



Chelation Therapy for Heavy Metal Toxicity: Ayurvedic & Contemporary Perspectives

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Abstract

Heavy metal toxicity is an important health concern associated with environmental pollution, industrialization, contaminated food & water and improper processing of metal-mineral-based Ayurvedic preparations. This review aimed to compile classical Ayurvedic approaches to heavy metal toxicity and compare them with contemporary chelation-based management. A narrative review was conducted using classical Ayurvedic texts, including Rasa Tarangini, Ayurveda Prakasha, Rasa Jala Nidhi and Brihat Rasa raja Sundara along with published contemporary scientific literature on heavy metal toxicity and chelation therapy. Relevant information on sources of exposure, toxic effects, laboratory assessment, adverse effects of improperly processed Bhasma, classical antidotes, natural chelating agents and modern chelation therapy was collected, compared and systematically presented. The review identified classical antidotal measures for toxicity associated with metals and minerals, including Tankana, Gandhaka, Haritaki, Dhanyaka, Godugdha, Goghrita and other herbal and dietary substances. Modern management includes chelating agents such as ethylenediaminetetraacetic acid (EDTA), dimercaprol, penicillamine and dimercaptosuccinic acid for selected cases of heavy metal poisoning. Boron, glutathione, coriander and garlic were also identified as substances with reported antioxidant or metal-binding potential. Ayurveda provides a traditional framework for prevention and management of toxicity through proper processing, antidotal therapy, dietary measures and detoxification approaches. Integration with modern toxicological and analytical methods may support evidence-based evaluation of these approaches, although further experimental and clinical studies are required to establish their safety and efficacy.

Keywords: Heavy Metal Toxicity; Bhasma; Chelation Therapy; Antidote; Shodhana; Marana

Introduction

Heavy metal toxicity is an important global health concern associated with environmental pollution, industrialization and contaminated food and water. Metals such as arsenic, cadmium, chromium, copper, lead, nickel, and zinc may accumulate in the body and adversely affect vital organs, particularly the kidneys, liver, brain, lungs, and blood. The concern is also relevant to Ayurveda, especially Rasashastra, where metals and minerals are therapeutically used after classical processes such as Shodhana and Marana. Improperly processed or contaminated preparations may produce toxic effects, and classical texts describe specific adverse manifestations and antidotal measures. Modern medicine manages heavy metal poisoning with supportive treatment and specific chelation therapy, whereas Ayurveda describes various Prativisha, herbal antidotes, dietary measures and detoxification approaches. However, information regarding these classical approaches is dispersed and their scientific validation remains limited. Therefore, this narrative review aims to compile and discuss the sources and toxic effects of important heavy metals, toxicity associated with improperly processed Bhasma, Ayurvedic antidotal approaches, natural chelating agents and contemporary chelation therapy, while highlighting the need for further scientific validation and standardization.

Ayurvedic literature describes several substances as general antidotes for toxicity caused by metals, minerals and poisonous substances. These include Tankana (Borax), Gandhaka (Sulphur), Saindhava Lavana (Rock Salt), Churnodaka (Lime Water), Triphala Kwatha, Adraka Swarasa (Zingiber officinale), Arjuna (Terminalia arjuna), Haridra (Curcuma longa), Jambira (Citrus limon), Maricha (Piper nigrum), Kumari Swarasa (Aloe vera), Dhanyaka (Coriandrum sativum), Madhu, Godugdha, Ajadugdha, Goghrit, and Gomutra. These substances are traditionally described for alleviating toxic manifestations and supporting detoxification [1]. Chelation: Certain substances can bind metal ions and facilitate their elimination from the body. In contemporary toxicology, this principle forms the basis of chelation therapy, while several Ayurvedic substances are traditionally described as antidotes or Prativisha. Saturation: Adequate availability of essential minerals may influence the absorption and distribution of toxic metals because certain minerals can compete with or antagonize the uptake of other elements. Antioxidant Protection: Heavy metals can induce oxidative stress. Antioxidant nutrients and endogenous antioxidant systems may therefore contribute to cellular protection against metal-induced oxidative damage [2]. Chelation therapy involves the administration of specific metal-binding agents that form stable complexes with toxic metals and facilitate their elimination from the body. Agents such as ethylenediaminetetraacetic acid (EDTA),

dimercaprol, penicillamine and dimercaptosuccinic acid are used selectively according to the metal involved and the clinical condition [3,4]. Chelating agents can form coordinate bonds with metal ions, producing relatively stable metal-chelator complexes. However, chelation therapy is not appropriate for all exposures and should be administered only under appropriate medical supervision.

