ANCIENT INDIAN RASASHASTRA PRACTICES AS PRECURSORS TO CONTEMPORARY HEAVY METAL REMEDIATION TECHNOLOGIES

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Abstract

Heavy metal like mercury (Hg), lead (Pb), arsenic (As), and cadmium (Cd) pose serious health and environmental risks, and modern remediation techniques like chemical precipitation, adsorption, electrochemical treatment, and bioremediation have limitations like high costs, secondary pollution, and efficiency constraints. It's interesting to note that ancient Indian 'Rasashastra', a branch of Ayurveda, offers a systematic approach to heavy metal detoxification and transformation through processes like Shodhana (purification), Marana (incineration), and Bhavana (triturating with herbal extracts). These traditional methods use herbal acids, bio-assisted purification, and controlled thermal treatments, which are similar to modern metallurgical and pharmaceutical techniques. Understanding the principles behind these time-tested, eco-friendly techniques may offer innovative solutions for modern heavy metal detoxification, bridging the gap between traditional knowledge and scientific advancements.

Keywords: Heavy Metal Detoxification, Rasashastra, Shodhana, Environmental Remediation.

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1. Introduction

Heavy metal contamination is a critical environmental and health concern, as toxic metals such as **mercury (Hg), lead (Pb), arsenic (As), and cadmium (Cd)** accumulate in water, soil, and biological systems, posing severe risks to human and ecological health[1]. Chemical precipitation, adsorption, electrochemical treatment, and bioremediation are examples of conventional heavy metal detoxification procedures that have been widely used. Nevertheless, these approaches frequently have high costs, secondary contamination, and low efficacy in complicated matrices[2]**.**

Ancient Indian Rasashastra, a specialized branch of Ayurveda, offers an alternative and time-tested approach to heavy metal purification[3]. It employs systematic Shodhana (purification), Marana (incineration), and Bhavana (triturating with herbal extracts) processes to detoxify and transform metals into bioavailable, non-toxic forms for medicinal use [4, 5]. These techniques involve acidic herbal extractions, controlled thermal treatments, and bio-assisted purification, many of which exhibit homology with modern metallurgical and pharmaceutical purification processes.

This paper explores the efficacy of Rasashastra methods in heavy metal removal, drawing parallels with contemporary purification techniques. By analyzing the chemical mechanisms underlying ancient metal detoxification practices, we aim to highlight their potential applications in environmental remediation, green chemistry, and sustainable metallurgy. Understanding these age-old methods in the context of modern science could contribute to cost-effective, eco-friendly solutions for heavy metal detoxification, offering an integrative approach between traditional wisdom and scientific advancements.

2. Limitations of Contemporary Heavy Metal Remediation

Contemporary heavy metal remediation technologies, while widely employed, exhibit several critical limitations that constrain their practical applicability. Many conventional and advanced methods are associated with high capital and operational costs, significant energy consumption, and the generation of secondary metal-laden wastes that require further treatment or secure disposal. Their efficiency often decreases at low contaminant concentrations and is strongly influenced by solution chemistry, particularly pH and the presence of competing ions, necessitating stringent process control. Membrane-based and electrochemical techniques further suffer from fouling, material degradation, and limited operational lifespan. Moreover, most existing approaches emphasize metal removal rather than recovery, limiting sustainability and circular resource utilization. Collectively, these technical, economic, and environmental challenges highlight the need for cost-effective, scalable, and environmentally benign remediation strategies.

3. Rasashastra Detoxification Principles

Rasashastra outlines a structured detoxification methodology for heavy metals based on the principles of *Shodhana*, *Marana*, and *Bhavana*, which collectively aim to reduce metal toxicity and environmental persistence.

Shodhana:

Shodhana is the primary detoxification step in Rasashastra and plays a crucial role in heavy metal removal by eliminating toxic and extraneous impurities from metals and minerals. The process involves repeated washing, boiling, grinding, or quenching of metals in herbal juices [6], plant decoctions, acidic, alkaline, or lipid-based media such as milk, ghee, or fermented liquids. These treatments promote the dissolution and leaching of loosely bound, water-soluble, or volatile toxic fractions of heavy metals and facilitate surface oxidation or corrosion, which weakens the metallic matrix. From a modern scientific viewpoint, Shodhana can be correlated with chemical leaching, solvent washing, and pre-conditioning processes that reduce metal toxicity, enhance surface reactivity, and improve the efficiency of subsequent stabilization or immobilization steps.

Marana:

Marana is the controlled incineration or calcination process in Rasashastra that transforms purified metals into stable, bio-assimilable forms called *bhasma*[7]. For heavy metal detoxification, Marana involves repeated cycles of grinding with herbal additives followed by high-temperature heating, which converts metals into oxides, sulfides, or other stable compounds. This reduces solubility, mobility, and bioavailability of toxic metal species, effectively minimizing environmental and biological hazards. Mechanochemically, the repeated grinding and thermal treatment decrease particle size and enhance surface uniformity, improving stability[8]. In modern terms, Marana parallels thermal stabilization and immobilization techniques used in heavy metal remediation to render toxic metals chemically inert and less hazardous[9].

