Scientific Journal for Publishing in Health Research and Technology
Volume 2, Issue 1, 2026, Pages: 79-87
Journal homepage: https://sjphrt.com.ly/index.php/sjphrt/en/index

Spatial Distribution and Ecological Risk Assessment of Heavy Metals in Agricultural Soils Around Industrial Hubs in Prayagraj Uttar Pradesh, India

Nouraldin Almahdi Ibrahim Basha [*1], Abhishek James[2], Ibadaiahun Myrthong
[1] College of Arts and Sciences -Wadi Ataba, Fezzan university, Wadi Ataba, Libya
[2,3] Department of Environmental Science and NRM, SHUATS, India

التوزيع المكاني وتقييم المخاطر البيئية للمعادن الثقيلة في التربة الزراعية حول المراكز الصناعية في براياغراج، ولاية أوتار براديش، الهند

نورالدين المهدي إبراهيم باشا [1*]، أبهيشيك جيمس [2]، إباداياهون ميرثونج [3]
[1] كلية الآداب والعلوم –وادي عتبة، جامعة فزان، وادي عتبة، ليبيا
[3،2] قسم العلوم البيئية وإدارة الموارد الطبيعية، شواتس، الهند

[*]Corresponding author: nou.basha@fezzanu.edu.ly

Received: October 20, 2025	Accepted: December 23, 2025	Published: January 22, 2026

Abstract:
The industrial expansion in the Naini and Jhunsi regions of Prayagraj, Uttar Pradesh, has raised significant concerns regarding heavy metal accumulation in agricultural soils, impacting crop safety and human health. This study provides a comprehensive evaluation of the occurrence, spatial distribution, and ecological consequences of metals such as Fe, Zn, Pb, Cd, Ni, Cr, and Cu in the local environment. Ten representative sampling sites (N1-N5 in Naini and J1-J5 in Jhunsi) were analyzed to assess physico-chemical properties and metal concentrations at a depth of 0-20 cm. Findings reveal that Naini soils exhibit higher levels of contamination compared to Jhunsi, particularly near industrial effluent channels and fields irrigated with wastewater from the Mawaiya drain. The soil pH across all sites ranged from 7.5 to 8.1, indicating slightly alkaline conditions that influence metal mobility. High values of the Pollution Load Index (PLI) and Enrichment Factor (EF) indicate moderate to high contamination in specific hotspots. Key sources of these pollutants include steel and metal fabrication industries, untreated sewage, and municipal waste dumping. The study concludes that immediate intervention is required, including systematic surveillance, wastewater treatment, and the adoption of remediation strategies like phytoremediation to safeguard food safety and agricultural livelihoods in the region.

Keywords: Heavy metals, soil contamination, Naini, Jhunsi, Prayagraj, pollution load index, wastewater irrigation, agricultural risk, India.

الملخص
أدى التوسع الصناعي في منطقتي نابيني وجهونسي في براياجراج، ولاية أوتار براديش، إلى إثارة مخاوف كبيرة بشأن تراكم المعادن الثقيلة في التربة الزراعية، مما يؤثر على سلامة المحاصيل وصحة الإنسان.

تقدم هذه الدراسة تقييماً شاملاً لتركز التلوث وتوزيعه المكاني والنتائج البيئية للفلزات مثل الحديد، الزنك، الرصاص، الكادميوم، النيكل، الكروم، والنحاس في البيئة المحلية .تم تحليل عشرة مواقع وأخذ عينات ممثلة (N1-N5) في نايبني (1J-J5) في جهونسي (لتقييم الخصائص الفيزيائية والكيميائية وتركيزات المعادن عند عمق 0-20 سم .كشفت النتائج أن تربة نايبني تظهر مستويات أعلى من التلوث مقارنة بجهونسي، لا سيما بالقرب من قنوات الصرف الصناعي والحقول المروية بمياه الصرف الصحي من مصرف ماويا .تراوح الرقم الهيدروجيني للتربة في جميع المواقع بين 7.5 و8.1، مما يشير إلى ظروف قلوية قليلاً تؤثر على حركة المعادن .تشير القيم العالية لمؤشر حمل التلوث (PLI) وعامل الإثراء (EF) إلى وجود تلوث متوسط إلى عالٍ في بقع ساخنة محددة .وتشمل المصادر الرئيسية لهذه الملوثات صناعات الصلب وتشكيل المعادن، ومياه الصرف الصحي غير المعالجة، وإلقاء النفايات البلدية .تخلص الدراسة إلى ضرورة التدخل الفوري، بما في ذلك المراقبة المنهجية، ومعالجة مياه الصرف الصحي، واعتماد استراتيجيات المعالجة مثل المعالجة النباتية لحماية سلامة الغذاء وسبل العيش الزراعية في المنطقة.

