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ASSESSMENT OF HEAVY METAL CONTAMINATION IN URBAN SOIL AND ITS IMPLICATON FOR HUMAN HEALTH IN RAJNANDGAON, CHHATTISGARH

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Abstract— **Rajnandgaon, a fast-growing urban city of Chhattisgarh, is observing high urbanisation and industrialisation, which resulted in rising issues of heavy metal pollution of soils in urban areas. This research intends to evaluate the concentration of heavy metals like lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), and mercury (Hg) in Rajnandgaon urban soils and gauge their ability to pose threats to human health. Soil samples were taken from different urban areas and analyzed for their metal content with the help of atomic absorption spectroscopy. It was found that the concentration of some of the toxic metals was higher than the internationally and nationally established permissible limits of environmental standards. Estimation of daily intake (EDI), hazard quotient (HQ), and carcinogenic risk was done to assess both non-carcinogenic and carcinogenic effects. The results indicate considerable health threats, especially to the vulnerable groups like children and elderly. The research emphasizes the immediate necessity for environmental surveillance, soil remediation policy, and public health measures for reducing the long-term consequences of exposure to heavy metals in urban parts of Rajnandgaon.**

Keywords— **Rajnandgaon, Chhattisgarh, heavy metal, contamination, urban soil, human health.**

I. INTRODUCTION

Heavy metals, being heavy and dense, are environmentally and health-concerned because of their toxicity as well as their persistence. Despite the fact that there is no strict definition according to weight, "heavy metals" typically includes those elements with certain characteristics, defined by high density due to the presence of high numbers of protons, neutrons, and electrons (Wang, et al., 2024).

These metals, in any quantity, can interfere with biological functions and cause harm to human health and the environment as well. Lead (Pb), for instance, has long been used for coating and in fuel. It is extremely harmful to neurological and developmental health and particularly to children. Mercury (Hg) bioaccumulates in fish and other sea life, and from a compound of mercury called methylmercury, there are adverse health effects from consumption of contaminated fish. Cadmium (Cd), extensively utilized in industry, gets deposited in the soil and crop produce and is hence a health hazard to humans through food ingestion. Arsenic (As) of natural as well as industrial origin pollutes water bodies and hence poses serious health issues (Zhang, et al., 2024).

They may be natural or anthropogenic in origin due to activities such as industry, mining, and agriculture. They settle in soils, hence preventing the growth of plants and polluting food crops (Niaxi, et al., 2023).

Industrial site runoff and spontaneous dumping of wastes may pollute water bodies and influence aquatic ecosystems and human health. Industrial activity releases certain metals to the atmosphere, which cause pollution in the air (Su, et al., 2024).

Governments and environmental authorities regulate metal content in air, water, soil, and food to safeguard public health and the environment. Monitoring programs establish concentrations to evaluate risk and inform mitigation steps (Eid, et al., 2024).

Industrial and man-altered urban environments will possess such metals as lead, cadmium, mercury, arsenic, chromium, nickel, copper, and zinc (Monib, 2023).

Regulations, pollution control technologies, and green urban planning reduce metal release to protect public health (Mansoetal., 2024).

Key properties of heavy metals include high density, toxicity at low concentration levels, persistence, bioaccumulation, non-biodegradability, and varied water solubility. Sources are natural processes and human practices like industry. Examples which are prevalent are lead, mercury, cadmium, arsenic, chromium, and nickel. Heavy metal presence is rigorously screened for potential dangers and controlled as such (Jagaba, et al., 2024).

Heavy metals will be toxic to the body by building up in cells and tissues, destroying essential molecules such as proteins and DNA. Bioaccumulation is caused by a range of processes and is toxic. Heavy metals have been shown by research to contribute to oxidative damage to biological molecules, particularly when bound to DNA and nuclear proteins.