Although chelation can be beneficial in confirmed heavy metal poisoning, it may also bind essential minerals and produce adverse effects. Potential complications include hypocalcemia, renal injury, dehydration, allergic reactions and depletion of essential nutrients. Incorrect selection or administration of a chelating agent can result in serious toxicity. Therefore, the choice of chelator, dose, duration and monitoring should be determined according to the specific metal exposure and clinical condition. Ayurvedic literature provides a distinct approach to metal and mineral toxicity through Shodhana, Prativisha and specific antidotal substances. Classical descriptions of these approaches, including antidotes for individual metals and minerals, are discussed in the subsequent sections and tables.

Materials and Methods

A narrative review was conducted to compile and synthesize information on heavy metal toxicity and its relevance to Ayurvedic metallic and mineral preparations. The review was based on information obtained from classical Ayurvedic texts of Rasashastra and available published scientific literature concerning heavy metal toxicity, toxicology, chelation therapy and Ayurvedic antidotal approaches. Relevant literature was identified and reviewed with emphasis on the toxic metals commonly discussed in relation to Ayurvedic preparations, particularly arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg). Information relating to other metals, including zinc, copper, aluminium, chromium and uranium, was also considered where relevant. The extracted information was systematically organized under the following parameters: sources of exposure, routes of absorption, chemical forms, distribution and target organs, mechanisms of toxicity, major toxic manifestations, laboratory investigations, management approaches and permissible limits. Classical Ayurvedic information was additionally reviewed for Shodhana, Marana, adverse effects of improperly processed preparations and traditionally described antidotes. The available information was then comparatively synthesized and presented in tabular and descriptive form to facilitate interpretation of the similarities and differences between conventional toxicological management and Ayurvedic approaches. Attention was given to the traditionally described antidotal substances and their possible relevance to modern concepts of detoxification and chelation. As this was a narrative review no original

experimental intervention, human/animal recruitment, statistical analysis or meta-analysis was performed. The compiled evidence was used to provide a structured overview

of heavy metal toxicity and to identify areas requiring further pharmacological, analytical and clinical validation (Tables 1 & 2).

S. No.	Parameter	Arsenic (As)	Cadmium (Cd)	Lead (Pb/Naga)	Mercury (Hg/Parada)
1	Major sources	Pesticides, fungicides, smelters, coal plants	Batteries, mining, electroplating, smoking	Paints, batteries, pipes, mining, petrol	Dental amalgams, thermometers, batteries, coal plants
2	Route of absorption	Inhalation, ingestion, skin	Mainly inhalation	Inhalation, ingestion	Inhalation, ingestion, skin
3	Target organs	Liver, kidneys, CNS, skin, hair	Kidneys, liver, bones	Blood, liver, kidneys, brain, bones	Kidneys, CNS, blood, GIT
4	Mechanism of toxicity	Inhibits sulfhydryl (–SH) enzymes	Binds metallothionein; oxidative stress	Enzyme inhibition; interference with calcium metabolism	Binds sulfhydryl (–SH) enzymes
5	Major toxic effects	Vomiting, diarrhea, neuropathy, skin lesions	Itai-Itai disease, osteoporosis, kidney damage	Anemia, abdominal pain, neuropathy, kidney damage	Gingivitis, tremors, renal failure, neurological disorders
6	Laboratory tests	Blood/urine arsenic	Blood and urine cadmium	Blood lead, ZPP, CBC	Blood and urine mercury
7	Management	Dimercaprol, Penicillamine	CaNa ₂ EDTA*	EDTA + Dimercaprol; Ayurvedic: Swarna Bhasma, Haritaki	Dimercaprol/ Penicillamine; Ayurvedic: Gandhaka, Dhanyaka
8	Permissible limit	3 ppm	0.3 ppm	10 ppm	1 ppm

Table 1: Important Toxic Heavy Metals in Ayurvedic Preparations [5-15].

