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HEAVY METAL ASSESSMENT IN SOIL OF AMBAGARH CHOWKI REGION, CHHATTISGARH, INDIA

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ABSTRACT

The link between soil nutrients and plant growth is handled by plant nutrition. Each nutrient (macro and micro) is essential to the physiological processes that allow plants to grow properly; a lack of any one of these nutrients leads to damage in plants. For a plant to finish its life cycle, some nutrients must be present in greater amounts while others must be present in smaller amounts. In our investigation, we have selected three sites: agriculture field (F1), grassland field (F2) and rhizospheric soil in college campus field (F3) for comparative study. Our results showed that different heavy metals (HMs) and nutrients vary in the selected area, which provides better understanding of the soil texture and quality, which will be beneficial for the agriculture sector. Our study also revealed the nutrient and HM assessment in soil of the Ambagarh Chowki region, Chhattisgarh, for its betterment in agriculture purposes.
***Keywords* :** Ambagarh Chowki, Heavy metal, Nutrients, Soil quality.

Introduction

Heavy metal (HM) pollution in soil has become a major global environmental issue due to rapid industrialization and agricultural activities. Potentially toxic heavy metals such as cadmium (Cd), lead (Pb), chromium (Cr), arsenic (As), and nickel (Ni) accumulate in soil and persist for long periods because they are not easily degraded by microorganisms (Mishra *et al*., 2018). The HM contamination is a serious global environmental problem caused mainly by human activities such as mining, agriculture, industrial processes, and increasing traffic (Gao *et al*., 2023). This contamination harms soil quality, disrupts ecosystems, reduces agricultural productivity, and threatens human health through the food chain. Along with HMs, pollutants like pesticides, and excess nutrients also contribute to soil degradation (Zhang *et al*., 2024). Therefore, effective soil remediation is essential. Among different remediation methods, biological remediation is considered the most eco-friendly and cost-effective approach for restoring contaminated soils and protecting ecological and human health (Zhakypbek *et al*., 2024). Toxic metals released into the soil can be absorbed by crops, enter the food chain, and pose significant risks to human health. Mining and transportation are major contributors to soil pollution, while industries also release heavy metals through chemical and manufacturing activities. Vehicle emissions, brake wear, and tyre particles are important sources of Pb and Cd contamination, especially in roadside agricultural areas where crops often contain higher levels of heavy metals (Pouresmaieli *et al*., 2022).

Ambagarh Chowki in Chhattisgarh is an important mining and agricultural region where heavy metal contamination has become an environmental concern. HM can easily transport from roots to shoots, as they are highly mobile. In addition, they disrupt the water transport into the plants, which hampers the physiological processes such as photosynthesis, transpiration, stomatal conductance etc (Abbas *et al*. 2018). The presence of mining activities, industrial emissions, traffic, and excessive use of agrochemicals contributes to the accumulation of HMs in soil and water bodies (Khute *et al*., 2024). These contaminants can reduce soil fertility, affect crop productivity, and enter the food chain, posing risks to human and animal health. The nearby forest and river ecosystems are also vulnerable to pollution due to runoff from mining and agricultural lands (Verma *et al*., 2025). Therefore, regular monitoring and the use of eco-friendly remediation methods, especially biological remediation, are essential for protecting the environmental quality and public health of the Ambagarh Chowki region. This study aims to evaluate the contamination in the soil of Ambagarh Chowki region (Chhattisgarh, India) due to the presence of potential toxic heavy metals from both natural and anthropogenic sources. Therefore, removing HM from contaminated soil is essential for environmental safety and public health protection. Our study aims to reveal the HM assessment in soil of Ambagarh Chowki for the betterment of crop growth and future agricultural applications.

Materials and Methods

Study area

The soil samples were collected in triplicate from three different locations of Ambagarh Chowki region of Mohla-Manpur-Ambagarh Chowki, district of Chhattisgarh by using GPS map camera for precise location of all the samples (Fig. 1). These soil samples were compositely collected from multiple sites within each location to minimize the error and enhance the accuracy. The selected locations are as follows: agriculture field F1 (Lat. 20.773528°, Long. 80.729799°), grassland field F2 (Lat. 20.78195°, Long. 80.734998°) and rhizospheric soil in the college campus field F3 (Lat. 20.775769°, Long. 80.739281°) mentioned in figure 1A-C. The rhizospheric soil was collected from the hyperaccumulated plant. The soil samples were collected from 0-15 cm depth within each selected area. The collected soil samples were then oven-dried and sieved through a 2 mm sieve to obtain a uniform particle size for analysis.

Fig. 1 : Sample collection site. [A] agriculture field F1, [B] grassland field F2 [C] rhizospheric soil in the college campus field F3.

Soil analysis

The field parameters such as, pH, soluble salt, and organic carbon were measured by using Ogwu *et al*. (2024) methodology.