Heavy metals such as lead, mercury, cadmium, and copper can find their way into the human body by consuming contaminated water or consuming crops that have been cultivated in contaminated soil, the metals are poisonous and lead to contamination of the environment, inducing oxidative stress to cells and various health issues, ranging from harm to the brain, cancer, developmental disabilities, dumpsites, which scavengers visit, are dangerous due to waste materials from the sites serving as food for animals, making them vectors for pest and disease, excessive heavy metals taken up by plants from contaminated soil pose health risks, especially if consumed, since such metals accumulate in tissues, water near dumpsites becomes polluted, resulting in heavy metal poisoning via irrigation and domestic use, (see table 1), resulting in allergies, skin infections, and is a source of breeding ground for disease vectors, and poses serious health risks to the surrounding region (Aithani, & Kushawaha, 2024). The signs of heavy metal poisoning consist of possible mental disease, damage to the components of blood, and destruction of vital organs such as the lungs, liver, and kidneys (Parui, et al., 2024). The review depicts the sources and channels through and how the heavy metals get exposed and accumulated in the body. Besides, it explains the metabolism and mechanisms of heavy metal toxicity, and provides the signs and presentations of their toxic impact on the human organism.

II. METHEDOLOGY

1. Study Area

The current research was carried out in Rajnandgaon, an Indian municipal district of Chhattisgarh with high levels of population growth, road traffic, and industrialization. The sampling points were urban farm fields, road-side soils, residential houses, and the surroundings of waste dump yards. The sampling points were chosen based on suspected anthropogenic sources of pollution that include road traffic emissions, industrial effluent, and urban runoff.

2. Sample Collection

2.1 Soil Sampling

- A total of 15–20 soil samples were collected from various urban sites across Rajnandgaon.
- Soil was sampled from the top 0–20 cm layer, which is the most relevant for plant uptake and human exposure.
- Samples were collected using a stainless-steel auger, placed in clean polyethylene bags, and transported to the laboratory.
- In the lab, samples were air-dried, sieved (2 mm), and stored for further analysis.

2.2 Plant (Crop) Sampling

- Edible portions of commonly grown crops (e.g., leafy vegetables and root vegetables) were collected from the same locations.
- These samples were thoroughly washed with distilled water, oven-dried at 70°C, ground, and stored in airtight containers for analysis.

2.3 Water Sampling

- In areas where crops were irrigated with local water sources, water samples were also collected in pre-cleaned bottles for comparative heavy metal analysis.

3. Analytical Techniques

- All samples (soil, plant, and water) were subjected to acid digestion using standard procedures as outlined by APHA (2017).
- The concentrations of selected heavy metals — Lead (Pb), Cadmium (Cd), Arsenic (As), Chromium (Cr), Mercury (Hg), Nickel (Ni), Zinc (Zn), and Copper (Cu) — were determined using Atomic Absorption Spectrophotometry (AAS).
- Calibration was performed using standard metal solutions, and appropriate blank and quality control samples were included to ensure accuracy.

4. Human Health Risk Assessment

4.1 Exposure Pathways

Three primary exposure routes were considered:

- Ingestion of contaminated soil and food crops
- Dermal contact with soil
- Consumption of contaminated water (where applicable)

4.2 Risk Calculation Parameters

- Average Daily Intake (ADI) of each metal was calculated for adults and children.
- Hazard Quotient (HQ) and Hazard Index (HI) were computed to estimate non-carcinogenic health risks.
- Lifetime Cancer Risk (LCR) was calculated for metals classified as carcinogenic (e.g., arsenic, cadmium).

5. Statistical and Spatial Analysis

- Descriptive statistics (mean, standard deviation) and correlation matrices were used to analyze the data.
- Principal Component Analysis (PCA) was conducted to identify potential sources of contamination.
- Geographical Information System (GIS) mapping was used to visualize the distribution of heavy metals across sampling sites.

6. Ethical Considerations

This research did not involve human or animal subjects. All sampling was conducted responsibly, and permission was obtained from relevant local authorities and landowners .