S. No.	Heavy Metal	Sources	Major Toxic Effects
1	Mercury	Coal power plants, pesticides, cosmetics, paper and pulp, cement industries, mining, electrical equipment	Minamata disease, memory problems, fatigue, hair loss, headache, bronchitis, asthma, respiratory disorders
2	Arsenic	Pesticides, fungicides, metal smelters	Skin pigmentation, keratosis, lung cancer, bronchitis, dermatitis, neurological disorders, hypertension, cardiovascular diseases
3	Lead	Coal, mining, automobiles, petrochemicals	Abdominal pain, headache, vertigo, fatigue, paralysis, brain and kidney damage, psychosis, muscular weakness
4	Cadmium	Toys, ceramics, coal industries, nuclear and coal power plants	Itai-Itai disease, osteoporosis, vomiting, fragile bones, renal stones, kidney and lung damage
5	Zinc	Phosphate fertilizers, distilleries, pharmaceuticals	Fever
6	Copper	Intrauterine devices, dental amalgams, occupational exposure, pesticides	Arthritis, thyroid dysfunction, kidney and liver dysfunction, hair loss, allergies, cardiovascular effects
7	Aluminum	Water, food, baking powder, bleached flour, aluminum-containing drugs, antacids	Neurological effects, memory loss, loss of coordination
8	Chromium	Fertilizers, thermal power plants, mining, leather, textile and photography industries	Allergies, bronchial asthma, nasal septum ulcers
9	Uranium	Mining	Cancer

Table 2: Sources and Toxic Effects of Heavy Metals [16].

Ayurvedic literature describes specific approaches for managing toxicity associated with poisonous substances and improperly processed metals and minerals. These approaches can be discussed in relation to the modern concept of metal detoxification, while recognizing that traditional Ayurvedic antidotal concepts should not automatically be equated with modern pharmacological chelation.

A classical principle described in the literature is that substances used during Shodhana (purification) of metals, minerals or poisonous substances may also be indicated as antidotes for their toxic effects. Vimala (Iron Pyrite): Vimala is purified using Meshashringi (*Gymnema sylvestre*) juice. The same plant material, along with sugar, is described for management of its toxicity. Gandhaka (Sulphur): Sulphur is purified using cow's milk and ghee. These substances are consequently described as antidotal measures for sulphur toxicity. Hartala (As_2S_3): Hartala is purified using Kushmanda

Swarasa (*Benincasa hispida*). Kushmanda Swarasa along with Jeeraka (*Carum carvi*) and Madhu (Honey) is described for its toxicity. Gauripashana (As_2O_3): Gauripashana is processed with Tankana (Borax) and cow's milk, which are also described in relation to its toxic manifestations [17].

Another concept described in the Ayurvedic literature involves the use of specific substances or preparations to counteract toxicity caused by another substance. Tankana (Borax) with Haridra (Turmeric) as an antidotal combination. Gauripashana toxicity Tankana with cow's milk. Naga (Lead) toxicity Swarna Bhasma with Haritaki (*Terminalia chebula*). Tamra (Copper) toxicity Gauripashana with sugar [18].

These descriptions demonstrate the diversity of classical approaches to managing toxicity caused by metals and minerals.

Ayurvedic Adverse Effects of Improperly Processed Bhasma (Table 3)

S. No.	Bhasma	Adverse effects
1	Rasa (Mercury)	Burning sensation, skin lesions, vomiting, stiffness and severe toxicity
2	Swarna (Gold)	Decrease in Ojas, disease manifestation and severe toxicity
3	Rajata (Silver)	Pyrexia, constipation, impotency and reduced resistance
4	Tamra (Copper)	Vertigo, unconsciousness, burning sensation, anorexia and vomiting
5	Naga (Lead)	Prameha, Kshaya, Kamala
6	Manahshila (As_2S_2)	Calculi, dysuria, burning micturition and constipation
7	Hartala (As_2S_3)	Prameha, pyrexia, skin blisters and severe toxicity

Table 3: Ayurvedic Quoted Adverse Effects of Improperly Processed Bhasma [19].

Ayurvedic Antidotes for Metal and Mineral Toxicity (Table 4)

S. No.	Metals / Minerals	Chelating Agent / Antidote	Reference
1	Rasa/Parada (Mercury)	Gandhaka (Sulphur) with Nagavalli (Piper betle)	Rasa Raj Sundar
2	Swarna (Gold)	Haritaki (<i>Terminalia chebula</i>) with Sita (Sugar)	Rasa Raj Sundar
3	Tamra (Copper)	Dhanyaka (<i>Coriander</i>) with Sita (Sugar)	Brihad Rasa Rajsundar
4	Naga (Lead)	Swarna Bhasma with Haritaki (<i>Terminalia chebula</i>) and Sita (Sugar)	Rasa Rajsundar
5	Vanga (Tin)	Meshashringi (<i>Gymnema sylvestre</i>) with Sita (Sugar)	Rasa Rajsundar
6	Hartala (As_2S_3)	Jeeraka (<i>Carum carvi</i>) with Sita (Sugar)	Rasa Rajsundar
7	Manahshila (As_2S_2)	Cow's Milk with Honey	Rasa Tarangini
8	Abhraka (Biotite)	Uma phala (Amalaki Phala / Atasi beeja) with Jala 3 day	Rasa Jalnidhi
9	Vimala (Iron Pyrite)	Meshashringi (<i>Gymnema sylvestre</i>) with Sita (Sugar)	Brihad Rasa Rajsundar
10	Sasyaka (Blue Vitriol)	Jambiri Nimbu (Lemon)	Brihad Rasa Rajsundar
11	Rasaka (Zinc Oxide)	Gomutra (Cow's Urine)	Brihad Rasa Rajsundar