الكلمات المفتاحية: المعادن الثقيلة، تلوث التربة، نايبني، جهونسي، برايا جراج، مؤشر حمل التلوث، الري بمياه الصرف الصحي، المخاطر الزراعية، الهند.

1. Introduction

The Global and Regional Challenge of Heavy Metal Contamination

Heavy metals are naturally occurring elements found within the Earth's crust; however, when their concentrations escalate significantly due to intensive anthropogenic practices, they become hazardous to soil health, sustainable crop production, and human well-being following their translocation into the food chain (Alloway, 2013). Unlike organic pollutants, these metals are non-biodegradable and possess a high degree of persistence in the environment, making their management a critical ecological challenge (Kabata-Pendias, 2011).

Dynamics of Accumulation in Food Chains

The localized accumulation of heavy metals in agricultural soils has become a widespread phenomenon driven by rapid industrialization and unplanned urbanization. This process involves the discharge of industrial effluents, untreated wastewater irrigation, and municipal solid wastes into local drains and fertile fields (Bhattacharya et al., 2012). Recent scientific reviews have emphasized that this contamination is not limited to soil but extends to diverse food groups. For instance, Salem et al. (2025a) detailed the chemical safety risks associated with dairy products, illustrating how the dynamics of lead (Pb) and cadmium (Cd) accumulation pose a direct threat to consumers through animal-derived food chains.

Similarly, investigation into fruit-based products has revealed concerning trends. Research on orange juices consumed in Libya has identified measurable heavy metal content (Amheisen et al., 2025), while an overview of date palm fruits highlights the vulnerability of essential desert crops to metallic contamination (Salem & Mohamed, 2025). These studies collectively underscore that heavy metals move fluidly from contaminated environmental mediums into the human diet.

Regional Case Study: Prayagraj, Uttar Pradesh

In the district of Prayagraj (formerly Allahabad), India, the industrial belts of Naini and Jhunsi have been identified as significant focal points for potential heavy-metal pollution. This risk is primarily attributed to a dense clustering of steel plants, metal-working facilities, and related manufacturing units (Lamma et al., 2018). The environmental impact is further compounded by peri-urban agricultural activities, where farmers occasionally utilize wastewater from industrial drains as a primary irrigation source (Lamma, 2021).

Specific localized data supports this concern:

Soil Degradation: Fields irrigated with wastewater from the Mawaiya drain in the Naini suburbs have shown a notable increase in their Pollution Load Index (PLI), signaling a rapid deterioration of soil quality (Yadav & Yadav, 2018).
Metallic Profile: Scientific investigations indicate elevated levels of toxic metals, specifically iron (Fe), zinc (Zn), lead (Pb), cadmium (Cd), nickel (Ni), chromium (Cr), and copper (Cu).
Vegetation Impact: These contaminants have been repeatedly detected in surface soils, drainage sediments, and various vegetable crops grown in and around the Naini industrial estate (Primescholars, 2013). Recent comparative studies have also highlighted the specific accumulation of Cd and Pb in soils irrigated with sewage water compared to non-sewage sources in the region.

2. Materials and Methods

2.1 Study Area

This was carried out in the agricultural lands around industrial clusters of Naini and Jhunsi in the district of Prayagraj, Uttar Pradesh, India. Naini is a developed industrial zone with large manufacturing units in the form of textiles, pharmaceutical, paper mills, chemical industries, and metal-processing unit whereas Jhunsi has medium- and small-sized industries such as printing, packaging, and agro-chemical units. The clusters are located near Yamuna River and also enclosed by a vast agricultural land where wheat, mustard, rice and pulses are grown. The area has a humid subtropical climate with average annual temperatures of 9 42 C and 900 1,050 mm rainfall which is mainly received in the monsoon season. The soils around the area are majorly alluvial sandy loam to loam soils with moderate ability to hold nutrients but contaminated as a result of swift percolation and industrial run off.

