J. Chemtracks 27 (1&2) 205-208, 2025
Abstracted / Indexed in
CAS
A division of the American Chemical Society
Chemical Abstract U.S.A.
ISSN 0973-239X
CODEN:JCOHF7
IMPACT FACTOR : 7.866

Heavy Metal Content in Biomasses of Some Herbal Plants

Anil Kumar[1], Santosh Kumar Singh[2] and Ved Prakash Sahay[3]
[1]Research Scholar, Department of Chemistry, S. K. M. University, Dumka (Jharkhand)
[2]University Department of Chemistry, S. K.M. University, Dumka (Jharkhand)
[3]Department of Chemistry, S. P. College Dumka (Jharkhand)

Email : anilkumar.skmu@gmail.com ,budhaina@gmail.com ,vpsahay121@gmail.com

Manuscript received online 25 August 2025, accepted on 11 September 2025

Abstract : This investigation was conducted to determine the concentrations of heavy metals—lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu), iron (Fe), and chromium (Cr)—in four commonly used medicinal plants Withania somnifera, Andrographis paniculata, Tinospora cordifolia, and Asparagus racemosus in the states of Bihar and Jharkhand: These plants are widely consumed in Indian society as herbal infusions and traditional remedies. The samples were collected from local markets in Patna,(Bihar) and Ranchi (Jharkhand) For analysis, 10 g of each plant sample was boiled in di-distilled water, filtered, and treated with nitric acid. The concentrations of heavy metals were determined using an atomic absorption spectrophotometer. The measured ranges were: Pb (0.15–0.80 mg/kg), Cd (0.28–0.63 mg/kg), Cu (0.30–1.90 mg/kg), Zn (3.90–11.50 mg/kg), Fe (2.20–7.00 mg/kg), and Cr(below detection limit to 1.80 mg/kg). Based on these values, the estimated daily intake of lead and cadmium for a 50 kg individual consuming an infusion prepared from 10 g of plant material was calculated

(Keywords : Heavy metals, Biomasses, Herbal Plants medicinal plants, Metal Toxicity).

Introduction

Environmental pollution, particularly contamination by heavy metals, has emerged as one of the most pressing global challenges. Food sources such as water, fruits, vegetables, and medicinal plants are highly susceptible to contamination since they are directly exposed to polluted air, soil, and water. During cultivation, transportation, and open-market storage, these pollutants can readily infiltrate consumable products. Toxic metals accumulate in plants across a wide range of concentrations, influenced by factors such as soil acidity, ambient temperature, and microbial activity[1].

Several minerals are essential for maintaining human health[2]. Trace elements like copper and zinc play critical roles in physiological functions[3,4]. In contrast, the biological significance of lead and cadmium remains uncertain, and the human requirement for these elements is negligible[5].

Elevated levels of heavy metals and trace elements in the body are strongly associated with numerous diseases and adverse health outcomes[6,7]. Among them, cadmium and lead are recognized as the most hazardous heavy metals and major environmental contaminants[8–10].

Lead accumulation in human organs poses severe health risks. Children are particularly vulnerable due to their developmental stage. Lead exposure adversely affects the central nervous system in foetuses and newborns, leading to neurological damage[11–13]. It also contributes to anaemia and may deposit in bones and teeth[12,13]. Chronic exposure has been linked to impaired growth, hearing loss, learning disabilities, antisocial behaviour, and damage to the liver, kidneys, reproductive system, and cellular processes[14].

Cadmium toxicity was first highlighted following the outbreak of Itai-Itai disease in Japan, which was attributed to excessive cadmium ingestion[15]. Cadmium accumulation induces a range of toxic effects, including respiratory distress, gastrointestinal disorders, hypertension, and kidney damage[16–18]. Its deposition in renal tissues impairs kidney function, often indicated by elevated blood urea levels. Furthermore, cadmium interferes with calcium and phosphate metabolism, leading to bone demineralization and softness, and it has been classified as a carcinogenic agent[13,19].

Experimental

Materials and Methods:

Sixteen randomly selected samples of biomasses of medicinal plants were obtained from local markets in Patna(Bihar) and Ranchi (Jharkhand).The precise cultivation sites of these samples were not known. Prior to analysis, all glassware and equipment were thoroughly cleaned with 0.1 M nitric acid (HNO_3) to eliminate potential contamination. For each determination, 10 g of plant material was weighed and transferred into a 1 L beaker. Subsequently, 500 mL of double-distilled water was added, and the mixture was boiled for 30 minutes. The resulting infusion was filtered using double-ring filter paper. The filtrate volume was reduced by evaporation to 80 mL and then transferred into a 100 mL volumetric flask. To achieve a final concentration of 0.1 M Nitric acid, 1 M HNO_3 was added, and the volume was adjusted to the mark. The concentrations of iron (Fe), lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), and copper (Cu) were determined using an atomic absorption spectrophotometer (Thermo Scientific, UK Model: AAS-ICE 3500) equipped with dual atomizer and incorporating a 50 mm titanium burner, were optimized according to the manufacturer's recommendations. Metal concentrations were initially obtained in mg/L and subsequently converted to mg/kg. A reference sample was processed under identical conditions. Each analysis was performed in quadruplicate, and the mean values with standard deviations were calculated. A. Quantitative Determination The concentrations of Pb, Cd, Cu, Fe, Zn, and Cr in the examined samples were calculated using the following equation:

$$\text{mg/kg in sample} = \frac{A \times B}{W}$$

Where:
A = concentration of the metal in mg/L (obtained by calibration)
B = final volume of prepared sample (L)
W = weight of the sample (kg)

The daily intake of heavy metals through medicinal plant consumption was estimated using a standardized calculation. The daily dose, expressed in mg $kg^{-1} \cdot day^{-1}$, was determined according to the following equation:

$$\text{Daily dose} = \frac{\text{Concentration of metals} \times C}{M}$$

Where:
C =the sample weight (kg) and
M =denotes the body weight of the consumer (kg).

This formulation allows for the quantitative assessment of potential exposure to toxic metals such as lead and cadmium from herbal infusions.

By applying this equation, the estimated intake values can be compared against internationally recognized safety thresholds, thereby providing a scientific basis for evaluating the health risks associated with the consumption of contaminated medicinal plants.

B. Statistical Analysis

For each metal, maximum, minimum, mean, and standard error values were calculated following previously reported procedures[21].

Results and Discussion:

Studies from India indicate that medicinal plants and vegetables often show elevated levels of Pb and Cd, particularly in regions like Bihar and Jharkhand where industrial activity, polluted irrigation water, and soil contamination contribute to heavy metal uptake.

The concentrations of Pb, Cd, Cu, Fe, Zn, and Cr in the examined medicinal plants are summarized in the table. The levels of lead and cadmium were compared against the maximum permissible limits of 0.30 mg/kg and 0.20 mg/kg, respectively, as established by the Codex Alimentarius Commission (FAO/WHO, 1984)[22].

Among the studied species, Tinospora cordifolia exhibited the highest lead concentration (0.80 ± 0.16 mg/kg), significantly exceeding the recommended threshold.

Elevated levels of lead were also observed in Andrographis paniculata (0.45 ± 0.08 mg/kg), while Asparagus racemosus and Withania somnifera contained lead concentrations within the permissible range.

Cadmium concentrations in all samples surpassed the Codex limit of 0.20 mg/kg [22]. The values ranged from 0.62 ± 0.20 mg/kg in Tinospora cordifolia to 0.28 ± 0.09 mg/kg in Withania somnifera. Despite the elevated Pb and Cd levels, the estimated daily intake for a 50 kg adult consuming an infusion prepared from 10 g of plant material for the highest concentration was calculated to be 0.00016 mg/kg/day for lead and 0.000124 mg/kg/day for cadmium. These values remain within the safe exposure limits previously reported[23].

Copper concentrations varied across the samples, ranging from 0.30 ± 0.12 mg/kg in Withania somnifera to 1.90 ± 0.65 mg/kg in Asparagus racemosus. All measured values were consistent with earlier reports [2]. Iron levels also showed variability, with concentrations spanning from 2.20± 0.40 mg/kg in Tinospora cordifolia to 7.00 ± 0.30mg/kg in Asparagus racemosus. These values fall within the acceptable limits reported for different agro-climatic zones of India, where the standard permissible concentration of iron in herbal infusions is approximately 10 ppm.

Zinc concentrations were highest in Tinospora cordifolia (11.50 ± 2.50 mg/kg) and lowest in Withania somnifera (3.90 ± 0.05mg/kg). Based on these values, the estimated daily intake of zinc for a 50 kg individual consuming 10 g of plant infusion was calculated to be 0.0023 mg/kg/day, which is well below the maximum permitted daily intake range of 50 mg/kg [24].

Chromium concentrations ranged from below detection limits in Asparagus racemosus to 1.80 ±1.20 mg/kg in Tinospora cordifolia. All values were below the permissible limit of 2 mg/kg for medicinal herbs [25].