12	Gandhaka (Sulphur)	Godugdha (Cow's Milk) with Goghrita (Cow's Ghee)	Brihad Rasa Rajsundar
13	Gauripashana (White Arsenic)	Tankana (Borax), Godugdha (Cow's Milk) and Goghrita (Cow's Ghee)	Ayurvedic Rasashastra
14	Loha (Iron)	Agastya Swarasa (Sesbania grandiflora) with Vidanga (Embelia ribes)	Ayurveda Prakash
15	Yashada (Zinc)	Bala (Sida cordifolia) mixed with Haritaki (Terminalia chebula) and Sugar	Rasa Rajsundar
16	Makshika (Copper Pyrite)	Kulattha Kwatha (Dolichos biflorus) and Dadima Kwatha (Punica granatum)	Brihad Rasa Rajsundar

Table 4: Ayurvedic Antidotes for Toxicity Associated with Improperly Processed Bhasma [20].

Ayurvedic Antidotes for Poisonous Herbal Drugs (Table 5)

S. No.	Poisonous Plant	Antidote / Chelating Agent
1	Vatsa Nabha (<i>Aconitum ferox</i>)	Borax with Clarified Butter (Ghee); Borax with Clarified Butter and Turmeric Juice
2	Ahiphena (<i>Papaver somniferum</i>)	Ginger Juice; Asafetida Water
3	Jayapal (<i>Croton tiglium</i>)	Coriander Juice with Sugar
4	Dhattura (<i>Datura stramonium</i>)	Vacha (<i>Acorus calamus</i>) Powder with Curd; Ricinus communis
5	Bhanga (<i>Cannabis indica</i>)	Buttermilk; Curd with Ginger Powder
6	Bhalla taka (<i>Seme carpus anacardium</i>)	Coriander; Terminalia arjuna; Coconut Water
7	Arka Ksheera (<i>Calotropis procera</i>)	Cow's Ghee (Clarified Butter)
8	Vishatinduka (<i>Strychnos nux-vomica</i>)	Cow's Ghee (Clarified Butter)

Table 5: Ayurvedic Antidotes for Selected Poisonous Herbal Drugs.

Natural Chelating and Antioxidant Agents

2,3-dimercaptosuccinic acid and N-acetyl-DL-penicillamine,

and the current remedies. In Ayurvedic literature garlic used in purification of impure mercury (Table 6).

S. No.	Agent	Source	Mechanism/Action	Potential role
1	Boron/Borax	Boron compounds	Antioxidant activity; may reduce oxidative and genotoxic effects	Protective role; traditionally described as an antidote
2	Glutathione (GSH)	Endogenous antioxidant; dietary sources	Metal binding and antioxidant defence; supports GST, GPx and SOD systems	Supports cellular detoxification and oxidative stress defence
3	Coriander (<i>Coriandrum sativum</i>)	Leaves/seeds	Antioxidant and reported metal-binding activity	Potential supportive role in heavy-metal exposure

Table 6: Natural Chelating and Antioxidant Agents Relevant to Heavy-Metal Toxicity.

Observations

The reviewed literature indicates that heavy metal toxicity is associated with accumulation of metals such as mercury, arsenic, lead and cadmium, producing multisystem toxic effects. Classical Ayurvedic literature describes specific adverse effects associated with improperly processed metallic and mineral preparations and recommends various

antidotal substances. The review identified three broad approaches to detoxification: chelation, mineral saturation and antioxidant protection. Ayurvedic sources describe Tankana, Gandhaka, Haritaki, Dhanyaka, Godugdha, Goghrita and other substances as antidotal measures for toxicity associated with metals and minerals. Modern literature describes chelating agents such as EDTA, dimercaprol, penicillamine and DMSA for specific heavy-metal poisoning.

The reviewed evidence also indicates that natural substances such as boron compounds, glutathione and coriander have reported antioxidant or metal-binding properties. However, the available evidence for Ayurvedic and natural chelation approaches is comparatively limited and requires further experimental and clinical validation.