Bhavana:

Bhavana is the wet trituration process in Rasashastra applied after purification (*Shodhana*) and calcination (*Marana*), aimed at further detoxifying metals and enhancing their stability. In this step, the processed metal or mineral is repeatedly ground with herbal juices, decoctions, or other bioactive liquids. For heavy metal removal, Bhavana facilitates surface modification and complexation of metal particles with organic compounds, which can reduce solubility, reactivity, and bioavailability of toxic species. Additionally, it aids in homogenizing particle size and forming organo-metallic complexes that immobilize residual toxic fractions. From a modern perspective, Bhavana resembles mechanochemical treatment and surface functionalization strategies in environmental remediation, enhancing safety and reducing heavy metal toxicity.

From a green chemistry perspective, Rasashastra emphasizes low-energy inputs, renewable biological reagents, and process circularity, aligning with modern principles of sustainable remediation. The integration of biological media with physicochemical transformations in Rasashastra mirrors emerging hybrid remediation technologies that combine chemical, thermal, and biological methods for improved efficiency. These parallels suggest that Rasashastra represents an early, empirically developed framework for heavy metal detoxification that anticipates several core principles of modern environmental engineering.

4. Homology between Rasashastra and Modern Techniques

- Both Rasashastra and modern water treatment techniques aim to **transform or purify** harmful substances, be they metals or toxins, to render them less harmful or more manageable.
- **Herbal and bio-based methods**, such as phytoremediation and the use of herbal formulations in Rasashastra, show clear connections between traditional wisdom and modern green chemistry approaches.
- The principle of **adsorption**, used in both Rasashastra's bhasma preparation and modern materials like activated carbon, reflects the ongoing relevance of these ancient purification techniques in addressing contemporary environmental challenges.

5. Methods of Shodhana and Their Modern Parallels

Shodhana Method	**Procedure in Rasashastra**	**Modern Equivalent**
Swedana (Boiling Purification)	Metal/mineral is boiled in herbal decoctions or acidic liquids like cow urine, lemon juice, or tamarind extract.	Acid leaching (hydrometallurgy), chemical extraction.
Nirvapa (Quenching Purification)	Metal is heated red-hot and immediately dipped into herbal liquids like buttermilk, decoctions, cow urine, or oils.	Annealing, quenching, and acid treatment in metallurgy.
Mardana (Trituration or Grinding)	Continuous grinding with herbal juices to remove toxicity.	Wet grinding, bioleaching, or mechanical purification.
Bhavana (Levigation with Liquids)	Mixing and grinding with specific herbal decoctions to detoxify the substance.	Bio-remediation, phytoremediation, solvent extraction.

Dhalana (Melting and Pouring)	The metal is melted and poured into liquids or specific molds to purify it.	Smelting and refining techniques.
Gavya Shodhana (Purification Using Cow Products)	Detoxification with cow urine, ghee, and milk.	Natural bio-filtration, organic solvent purification.
Gajaputa, Kukkutaputa, Mahaputa (Controlled Heating Techniques)	Metal is placed in crucibles and heated using cow dung cakes at specific temperatures.	Pyro-metallurgy, calcination, and thermal decomposition.

5. Conclusion

The ancient Rasashastra techniques show a remarkable similarity to modern metallurgical and detoxification processes. Shodhana, as described in Rasashastra, is a well-structured detoxification process that aligns with modern metallurgical and pharmaceutical purification techniques. Its relevance in modern science can be explored further through interdisciplinary research, especially in the fields of green chemistry, metallurgy, and pharmacology. While modern science uses advanced chemical treatments, the ancient methods relied on natural substances and bio-transformation, making them sustainable and eco-friendly. Further interdisciplinary research can validate and integrate these methods into modern heavy metal remediation techniques.

References:

1. Das, S., Sultana, K.W., Ndhlala, A.R., Mondal, M. and Chandra, I. (2023). Heavy Metal Pollution in the Environment and Its Impact on Health: Exploring Green Technology for Remediation, Environmental health insights, 17.

2. Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K. and Sutton, D.J. (2012). Heavy metal toxicity and the environment, Experientia supplementum., 101, 133-64.

3. Satish, V.D. (2023). Significance of Parada in Rasashastra. *Journal of Ayurveda and Integrated Medical Sciences*, 8(5), 204 - 207.

4. Magesh, R. and Jayalekshmi, R. (2023). Review of Shodhana in Rasashastra. *Journal of Ayurveda and Integrated Medical Sciences,* 8, 155-157.

5. Pal, D., Sahu, C.K. and Haldar, A. (2014). Bhasma : The ancient Indian nanomedicine. *Journal of advanced pharmaceutical technology & research*, 5(1), 4-12.

6. Gunaratna, T.A.N.R., Prajapati, P.K. De Silva, K.M.N. and De Silva, W.R.M. (2023). Comparision of traditional and laboratory methods of sulphur processing. *Journal of Ayurveda and Integrative Medicine*, 14(4), 100751.

7. Pareek, A. and Bhatnagar, N. (2020). Physico-chemical characterization of traditionally prepared Yashada bhasma. *Journal of Ayurveda and Integrative Medicine*, 11(3), 228-235.

8. Bimal, R., Pramod, B. and Rameshwar, A. (2025). Exploring the Nanomedicinal Features of Ayurvedic Bhasmas: Insights from Traditional Medicine. *International Journal of Complementary Medicine*, 1(2), 01-22.

9. Jagtap, C.Y., Prajapati, P.K., Patgiri, B. and Shukla, V.J. (2012). Standard manufacturing procedure of Tamra Bhasma, Ayu, 33(4), 561-8.