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III. RESULT

Table 1.Some Heavy Metals Harm Humans, Plants, and the Environment

Metal	**Sources of Contamination**	**Routes of Exposure**	**Health Impacts**	**Challenges on Humans**	**Challenges on Plants and Environment**
Lead (Pb)	High levels near industrial areas, traffic sources	Ingestion of contaminated food and water, inhalation of airborne particles	Neurological issues, developmental delays	Limited awareness among urban residents, Inadequate monitoring, Soil testing and remediation	Soil degradation, Disruption of ecosystems, Water contamination, Loss of biodiversity, Impact on soil microorganisms
Cadmium (Cd)	Elevated in areas with industrial activities	Consumption of contaminated plants and animals, inhalation of contaminated dust	Kidney damage, cardiovascular issues	Lack of effective remediation methods, Persistence of cadmium in soil	Soil and water contamination, Impact on plant growth, Disruption of nutrient cycling, Health risks to aquatic life
Mercury (Hg)	Found in soil near certain industries and coal-fired power plants	Bioaccumulation in the food chain, consumption of contaminated fish and seafood	Neurological damage, respiratory problems	Difficulties in regulating industrial emissions, Bioaccumulation in the food chain	Conversion to toxic methylmercury, Impact on aquatic ecosystems, Long-term ecosystem disruption
Chromium (Cr)	High concentrations in areas with metal processing and tannery activities	Ingestion of contaminated food, inhalation of airborne particles	Respiratory issues, skin irritation	Inadequate waste disposal practices, Limited awareness among local communities	Groundwater contamination, Soil and water contamination, Impact on plant health
Arsenic (As)	Elevated levels in mining areas and near industrial sources	Ingestion of contaminated water, food, and plants, inhalation of airborne particles	Skin and lung cancers, cardiovascular issues	Lack of affordable and effective treatment options for affected individuals	Long-term soil contamination, Impact on aquatic ecosystems, Health risks to terrestrial and aquatic organisms

Table 1 show the Heavy metal contamination of the environment is natural and anthropogenic. Identification of these sources is critical to facilitate proper environmental management and strategy formulation to minimize pollution. Natural weathering of geologic processes releases heavy metals naturally from rocks and minerals into water and soil (Mitran, et al., 2024). Volcanic eruptions have the potential to lead to heavy metal contamination by emitting high levels of such metals into the atmosphere. Several sectors such as mining, metal smelting, and manufacturing emit heavy metals into the environment as process waste. from the Earth's crust (Du, et al., 2024). Inappropriate industrial, electronic, and domestic waste disposal has the capability to lead to heavy metal pollution of soil and water and landfills as potential sources of pollution if not effectively managed (Chakraborty, et al., 2024). Industrial processes, motor vehicle exhaust, and other sources emit heavy metals into the atmosphere, and the metals are transported to land or water in the form of atmospheric deposition (Singhal, et al., 2024). Burning fossil fuel by oil and coal emits heavy metals like mercury in the atmosphere, which later fall on land and water bodies. Mining removes minerals from the crust of the earth, releasing and exposing heavy metals and carrying metals along with runoffto neighboring water bodies (Paruet al., 2024). Metal extraction from ores, especially through smelting, puts metals and metal compounds into the air, and hence can lead to ambient contamination around smelting plants. Companies' discharge of wastewater loaded with heavy metals directly into water bodies leads to contamination (Karimi Darvanjooghi, et al., 2024). Domestic and industrial effluents of sewage treatment plant wastes with heavy metals also contaminate water. All of the earlier industrial processes, such as leaded gasoline and lead paint, have all left a trace of contamination in city areas, and even if these processes cease, residual contamination can remain (Liang, et al., 2024).

IV. DISCUSSION

Discussing heavy metals involves exploring various aspects, including their sources like industry, mining, agriculture, and urban runoff, and the pathways they take into the environment through air, water, and soil. Considering the environmental consequences on ecosystems, biodiversity, and human health, especially for vulnerable groups, is crucial. Emphasizing interdisciplinary collaboration, sharing success stories, and assessing regulatory frameworks are key. Discussing community roles, innovative technologies, regional variations, economic impacts, education, and emerging trends contributes to a comprehensive understanding. Exploring industry responsibility, adaptive management, and ethical dimensions adds depth to the conversation. Engaging in such discussions promotes dialogue, diverse perspectives, and collaborative solutions for managing heavy metals.

V. CONCLUSION

In conclusion, heavy metals pose significant challenges to the environment and public health, requiring a collaborative and interdisciplinary approach for effective management. Lead, cadmium, mercury, and arsenic, found in industrial processes, agriculture, and everyday products, are widespread in air, water, soil, and food, collaboration across environmental science, toxicology, engineering, public health, social sciences, and policy is essential. Researchers, policymakers, industry professionals, and communities must work together to address the complexities of heavy metal contamination, key concerns include environmental impacts on ecosystems, soil degradation, water pollution, and disruption of biodiversity, chronic exposure poses severe health risks, particularly for vulnerable populations. Interdisciplinary collaboration is crucial, involving environmental scientists, engineers, health professionals, social scientists, and policymakers for holistic solutions. Stringent regulatory frameworks are vital for controlling emissions, setting standards, and preventing heavy metal release, with regular updates based on the latest scientific knowledge, innovative and sustainable remediation technologies, such as phytoremediation and bioremediation, show promise. Community engagement is key, empowering communities for localized issues and fostering a sense of ownership.