Discussion

Heavy metal toxicity represents a significant public health concern because metals such as mercury, arsenic, lead and cadmium can accumulate in biological tissues and produce toxic effects involving multiple organ systems. The reviewed literature indicates that the severity of toxicity depends on the type of metal, dose, route, duration of exposure and individual susceptibility. Therefore, appropriate identification of the toxic metal and assessment of exposure are important for selecting a suitable management strategy.

From the Ayurvedic perspective, Rasashastra provides a systematic pharmaceutical approach for the therapeutic use of metals and minerals. Proper identification of raw materials, followed by Shodhana and Marana, is considered essential for obtaining properly processed preparations. The classical descriptions of adverse effects associated with improperly processed Bhasma emphasize the importance of pharmaceutical processing and quality control. These observations are particularly relevant because improper processing of metallic and mineral preparations may increase the risk of undesirable effects.

The reviewed Ayurvedic literature describes several approaches for managing toxicity. One important principle is the use of substances employed during Shodhana as antidotal measures. Examples include Godugdha and Goghrita for Gandhaka, Tankana and Godugdha for Gauripashana and specific combinations described for Naga, Tamra, Hartala, Manahshila and other substances. Another approach involves specific antidotes or combinations traditionally indicated for individual metals and minerals. These classical descriptions provide a valuable pharmacological basis for investigating possible protective, antioxidant, binding or detoxifying mechanisms.

The review also highlights three broad principles involved in the removal or reduction of toxic elements: chelation, saturation and antioxidant protection. Chelation involves binding of metal ions and facilitating their elimination, whereas adequate levels of essential minerals may reduce the uptake of certain toxic elements through competitive mechanisms. Antioxidant protection is also relevant because heavy metals can induce oxidative stress and cellular damage. Natural substances such as boron compounds, glutathione and coriander have been reported

in the reviewed literature to possess antioxidant or metal-binding properties. However, these findings should not be interpreted as establishing clinical efficacy of these substances for heavy-metal poisoning.

Modern medicine provides specific chelating agents such as dimercaprol, EDTA, penicillamine and DMSA for selected cases of heavy-metal poisoning. These agents have established roles in appropriate clinical situations, but their use requires medical supervision because chelation may also affect essential minerals and may produce adverse effects. Thus, conventional chelation therapy cannot be considered universally applicable to all types of metal exposure.

A major observation from the comparison is that Ayurvedic antidotal concepts and modern chelation therapy share a broad objective of reducing the toxic burden, but their mechanisms and levels of scientific validation are different. Ayurvedic descriptions are primarily derived from classical pharmaceutical and toxicological principles, whereas modern chelation therapy is based on defined chemical interactions between chelating agents and metal ions. Therefore, Ayurvedic antidotes should presently be described as traditionally documented remedies rather than proven clinical chelating agents, unless supported by experimental and clinical evidence.

The findings also emphasize the importance of quality control and standardization in Rasashastra. Modern analytical techniques such as elemental analysis, spectroscopy, chromatography and other physicochemical methods can help characterize metallic preparations and assess their quality. Integrating these techniques with classical Grahya Lakshana, Shodhana, Marana and Bhasma Pariksha may provide a stronger framework for evaluating safety and consistency.

Overall, the reviewed evidence suggests that classical Ayurvedic knowledge provides important leads for investigating the management of metal toxicity, but these claims require systematic scientific validation. Experimental studies should first establish mechanisms and safety followed by appropriately designed clinical studies to determine efficacy. Integration of classical Rasashastra principles with modern toxicology, analytical science, pharmacology and clinical research may ultimately contribute to evidence-based and standardized approaches for the safe management of heavy-metal toxicity.

Conclusion

Heavy metal toxicity remains a significant public health concern, particularly due to environmental exposure and the inappropriate use of metal-containing substances.

In Rasashastra, appropriate Shodhana and Marana are emphasized to ensure the safety and therapeutic suitability of metallic and mineral preparations. Modern chelation therapy has an established role in the management of selected cases of heavy metal poisoning, whereas Ayurvedic literature describes various traditional antidotal approaches. Substances such as Tankana, Gandhaka, Haritaki and Dhanyaka, have been reported to exhibit potential protective, antioxidant, or metal-binding properties. However, their precise mechanisms of action, clinical efficacy, and safety require systematic scientific validation. Integrating classical Ayurvedic principles with modern toxicology, analytical techniques, and evidence-based research may contribute to the development of safe, standardized, and scientifically validated strategies for the management of heavy metal toxicity.

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