Estimation of essential nutrients and heavy metals

To determine the contents of micronutrients, macronutrients and potentially toxic heavy metals according to the methodology of Allen *et al*. (1986). The 100 mg of oven-dried soil samples were digested in a tri-acid mixture containing HNO_3:H_2SO_4:$HClO_4$ in a ratio of 5:1:1 (v/v) at 80-90°C till a clear solution was obtained. Thereafter, the solutions were filtered, and the contents of nutrients and heavy metals were estimated by using an inductively coupled plasma mass spectrometry (ICP-MS) (Agilent 7900).

Statistical analysis:

The data were analysed statistically using one-way analysis of variance (ANOVA) with SPSS-16 software. Duncan's multiple range test was applied for mean analysis of three independent experiments (n=3) to identify significant differences among treatments at $p<0.05$ levels. Sigma plot 10.0 software was used for the graphical analysis.

Result and Discussion

We have examined soil characteristics such as soil type, pH, soluble salt and organic carbon of three selected areas: agricultural soil (F1), grassland soil (F2) and rhizospheric soil within the college campus (F3) mentioned in table 1 and figure 2. We found kanhar-type of soil in all the three selected areas (F1, F2 and F3) with pH 6.8, 6.5 and 6.1 respectively. The F3 has high soluble salt due to water uptake by roots, selective ion exclusion and root exudates (Liu *et al*., 2022). While F2 has high organic carbon due to lack of soil disturbance, absence of tillage and highly efficient microbial turnovers (Danise *et al*., 2025). Our study revealed that the contents of Cr and Pb were found to be comparatively high in F2; however, the contents of Ni and As were found to be comparatively high in F3 (Table 1). In contrast to this, Cr content was found to be high in F1. The grasslands often accumulate higher levels of Cd and Pb in top soils than agricultural fields. This occurs because the grassland acts as undisturbed, long-term sinks for atmospheric pollutants, lacks the soil dilution caused by deep tilling, and relies on organic matter that tenaciously traps these HMs. Grassland soils frequently exhibit higher concentrations of heavy metals than agricultural fields. This is primarily due to the lack of soil disturbance, greater organic matter accumulation, and the continuous removal of metals through crop harvesting in farmlands (Chai *et al*., 2015). The rhizosphere (the narrow zone of soil directly surrounding plant roots) often exhibits higher concentrations and bioavailability of heavy metals than bulk agricultural soil. This occurs because the continuous release of root exudates alters the soil chemistry, and the roots selectively accumulate or mobilize certain elements from the broader soil environment (Zhu *et al*., 2024). Agricultural soils frequently have higher Cr contents than grasslands and rhizospheric soils primarily due to anthropogenic inputs (synthetic fertilizers and pesticide usages), tillage practices, and lower natural dilution caused by diminished root-driven biological activity (Yu *et al*., 2023). Grasslands often exhibit higher micronutrient availability and more balanced or lower macronutrients compared to agricultural land due to natural and undisturbed soil process. In contrast to this, agricultural soil is frequently depleted of micronutrients due to high intensity crop uptake, while macronutrients are artificially replenished. Therefore, our study will be beneficial for agriculture sector due to the variation in heavy metal accumulation in all three selected areas. Our study also revealed the macro and micronutrients available in selected areas for better crop growth.

Table 1: Physico-chemical analysis of soil

S. No.	Parameters	F1	F2	F3
1	Soil type	Kanhar	Kanhar	Kanhar
2	pH	6.8	6.5	6.1
3	Soluble salt (mmhos/cm)	0.3 ± 0.16	0.2 ± 0.01	0.4 ± 0.01
4	Organic carbon (%)	0.3 ± 0.01	0.6 ± 0.01	0.45 ± 0.01
5	Nitrogen (µg/g)	263 ± 6.51	225 ± 3.46	238 ± 3.05
6	Phosphorus (µg/g)	232.45 ± 7.53	652.47 ± 2.27	176.84 ± 1.6
7	Potassium (µg/g)	5536.29 ± 2.76	4523.77 ± 2.7	3463.58 ± 1.12

Table 2: ICP-MS analysis of micronutrient and heavy metal content in soil

S. No.	Micronutrients (µg/g)	F1	F2	F3
1	Mg	1822.73 ± 4.74	2945.04 ± 2.95	3533.69 ± 1.43
2	Ca	148.25 ± 2.59	216.42 ± 3.22	1457 ± 0.88
3	Mn	242.22 ± 4.16	795.39 ± 2.75	594.44 ± 1.1
4	Fe	285 ± 2.61	54012.61 ± 1.41	46625.4 ± 1.4
5	Cu	22.95 ± 2.09	33.31 ± 1.02	53.88 ± 0.48
6	Zn	35.64 ± 2.63	273.08 ± 1.8	60.69 ± 0.37
Heavy metals (µg/ g)				
7	Cr	86.07 ± 1.09	46.58 ± 0.34	36.01 ± 0.58
8	Ni	29.54 ± 0.79	38.08 ± 0.54	40.72 ± 0.83
9	As	10.38 ± 0.31	7.65 ± 0.78	14.26 ± 0.41
10	Cd	0.09 ± 0.01	1.22 ± 0.01	0.13 ± 0.01
11	Pb	13.41 ± 0.16	145.26 ± 0.37	137.05 ± 0.58

[Note: Vaues represent as Mean ± SD (Standard deviation) in table 1 & table 2].