2.2 Sampling Sites and Sample Collection

Ten representative sampling sites were chosen and they were N1-N5 on Naini and J1-J5 on Jhunsi and were selected in terms of closeness to the industrial effluent channels, agricultural activity and accessibility. Composite soil samples were sampled at both sites at the depth of 0-20cm plough layer, using the standard methods of soil sampling procedures (Jackson, 1973; Sparks et al., 1996). Composite samples were prepared in each subsample by a mixture of five subsamples randomly picked at a distance of 2530 m to minimize the spatial effect. In this manner, 50 subsamples were obtainable and mixed together to 10 composite soil samples that were to be analyzed in the laboratory.
This was done by using a stainless-steel auger to collect samples without contaminated samples and preserving them in clean polythene bags with labels and transported to a laboratory. Physico-chemical analyses were done on samples which were air-dried, ground using a wooden mortar and subjected to a 2 mm sieve. Separate subsamples were filtered by using 0.5 mm mesh to obtain organic carbon.

2.3 Physico-Chemical Parameters Analyzed

S.No.	Soil Parameter	Methods
1.	Soil pH	(Jackson, 1973)
2.	Conductivity (EC)	(Jackson, 1973)
3.	Organic Carbon (OC)	(Walkley & Black, 1934)
4.	Cation Exchange Capacity (CEC)	Chapman (1965)
5.	Bulk Density	(Blake & Hartge, 1986)
6.	Heavy Metal Analysis Pb, Cd, Cr, Ni, Cu, and Zn	APHA (2012)

3. Results and Discussion

3.1 Physico-Chemical Properties of Soil

The combined table shows the physico-chemical properties of soils in five locations each in the Naini and Jhunsi industrial areas. The findings revealed that the pH of the soil in all sites was between 7.5 and 8.1, which implies that there were slightly alkaline soils characteristic of the alluvial soils of the Indo-Gangetic Plains. This alkalinity may affect the solubility and movement of the heavy metals and lead to the occurrence of metals on the surface layers. At some sites (e.g., N4), Naini soils had slightly higher values of pH and this might be explained by industrial deposition of dust or by calcareous parent material.

Table 3.1. Physico-Chemical Properties of Soil at Different Sites of Naini Industrial Region

Parameter	Site N1	Site N2	Site N3	Site N4	Site N5
pH	7.5	7.6	7.8	8.0	7.7
EC (dS/m)	0.32	0.41	0.58	0.63	0.47
Organic Carbon (%)	0.52	0.61	0.48	0.72	0.66
Texture	Sandy loam	Sandy loam	Loam	Clay loam	Sandy loam
CEC (cmol/kg)	12.4	13.7	15.2	18.3	14.9
Bulk Density (g/cm³)	1.41	1.39	1.48	1.52	1.44

The electrical conductivity (EC) ranged 0.32- 0.63 dS/m in Naini and 0.27- 0.55 dS/m in Jhunsi. The relatively high EC at N3 and N4 indicate high salt content, which is probably because of the closeness to an industrial effluent or wastewater irrigation. Jhunsi soils exhibited intermediate EC values which meant that salinity would have less impact than Naini. The organic carbon level was found to be 0.48-0.72 in Naini and 0.44-0.71 in Jhunsi which indicated moderately fertile soils. Sites N4 and J5 had the highest levels of organic carbon and this could increase biological activity in the soil and contributes towards the trapping of heavy metals through the formation of organo-metallic complex.

Table 3.2. Physico-Chemical Properties of Soil at Different Sites of Jhunsi Industrial Region

Parameter	Site N1	Site N2	Site N3	Site N4	Site N5
pH	7.6	7.8	8.1	7.9	7.7
EC (dS/m)	0.27	0.33	0.45	0.55	0.39
Organic Carbon (%)	0.44	0.58	0.63	0.49	0.71
Texture	Sandy loam	Sandy loam	Loam	Sandy clay loam	Sandy loam
CEC (cmol/kg)	11.8	13.2	14.6	16.7	15.1
Bulk Density (g/cm³)	1.46	1.40	1.43	1.49	1.38

The texture of soils in both areas was largely sandy loam, though some locations had loam or clay loam traits (N4 and J4). The textural differences are important in metal mobility because in the sandy loam soils, it is easy to infiltrate and move the pollutants due to the high rate of infiltration, whereas under clay soils it adsorbs and immobilizes the metals. This is observed in the values of Cation Exchange Capacity (CEC), which showed greater values in the clay-rich soils N4 (18.3 cmol/kg) and J4 (16.7 cmol/kg). Increased CEC means that there is an increased possibility of holding nutrients and metal ions within the soil matrix.

