analysis of heavy metals is essential for assessing soil quality, identifying contamination sources, and ensuring food safety. This study aims to evaluate heavy metal concentrations in agricultural soil and assess associated environmental risks.

II. MATERIALS AND METHODS

1. Soil Sampling

Soil samples were collected from agricultural fields using standard sampling techniques. Surface soil (0–15 cm) was collected from multiple locations to ensure representativeness.

2. Sample Preparation

- Samples were air-dried
- Crushed and sieved
- Stored in clean containers

3. Digestion Procedure

Soil samples were subjected to acid digestion using:

- Nitric acid (HNO₃)
- Hydrochloric acid (HCl)

This ensured complete extraction of heavy metals.

4. Heavy Metal Analysis

Quantitative analysis was performed using:

- Atomic Absorption Spectroscopy (AAS)

Metals analyzed

- Lead (Pb)
- Cadmium (Cd)
- Chromium (Cr)
- Nickel (Ni)
- Zinc (Zn)
- Copper (Cu)

5. Statistical Analysis

- Mean and standard deviation calculated
- Correlation analysis performed
- Compared with permissible limits

III. RESULTS AND DISCUSSION

1. Sources of Heavy Metals

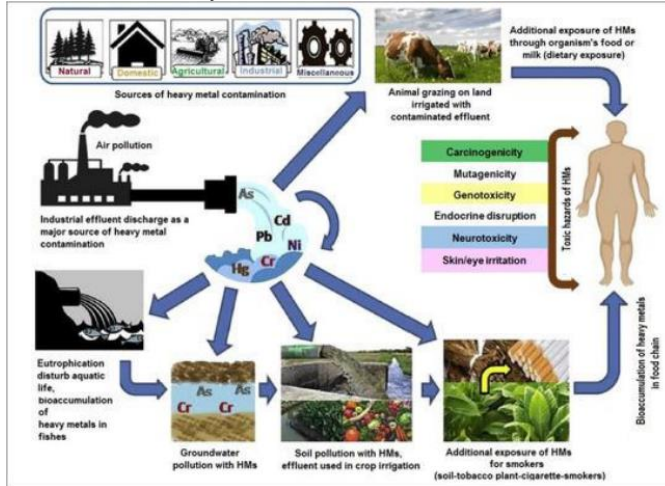


Figure 1: Sources and pathways of heavy metal contamination

2. Heavy Metal Concentration

Table 1: Concentration of Heavy Metals in Soil

Metal	Concentration Level	Permissible Limit	Status
Pb	Moderate–High	Standard limit	Concern
Cd	Low–Moderate	Very low limit	Sensitive
Cr	Moderate	Standard	Acceptable
Ni	Moderate	Standard	Acceptable
Zn	Moderate	Essential metal	Safe range
Cu	Moderate	Essential metal	Safe range

3. Spatial Variation

Variation in concentrations indicates:

- Different land-use patterns
- Fertilizer application
- Proximity to pollution sources

4. Effect on Soil Quality

Table 2: Impact of Heavy Metals on Soil

Property	Effect
Physical	Poor structure, reduced porosity
Chemical	Nutrient imbalance, altered pH
Biological	Reduced microbial activity

5. Environmental and Health Risk

- Heavy metals accumulate in soil
- Enter crops → food chain

Cause

- Kidney damage
- Neurological disorders
- Cancer

6. Correlation Analysis

Correlation among metals suggests:

- Common sources (fertilizers, wastewater, industrial inputs)

7. Mechanism of Uptake

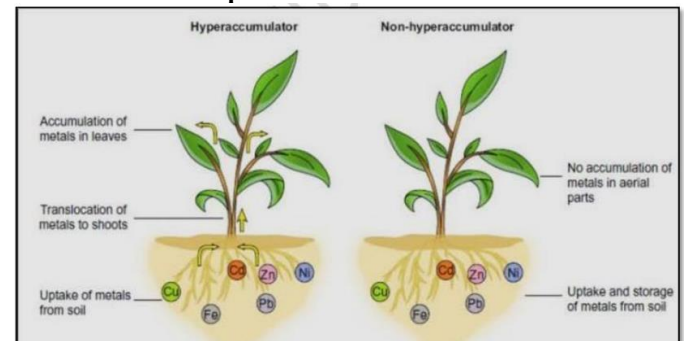


Figure 2: Heavy metal uptake by crops

8. Sample Processing

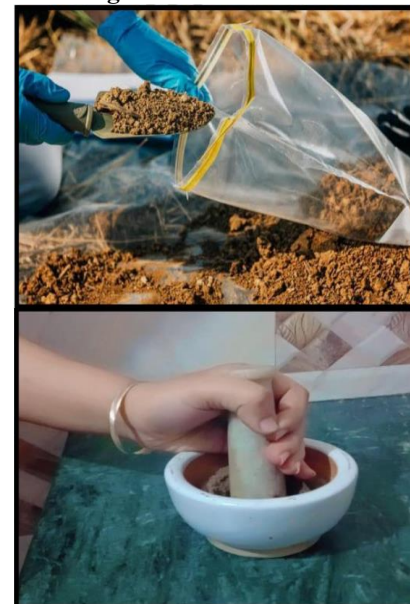


Figure 3: Soil sampling and preparation process

IV. CONCLUSIONS

The study demonstrates that agricultural soils are susceptible to heavy metal contamination due to anthropogenic activities. Although most metal concentrations were within permissible limits, certain locations showed elevated levels, indicating potential risk. Continuous monitoring and sustainable agricultural practices are essential to prevent long-term soil degradation and ensure food safety.

REFERENCES

1. Alloway, B.J. (2013). Heavy Metals in Soils. Springer.
2. Kabata-Pendias, A. (2010). Trace Elements in Soils and Plants. CRC Press.
3. WHO (2017). Guidelines for soil and water quality.
4. FAO (2015). Soil pollution and sustainable agriculture.
5. Sharma, R.K. et al. (2007). Heavy metal contamination in soils. Environmental Monitoring and Assessment.
6. Singh, A. et al. (2010). Heavy metals in agricultural soils. Journal of Environmental Science.
7. Tchounwou, P.B. et al. (2012). Toxicity of heavy metals. Environmental Toxicology.
8. Gupta, N. et al. (2019). Soil contamination and risk assessment. Environmental Science and Pollution Research.
9. Wuana, R.A., Okieimen, F.E. (2011). Heavy metals in contaminated soils. ISRN Ecology.
10. Bhargava, A. et al. (2012). Metal uptake in plants. Plant Physiology Reports.
11. APHA (2012). Standard methods for environmental analysis.
12. USEPA (2007). Soil screening guidelines.