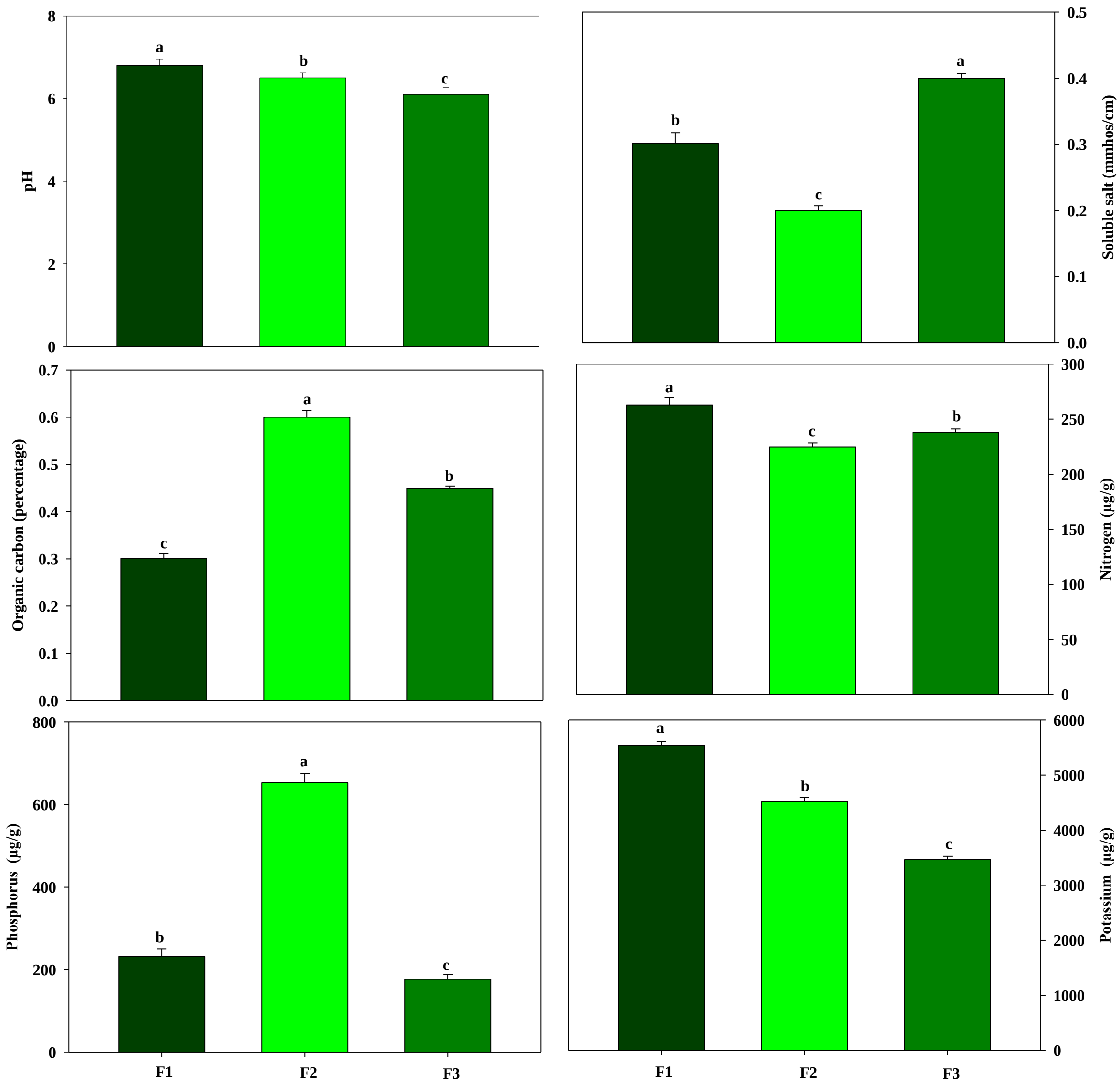

Fig. 2: Soil parameters (pH, soluble salt, organic carbon, nitrogen, phosphorus and potassium) in F1, F2 and F3.

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Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this work.

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