Bulk density (BD) measured 1.39 1.52 g/cm 3 between the sites with more values at N4 and N3 indicating that compaction possible due to industrial action, low organic content, or heavy agricultural activities. Reduced bulk density at J5 means that the soil structure and aeration are good that favors the developmental of the roots and the activity of the microbes.

3.2 Comparative Interpretation Between Naini and Jhunsi

Generally, the EC, CEC and the bulk density values of the soils at the Naini region are high than at the Jhunsi region, indicating that industrial activity is more prominent on the soil quality at Naini. The high EC and CEC in and around Naini could be due to the deposition of the industrial remains, release of effluents as well as the fallouts produced by the chemical and metallurgical industries situated at the location. Conversely, Jhunsi soils are comparatively less impacted yet they exhibit evidence of anthropogenic impact because of medium alkalinity and EC.

These physico-chemical differences have a direct impact on heavy metal behavior on the study region. Clayier soils and those with greater CEC (N4, J4) have more adsorption capacity of metals and thus they accumulate in the top soil profile. Conversely, the sandy loam soils that have low CEC can cause enhanced downward migration of metals, which can be hazardous to groundwater contamination and uptake in the plants. The presence of alkalinity, moderate organic carbon, and sites and difference stemming out of the varying nature of the texture elucidates how heavy metal will interact dynamically within the agricultural soils of Naini and Jhunsi.

Table:3.3. Comparative Physico-Chemical Properties of Soil at Naini and Jhunsi Industrial Regions

Parameter	N1	N2	N3	N4	N5	J1	J2	J3	J4	J5
pH	7.5	7.6	7.8	8.0	7.7	7.6	7.8	8.1	7.9	7.7
EC (dS/m)	0.32	0.41	0.58	0.63	0.47	0.27	0.33	0.45	0.55	0.39
Organic Carbon (%)	0.52	0.61	0.48	0.72	0.66	0.44	0.58	0.63	0.49	0.71
Texture	Sandy loam	Sandy loam	Loam	Clay loam	Sandy loam	Sandy loam	Sandy loam	Loam	Sandy clay loam	Sandy loam
CEC (cmol/kg)	12.4	13.7	15.2	18.3	14.9	11.8	13.2	14.6	16.7	15.1
Bulk Density (g/cm³)	1.41	1.39	1.48	1.52	1.44	1.46	1.40	1.43	1.49	1.38

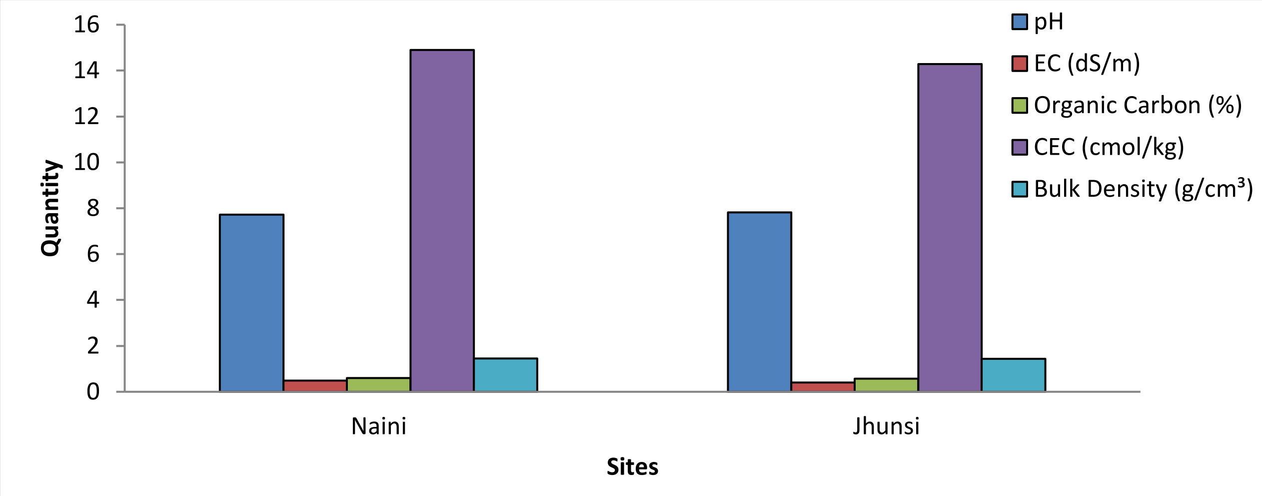

Figure: 3.1 Comparative Average Physico-Chemical Properties of Soil at Naini and Jhunsi Industrial Regions