Conclusion

The findings of the present investigation demonstrate that Medicinal plants from Patna (Bihar) and Ranchi (Jharkhand) show contamination with Pb and Cd consistently above permissible limits. Medicinal plants are contaminated with certain heavy metals, posing potential risks to human health. Such contamination primarily arises from environmental pollution of air, water, and soil, through which these metals are absorbed by plants and subsequently enter the food chain. Since all metals exhibit toxicity, the human body requires specialized transport and regulatory mechanisms to prevent their harmful effects. This principle applies not only to essential trace elements such as iron, zinc, and chromium, but also to non-essential and highly toxic metals and metalloids, including cadmium. To safeguard public health and reduce the adverse impacts of these pollutants, it is imperative to implement strict and continuous monitoring of heavy metal residues in food products. Furthermore, consumption of food items exceeding the permissible limits should be avoided to minimize exposure and associated health hazards

Table-1 (Heavy Metal Concentrations in the Biomasses of Some Herbal Plants)

Metal	Withania somnifera	Andrographis paniculata	Tinospora cordifolia	Asparagus racemosus	Permissible Limit (FAO/WHO)
Pb	0.15 ± 0.04	0.45 ± 0.08	0.80 ± 0.16	0.18 ± 0.05	0.30 mg/kg
Cd	0.28 ± 0.09	0.40 ± 0.10	0.62 ± 0.20	0.32 ± 0.12	0.20 mg/kg
Cu	0.30 ± 0.12	1.05 ± 0.20	0.75 ± 0.05	1.90 ± 0.65	10 mg/kg (approx.)
Zn	3.90 ± 0.05	6.70 ± 1.10	11.50 ± 2.50	6.80 ± 0.50	50 mg/kg
Fe	2.20 ± 0.40	5.40 ± 3.00	2.20 ± 0.40	7.00 ± 0.30	10 mg/kg (juice standard)
Cr	0.45 ± 0.30	0.70 ± 0.20	1.80 ± 1.20	< detection limit	2 mg/kg

References

1. Kabata-Pendias, A., & Mukherjee, A. B. (2007). Trace elements from soil to human. Springer.
2. R. K. Sharma, M. Agrawal, & F. Marshall, *Bulletin of Environmental Contamination and Toxicology*, **77**(2), 312 (2006)
3. H. Tapiero, & K.D. Tew, *Biomedicine & Pharmacotherapy*, **57(9)**, 399 (2003)
4. A.S. Prasad, *Molecular Medicine*, **14**(5–6), 353 (2008)
5. L. Järup, *British Medical Bulletin*, **68**(1), 167 (2003)
6. P.B. Tchounwou, C.G. Yedjou, A. K. Patlolla, & D. J. Sutton, *Environmental toxicology* Vol. **3**., 133 (2012)
7. P.K. Rai, S.S. Lee, M. Zhang, Y.F. Tsang, & K. Kim, Environment International,**125**, 365 (2019)
8. World Health Organization. *World Health Organization* (2019). .
9. Agency for Toxic Substances and Disease Registry. (2020).
10. J. Godt, F. Scheidig, C. Grosse-Siestrup, C.,V. Esche, P. Brandenburg, A. Reich, & D.A. Groneberg, *Journal of Occupational Medicine and Toxicology*, **1**, 22 (006).)
11. H. Needleman, *Annual Review of Medicine*, **55**, 209 (2004)
12. B.P. Lanphear, R. Hornung, J. Khoury, K. Yolton, P. Baghurst, D.C. Bellinger, R.L. Canfield, K. N. Dietrich, R. Bornschein, T. Greene, S.J. Rothenberg, H.L. Needleman, L., Schnaas, G. Wasserman, J. Graziano & R. Roberts, *Environmental Health Perspectives*, **113**(7), 894 (2005)
13. Flora, S. J. S., Mittal, M., & Mehta, A. *Indian Journal of Medical Research,* 128(4), 501 (2008)
14. R.A. Goyer, *Environmental Health Perspectives,* **100**, 177 (1993)
15. K.Aoshima, J*ournal of Epidemiology,* **26**(8), 349 (2016)
16. S. Satarug, J.R. Baker, S. Urbenjapol, M. Haswell-Elkins, P.E.B. Reilly, D.J. Williams, M.R. Moore *Toxicology Letters*, **137**(1–2), 65 (2003)
17. G.F. Nordberg, *Journal of Trace Elements in Medicine and Biology,* **23(3),** 145 (2009)
18. L. Järup, & A. Åkesson, Toxicology and Applied Pharmacology, 238(3), 201 (2009)
19. International Agency for Research on Cancer. Vol. 100C (121).*World Health Organization* (2012).
20. Food and Agriculture Organization/World Health Organization. Codex Alimentarius Commission. (Original work published 1984) (1995)
21. S. Gupta, S. Satpati, S. Nayek, & D. Garai, *Environmental Monitoring and Assessment,* **167** (1–4),183 (2010).
22. Food and Agriculture Organization/World Health Organization. World Health Organization. (1982).
23. World Health Organization. *World Health Organization.* **23** (2011)
24. Institute of Medicine. *National Academies Press.* (2001).
25. European Medicines Agency. Guideline on specifications: Test procedures and acceptance criteria for herbal substances, herbal preparations and herbal medicinal products/traditional herbal medicinal products (CPMP/QWP/2819/00 Rev. 2). (2011)