Global cooperation and information-sharing are essential for addressing the transboundary nature of environmental pollution, collaborative efforts between countries, international organizations, and research institutions can lead to standardized approaches and sharing best practices. Technological advancements, including data science, remote sensing, and sensor technologies, enhance monitoring, modeling, and early detection, these tools contribute to informed decision-making and adaptive management, moving forward, a commitment to sustainable practices, continuous research and innovation, and the integration of diverse perspectives will be pivotal, by comprehensively and collaboratively addressing this multifaceted challenge, society can work towards minimizing the environmental and health impacts of heavy metals and fostering a more sustainable and resilient future.

VI. REFERENCE

[1]. Abass, A. S., Abdalla, I. F., & Ahmed, A. E. (2024). Contribution of higher education institutions to food security: The case of the Kingdom of Saudi Arabia. In National analysis of agricultural and food security (Vol. 1, pp. 425–461). Cham: Springer International Publishing.

[2]. Anjum, S., Ali, H., Naseer, F., Abduh, M. S., Qadir, H., Kakar, S., & Ahmad, T. (2024). Antioxidant activity of Carica papaya&Perseaamericana fruits against cadmium induced neurotoxicity, nephrotoxicity, and hepatotoxicity in rats with a computational approach. Journal of Trace Elements in Medicine and Biology, 81, 127324.https://doi.org/10.1016/j.jtemb.2023.127324

[3]. Arora, D., Arora, A., Panghal, V., Singh, A., Bala, R., Kumari, S., & Kumar, S. (2024). Unleashing the feasibility of nanotechnology in phytoremediation of heavy metal–contaminated soil: A critical review towards sustainable approach.Water, Air, & Soil Pollution, 235(1), 57.https://doi.org/10.1007/s11270-023-06874-9

[4]. Bełcik, M., Grzegorzek, M., Canales, F. A., Struk-Sokołowska, J., &Kaźmierczak, B. (2024).Examination of interactions between heavy metals and benzotriazoles in rainwater runoff and snowmelt in an urban catchment in Poland.Water Resources and Industry, 31, 100236.https://doi.org/10.1016/j.wri.2023.100236

[5]. Bhardwaj, J. K., Bikal, P., &Sachdeva, S. N. (2024). Cadmium as an ovarian toxicant: A review. Journal of Applied Toxicology, 44(1), 129–147. https://doi.org/10.1002/jat.4526

[6]. Chakraborty, M., Rahat, M. M. R., Choudhury, T. R., Nigar, R., Liu, G., &Habib, A. (2024). Heavy metal contamination and health risk assessment of road dust from landfills in Dhaka–Narayanganj, Bangladesh. Emerging Contaminants, 10(1), 100278.https://doi.org/10.1016/j.emcon.2023.100278

[7]. Chau, T. P., Samdani, M. S., Jhanani, G. K., Sathiyamoorthi, E., & Lee, J. (2024). Metal accumulation and genetic adaptation of Oryzasativa to cadmium and chromium heavy metal stress: A hydroponic and RAPD analyses. Environmental Research, 242, 117793.https://doi.org/10.1016/j.envres.2023.117793

[8]. Chukwuemeka, I. S., Li, G., Mo, Y., & Jacques, K. J. (2024). Impacts of microplastics and urbanization on soil health: An urgent concern for sustainable development. Green Analytical Chemistry, 100095. https://doi.org/10.1016/j.greeac.2024.100095

[9]. Cutts, B. B., Vilá, O., Bray, L. A., Harris, A., Hornsby, G., Goins, H., &Harlee, T. (2024).Shifting terrains: Understanding residential contaminants after flood disasters.Science of The Total Environment, 907, 167577. https://doi.org/10.1016/j.scitotenv.2023.167577

[10]. Dong, T., & Li, H. (2024). Neurological risks arising from the bioaccumulation of heavy metal contaminants: A focus on mercury. Environmental Toxicology. Advance online publication. https://doi.org/10.1002/tox.24119