Heavy Metals in Naini Industrial Region

The Naini industrial area soils had relatively a higher level of the hard metals, especially the Fe, Zn, Ni, Cr, Pb, and Cd, signifying that the soil was more affected by industrial and anthropogenic processes. Mean concentrations were also in sequence; Fe > Zn > Cr > Ni > Pb > Cu > Cd with highest values always registered in sites N3 and N4 which are nearer to industrial effluent channels and the waste water irrigated fields (lamma,2021). Metallurgy, steel industries, motor traffic, and disposition of untreated industrial wastes are common sources of high levels of Zn, Ni, and Cr, all of them are very common in the Naini industrial estate. Even though the levels of metal have not exceeded the recommended allowable levels, the enrichment of the harmful metal Pb and Cd are also of concern, as they are persistent and bioaccumulative. Previous research identified similar patterns of moderate- high levels of contamination and high values of Pollution Load Index (PLI) in Naini soils irrigated with wastewater, which indicated the long-term risks of soil degradation and crop contamination in the area (Alloway, 2013; Yadav & Yadav, 2018; Kabata-Pendias, 2011).

Table 3.4(a). Heavy metal concentrations (mg kg^{-1}) in surface soils (0–20 cm) of Naini industrial region, Prayagraj

Site	Fe	Zn	Cu	Ni	Cr	Pb	Cd
J1	34,500	68.4	22.1	31.5	44.2	27.6	0.62
J2	36,200	72.8	24.6	34.1	47.9	29.3	0.71
J3	38,900	81.5	28.2	39.4	52.6	33.7	0.85
J4	41,300	89.6	31.4	42.7	58.3	36.9	0.96
J5	37,600	76.9	26.8	36.2	49.8	31.5	0.78
Mean	**37,700**	**77.8**	**26.6**	**36.8**	**50.6**	**31.8**	**0.78**

Heavy Metals in Jhunsi Industrial Region

Conversely, the Jhunsi soils exhibited comparatively lesser concentrations of the heavy metals than the Naini soils yet there were traces of anthropogenic enrichment. The mean values of Fe, Zn, Cu, Ni, Cr, Pb, and Cd were lower in most sites, which represent the decreased intensity of the industry and the relative exposure to the wastewater irrigation. The sites like J3 and J4 however contained relatively high amounts of Zn, Cr, and Pb that can be explained by mixed land use, presence of urban runoff, and the fact that irrigation of the land was sometimes carried out using sewage-contaminated water (Lamma,2024). Jhunsi soils have a moderate organic carbon content and a low pH of soil; this alkalinity may contribute to the partial immobilization of the metals; however, with constant efforts by diffusive sources, this may be accumulated with time. The moderate enrichment of heavy metal in the Jhunsi soils and vegetables in peri-urban zones of Prayagraj was also reported in the past (Bhattacharya et al., 2012; Gupta, 2021; Prime scholars, 2013; Asanousi,2018), which highlights the necessity of periodic monitoring as a preventive effort to avert future risks to agriculture and health.

Table 3.4(b). Heavy metal concentrations (mg kg^{-1}) in surface soils (0–20 cm) of Jhunsi industrial region, Prayagraj

Site	Fe	Zn	Cu	Ni	Cr	Pb	Cd
J1	32,400	61.2	19.4	28.7	40.6	24.1	0.48
J2	33,700	64.5	21.3	30.2	43.1	25.9	0.54
J3	35,900	70.8	23.7	33.8	46.7	28.6	0.63
J4	37,800	78.4	27.5	37.9	51.2	32.4	0.74
J5	34,600	66.9	22.9	31.6	45.4	26.8	0.59
Mean	**34,880**	**68.4**	**23.0**	**32.4**	**45.4**	**27.6**	**0.60**