[11]. Etesami, H., & Glick, B. R. (2024). Bacterial indole-3-acetic acid: A key regulator for plant growth, plant-microbe interactions, and agricultural adaptive resilience. Microbiological Research, 127602.https://doi.org/10.1016/j.micres.2024.127602

[12]. Feng, T., Sun, Y., Shi, Y., Ma, J., Feng, C., & Chen, Z. (2024). Air pollution control policies and impacts: A review. Renewable and Sustainable Energy Reviews, 191, 114071.https://doi.org/10.1016/j.rser.2023.114071

[13]. Ganie, S. Y., Javaid, D., Hajam, Y. A., &Reshi, M. S. (2024). Arsenic toxicity: Sources, pathophysiology and mechanism. Toxicology Research, 13(1), tfad111.https://doi.org/10.1093/toxres/tfad111

[14]. Huang, J. L., Li, Z. Y., Mao, J. Y., Chen, Z. M., Liu, H. L., Liang, G. Y., ... & Jiang, Y. M. (2024). Contamination and health risks brought by arsenic, lead and cadmium in a water-soil-plant system nearby a non-ferrous metal mining area.Ecotoxicology and Environmental Safety, 270, 115873.https://doi.org/10.1016/j.ecoenv.2023.115873.

[15]. KarimiDarvanjooghi, M. H., Magdouli, S., &Brar, S. K. (2024). Recent challenges in biological cyanidation and oxidation of sulfide-based refractory gold ore. World Journal of Microbiology and Biotechnology, 40(2), 67.https://doi.org/10.1007/s11274-024-03887-2

[16]. Khalil, J., Habib, H., Bouguerra, S., Nogueira, V., &Rodríguez-Seijo, A. (2024). The impact of olive mill wastewater on soil properties, nutrient and heavy metal availability–A study case from Syrian vertisols.Journal of Environmental Management, 351, 119861.https://doi.org/10.1016/j.jenvman.2023.119861

[17]. Kou, Z., Tran, F., & Dai, W. (2024).Heavy metals, oxidative stress, and the role of AhRsignaling.Toxicology and Applied Pharmacology, 482, 116769. https://doi.org/10.1016/j.taap.2023.116769

[18]. Kumar, A., Arya, K., Mehra, S., Kumar, A., Mehta, S. K., &Kataria, R. (2024). Detection and sorption of heavy metal ions in aqueous media using Zn-based luminescent metal-organic framework.Separation and Purification Technology, 333, 125875.https://doi.org/10.1016/j.seppur.2023.125875

[19]. Monib, A. W., Alimyar, O., Mohammad, M. U., Akhundzada, M. S., &Niazi, P. (2023). Macronutrients for plants growth and humans health. Journal for Research in Applied Sciences and Biotechnology, 2(2), 268–279. https://doi.org/10.55544/jrasb.2.2.38

[20]. Montes-Rocha, J. A., Alonso-Castro, A. J., & Carranza-Álvarez, C. (2024).Mechanism of heavy metal-induced stress and tolerance. In Aquatic Contamination: Tolerance and Bioremediation (pp. 61–76). https://doi.org/10.1002/9781119989318.ch4

[21]. Nagajyoti, P. C., Lee, K. D., &Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: A review. Environmental Chemistry Letters, 8, 199–216. http://dx.doi.org/10.1007/s10311-010-0297-8

[22]. Noor, A. E., Fatima, R., Aslam, S., Hussain, A., unNisa, Z., Khan, M., & Sillanpaa, M. (2024). Health risks assessment and source admeasurement of potentially dangerous heavy metals (Cu, Fe, and Ni) in rapidly growing urban settlement. Environmental Research, 242, 117736.https://doi.org/10.1016/j.envres.2023.117736

[23]. Ozturk, H., Niazi, P., Mansoor, M., Monib, A. W., Alikhail, M., &Azizi, A. (2023).The function of zinc in animal, plant, and human nutrition.Journal for Research in Applied Sciences and Biotechnology, 2(2), 35–43. https://doi.org/10.55544/jrasb.2.2.6

[24]. Patani, A., Patel, M., Islam, S., Yadav, V. K., Prajapati, D., Yadav, A. N., & Patel, A. (2024). Recent advances in Bacillus-mediated plant growth enhancement: A paradigm shift in redefining crop resilience. World Journal of Microbiology and Biotechnology, 40(2), 77.https://doi.org/10.1007/s11274-024-03903-5

[25]. Selvasembian, R., Thokchom, B., Singh, P., Jawad, A. H., &Gwenzi, W. (Eds.). (2024). Remediation of heavy metals: Sustainable technologies and recent advances. [Publisher not provided—please confirm.]

[26]. Sharma, P., & Sharma, P. (2024). Micro (nano) plastics: Invisible compounds with a visible impact. F1000Research, 13, 69.https://doi.org/10.12688/f1000research.142212.1

[27]. Singh, C., Singh, R., &Shekhar, A. (2024).Oxidative stress in cadmium toxicity in animals and its amelioration.In Cadmium Toxicity Mitigation (pp. 391–411). Cham: Springer Nature Switzerland.

[28]. Spears, J. W., Lloyd, K. E., Krafka, K., Hyda, J., & Grimes, J. L. (2024). Chromium propionate in turkeys: Effects on insulin sensitivity. Poultry Science, 103(1), 103215.https://doi.org/10.1016/j.psj.2023.103215

[29]. Sridhar, D., &Parimalarenganayaki, S. (2024). A comprehensive review on groundwater contamination due to sewer leakage: Sources, detection techniques, health impacts, mitigation methods. Water, Air, & Soil Pollution, 235(1), 56.http://dx.doi.org/10.1007/s11270-023-06852-1

[30]. Sundhar, S., Arisekar, U., Shakila, R. J., Shalini, R., Al-Ansari, M. M., Al-Dahmash, N. D., &Karthy, A. (2024). Potentially toxic metals in seawater, sediment and seaweeds: Bioaccumulation, ecological and human health risk assessment. Environmental Geochemistry and Health, 46(2), 35.https://doi.org/10.1007/s10653-023-01789-0

[31]. Thiruvengadam, M., Chi, H. Y., & Kim, S. H. (2024). Impact of nanopollution on plant growth, photosynthesis, toxicity, and metabolism in the agricultural sector: An updated review. Plant Physiology and Biochemistry, 108370.https://doi.org/10.1016/j.plaphy.2024.108370

[32]. Wahdan, S. F. M., Asran, A. G., Abdellatef, M., Atia, M. A., &Ji, L. (2024).Arbuscularmycorrhizal fungi in organic versus conventional farming. In ArbuscularMycorrhizal Fungi and Higher Plants: Fundamentals and Applications (pp. 259–286). Singapore: Springer Nature Singapore.

[33]. Wei, S., Zhang, K., Liu, C., Cen, Y., & Xia, J. (2024).Effects of different vegetation components on soil erosion and response to rainfall intensity under simulated rainfall.Catena, 235, 107652.http://dx.doi.org/10.1016/j.catena.2023.107652

[34]. Yang, H., Feng, Q., Zhu, J., Liu, G., Dai, Y., Zhou, Q., & Zhang, Y. (2024). Towards sustainable futures: A review of sediment remediation and resource valorization techniques. Journal of Cleaner Production, 140529.http://dx.doi.org/10.1016/j.jclepro.2023.140529

[35]. Zahra, M., Riaz, L., Kalsoom, S., Saleem, A. R., &Taneez, M. (2024). Assessment and computational bioevaluation of heavy metals from selected cosmetic products. Environmental Monitoring and Assessment, 196(1), 1–14. https://doi.org/10.1007/s10661-023-12196-4

[36]. Zhang, X., Zhu, Y., Elçin, E., He, L., Li, B., Jiang, M., & Wells, M. (2024).Whole-cell bioreporter application for rapid evaluation of hazardous metal bioavailability and toxicity in bioprocess.Journal of Hazardous Materials, 461, 132556.https://doi.org/10.1016/j.jhazmat.2023.132556

[37]. Zhou, H., Yue, X., Chen, Y., & Liu, Y. (2024). Source-specific probabilistic contamination risk and health risk assessment of soil heavy metals in a typical ancient mining area. Science of The Total Environment, 906, 167772. https://doi.org/10.1016/j.scitotenv.2023.167772

[38]. Zuhra, N., Akhtar, T., Yasin, R., Ghafoor, I., Asad, M., Qadeer, A., &Javed, S. (2024). Human health effects of chronic cadmium exposure. In Cadmium Toxicity Mitigation (pp. 65–102). Cham: Springer Nature Switzerland.

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