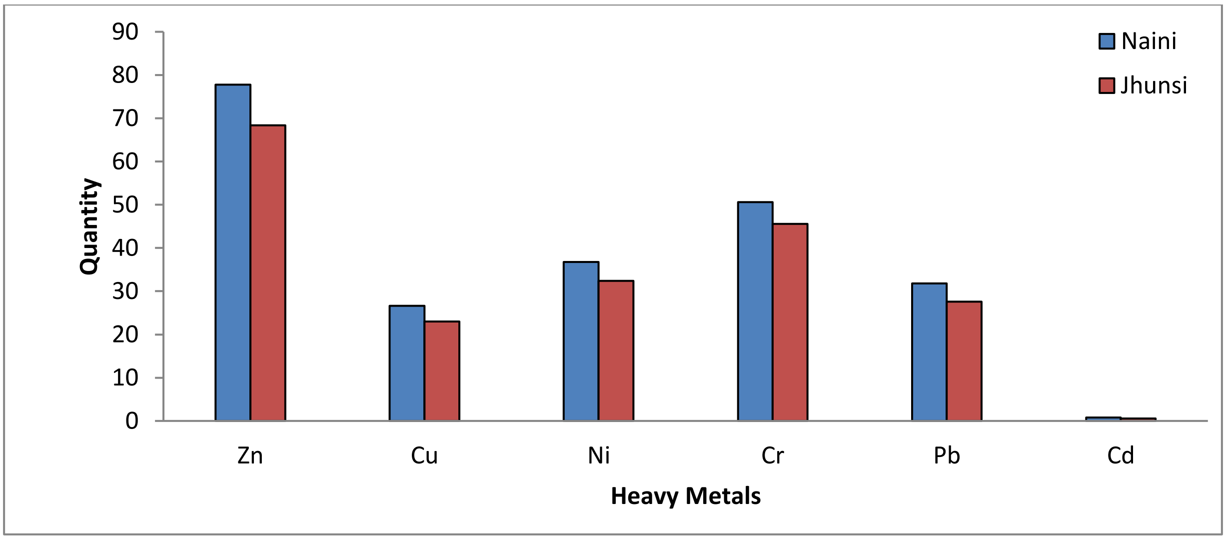

Figure:3.2 Heavy metal concentrations (mg kg^{-1}) in surface soils (0–20 cm) of Naini and Jhunsi industrial region, Prayagraj

4. Conclusion

In this empirical evaluation, the results demonstrate a moderate to high level of heavy-metal contamination in the agricultural soils within the Naini industrial cluster, contrasted with low to moderate contamination levels in the Jhunsi cluster. Key findings include significantly elevated concentrations of Pb, Cd, Cr, and Ni in Naini soils. The calculated pollution indices—specifically the Contamination Factor (CF), Geo-accumulation Index (I_{geo}), and Pollution Load

Index (PLI)—confirm the existence of localized environmental hotspots, particularly in areas adjacent to industrial drain discharge points and fields under long-term wastewater irrigation. The study highlights how the physico-chemical properties of the soil—characterized by alkaline pH, variable textures, medium organic carbon levels, and increased Cation Exchange Capacity (CEC) in clay-rich sites—directly influence metal retention and bioavailability. This interaction creates a heterogeneous landscape of risk regarding crop uptake and potential human exposure. Given the documented risk of food-chain contamination and its subsequent impact on public health, a unified multi-sectoral approach is essential. Critical interventions should include the cessation of untreated wastewater irrigation and unregulated industrial discharges, alongside the implementation of systemic, multi-seasonal monitoring of both soil and crops (Lamma, 2021). Furthermore, the adoption of specialized agronomic practices and innovative remediation strategies, such as phytoremediation, must be strictly overseen by local environmental authorities. Future research should prioritize the quantification of plant uptake and human-health risk assessments, including Estimated Daily Intake (EDI) and Target Hazard Quotient (THQ). Additionally, investigating metal speciation and groundwater migration is necessary to fully characterize the pathways of exposure. These steps are crucial for safeguarding agricultural livelihoods and ensuring food safety in the Prayagraj (Naini–Jhunsi) region.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Aggarwal, M., Anbukumar, S., & Vijaya Kumar, T. (2022). Heavy metals concentrations and risk assessment in the sediment of Ganga River between Kanpur and Prayagraj, UP, India. Sādhanā, 47(4), 195.

[2] Ahmed, M., David, A. A., Thomas, T., & Swaroop, N. (2019). Assessment of heavy metals (Cr, Cu, Cd, Pb & Zn) in soil and potato crop amended with solid liquid Waste in Prayagraj India.

[3] Alloway, B. J. (Ed.). (2012). *Heavy metals in soils: trace metals and metalloids in soils and their bioavailability* (Vol. 22). Springer Science & Business Media.

[4] Amheisen, A. A., Salem, M. O. A., Ali, G. M., Abdulrahim, J. A., & Momammed, S. J. S. (2025). Determination of some heavy metal content in orange juices consumed in Libya. Al-imad Journal of Humanities and Applied Sciences (AJHAS), 01-04.

[5] Asanousi Lamma, O., Swamy, A. V. V. S., & Alhadad, A. A. (2018). Assessment of Heavy Metal Pollution in Ground Water and its Correlation with other Physical Parameters at Selected Industrial Areas of Guntur, AP, India. AP, India.

[6] Bhattacharya, A., Routh, J., Jacks, G., & Bhattacharya, P. (2012). Heavy metal contamination in agricultural soils. Environmental Monitoring and Assessment, 184(7), 4119–4134.

[7] Gupta, N., Yadav, K. K., Kumar, V., Cabral-Pinto, M. M., Alam, M., Kumar, S., & Prasad, S. (2021). Appraisal of contamination of heavy metals and health risk in agricultural soil of Jhansi city, India. Environmental Toxicology and Pharmacology, 88, 103740.

[8] Kabata-Pendias, A. (2000). Trace elements in soils and plants. CRC press.

[9] Kumar, M. A. N. O. J., Mani, D. I. N. E. S. H., Sahu, V. I. P. I. N., Shukla, D. P., Vishwakarma, H. I. M. A. N. C. H. A. L., Verma, J. E. E. T. E. N. D. R. A., ... & Patel, S. U. R. A. J. (2024). Profile-wise enrichment of metallic pollutants (Pb, Cr and Cd) in various sewage and non-sewage irrigated soils of Prayagraj. Annals of Plant and Soil Research, 26(2), 323-332.

[10] Lamma, O. A. (2021a). Waste disposal and landfill: Potential hazards and their impact on groundwater. International Journal of Geography, Geology and Environment, 3, 133-14.

[11] Lamma, O. A. (2021b). Groundwater problems caused by irrigation with sewage effluent. International Journal for Research in Applied Sciences and Biotechnology, 8(3), 64-70.
[12] Lamma, O. A. (2024). Innovative Remediation Strategies for Tackling Groundwater Pollution: A Comparative Analysis. African Journal of Advanced Pure and Applied Sciences (AJAPAS), 90-98.
[13] Mohammed, A. M., & Lamma, O. A. Studying altitude influence on Uludağ fir, scots pine and black pine growth and soil properties in Kastamonu.
[14] Primescholars. (2013). Heavy metal status in different drains discharging into the River Ganga and accumulation in land and plants at Allahabad, Uttar Pradesh. Pelagia Research Library.
[15] Salem, I. A. S., Khalil, R. A. A., & Salem, M. O. A. (2025). Chemical safety of dairy products: A review study on the dynamics of lead and cadmium accumulation. Scientific Journal for Publishing in Health Research and Technology, 1(2), 241–256. https://doi.org/10.65420/sjphrt.v1i2.47
[16] Salem, M. O. A. (2025). Review Study on the Concentration of Heavy Metals in Canned Tuna. Al-imad Journal of Humanities and Applied Sciences (AJHAS), 05-11.
[17] Salem, M. O. A., & Mohamed, N. M. (2025). Heavy Metal Contamination in the Fruit of Date Palm: An Overview. Bani Waleed University Journal of Humanities and Applied Sciences, 10(1), 165-179. https://doi.org/10.58916/jhas.v10i1.661
[18] Salem, M. O. A., & Salem, I. A. S. (2023).Detection of Heavy Metals in Goat Milk in Bani Waleed City-Libya. (2023). Libyan Journal of Ecological & Environmental Sciences and Technology, 5(2), 73-77. https://doi.org/10.63359/grq3pd16
[19] Verma, J., Mani, D., Sahu, V., Shukla, D. P., Vishwakarma, H., Kumar, M., & Ojha, R. K. (2024). Accumulation of Cd and Pb in soils irrigated with sewage and nonsewage water in Prayagraj, India. Crop Research, 59(5and6), 227-234.
[20] Yadav, A., & Yadav, P. K. (2018). Pollution load index (pli) of field irrigated with wastewater of mawaiya drain in naini suburbs of allahabad district. Current World Environment, 13(1), 159.

