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REVIEW ARTICLE ON KNOWLEDGE OF TOXICITY AND PHARMACOLOGICAL ACTIVITIES OF HERBO-MINERAL COMPOUNDS

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ABSTRACT :

In Ayurveda, Herbo-mineral formulations, or Rasaushadhis, are traditional remedies made from plant and mineral components that have undergone complex purification and incineration processes. For millennia, these formulas have been used to treat chronic illnesses with modest dosages and high efficacy. However, in contemporary pharmaceutical contexts, the addition of metallic and mineral compounds including lead, gold, silver, arsenic, and mercury has created safety issues. This article examines the pharmacological activity, safety evaluation, toxicity, and therapeutic potential of Herbo-mineral compounds, emphasizing how traditional Ayurvedic methods like Marana and Bodhana can change them into bioavailable, non-toxic forms. It also covers how their pharmacological efficacy and safety are confirmed by contemporary analytical and toxicological research.

Introduction

Both herbal and mineral-based formulations are used in Ayurveda, the traditional Indian medical system, to promote health and treat illnesses. The mineral-based preparations, also known as Herbo-mineral compounds or Rasaoushadhis, are distinct in their production and content. These include Kupipakva Rasayanas, Sinduras, Pishti, and Bhasma. (forms of calcined ash)[1].

Ayurvedic pharmaceutics that contain metals like mercury (Parada), gold (Swarna), silver (Rajata), copper (Tamra), lead (Naga), and zinc (Yashada) are guided by a rigorous purification (Shodhana) and incineration (Marana) process that minimizes their toxicity while increasing their bioavailability and therapeutic action[2].
These procedures have started to be validated by contemporary pharmacological and toxicological research, which demonstrates that appropriately synthesized Herbo-mineral compounds exist mainly as nanoscale or micron-sized particles, frequently complexed with organic molecules. which influence their pharmacokinetics and biological interactions[3,4].

2. Concept of Herbo-Mineral Formulations in Ayurveda

Herbo-mineral preparations are classified according to their physical characteristics and preparation techniques in Rasa Shastra, the branch of Ayurveda that deals with metals and minerals. Among the primary kinds are:
• Bhasma: Burned ashes of metals or minerals
• Sindura: Sublimed mercurial compounds
• Triturated preparations for Khalviya Rasayana
• Kupipakva Rasayana: Preparations cooked under regulated circumstances in glass bottles
These formulations main goal is to lower the dosage while increasing the medication's potency. Their preparation ensures detoxification and conversion into assimilable forms. Proper Shodhana and Marana are crucial for safety and effectiveness, according to traditional Ayurvedic writings like Rasa Ratna Samucchaya and Rasa tarangini[5].

3. Toxicity Concerns and the Role of Shodhana

3.1 Concept of Toxicity in Ayurveda

3 In Ayurveda, the concept of toxicity (Visha) is well-recognized, and the process of detoxification (Shodhana) is mandatory before using metals or minerals in therapeutic formulations. Bioaccumulation, nephrotoxicity, hepatotoxicity, and neurotoxicity can result from improperly handled metals[6].

.2 The Detoxification Process (Shodhana)

To eliminate chemical and physical contaminants, Shodhana entails repeated heating, quenching, and processing with herbal juices or decoctions. For instance:

• Lead (Naga) and copper (Tamra) are quenched in plant decoctions to change their chemical state and lessen toxicity;

• Mercury (Parada) is purified using garlic juice (Lasuna Swarasa), rock salt, and lime to remove harmful sulphides and oxides[7]. According to recent research, these procedures reduce toxicity by converting metals into stable oxides or sulphides with little free metal content[8].

4. Pharmacological Activities of Herbo-Mineral Compounds

Numerous pharmacological properties, including anti-inflammatory, immunomodulatory, antibacterial, antioxidant, antidiabetic, and anticancer effects, are displayed by Herbo-mineral formulations. The synergistic interplay of herbal and metallic components is responsible for these activities.

4.1 Immunomodulatory Activity

The immune-boosting properties of Swarna Bhasma (gold calx) and Abhraka Bhasma (mica calx) are widely recognized. Swarna Bhasma has been shown in experiments to increase the generation of antibodies and boost macrophage activity[9]**.**

4.2 Antioxidant and Anti-inflammatory Activities

Because they may scavenge reactive oxygen species (ROS), Tamra Bhasma and Lauha Bhasma (Iron calx) have demonstrated strong antioxidant qualities[10].

It is commonly known that they can be used to treat ailments like oxidative stress, chronic inflammation, and anaemia**.**

4.3 Antimicrobial and Antiviral Activities

A mercury-sulfur compound called Ras Sindura has shown antibacterial efficacy against Escherichia coli and Staphylococcus aureus. Research indicates that the nanoparticles generated in these preparations disrupt the metabolic activities of microorganisms[11].

4.4 Anticancer Properties

Recent research on Ras Sindura and Swarna Bhasma demonstrates cytotoxic effects on cancer cell lines like MCF-7 and HeLa. Tumor angiogenesis inhibition and apoptosis induction are part of the mechanism[12]**.**

5. Modern Scientific Insights

5.1 Nanoparticle Nature

The existence of Bhasmas as nanoparticles (10–60 nm) has been demonstrated by contemporary analytical methods as Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD), and Energy Dispersive X-ray Analysis (EDAX)[13]. This nanoscale dimension enhances their bioavailability, tissue penetration, and interaction with biomolecules.

5.2 Physicochemical Characterization

• XRD tests reveal the presence of metallic oxides and sulphides instead of free metals.

• Organic functional groups derived from the herbal media used during processing are revealed by FTIR and Raman spectroscopy, indicating complexation and stabilization of metal nanoparticles[14].

• SEM analysis supports the safety of well-prepared compounds by demonstrating uniform morphology and the absence of impurities [15].

5.3 Pharmacokinetic Studies

According to research on animals, metals in Bhasma form show regulated absorption and elimination without building up in tissue. It has been demonstrated that Swarna Bhasma can pass through the blood–brain barrier and positively affect neurotransmitter levels without exhibiting any neurotoxic effects[16].

6. Toxicological Studies and Safety Evaluation

6.1 Preclinical Toxicity Studies

Numerous preclinical investigations have confirmed the safety of appropriately produced Herbo-mineral compounds.

• Lauha Bhasma showed no adverse effects on liver and kidney markers at therapeutic doses in rats[17].
• Tamra Bhasma exhibited no genotoxicity or teratogenicity when administered at clinically relevant doses[18].
• Abhraka Bhasma demonstrated no organ toxicity even after chronic administration [19].

6.2 Clinical Safety Reports

Clinical experiments utilizing Swarna Bhasma and Ras Sindura report no heavy metal toxicity when formulations are made as per classical recommendations. Hematological and biochemical parameters remain within normal limits [20].
However, improperly prepared or spurious formulations, lacking proper purification, have been associated with toxic manifestations such as nephrotoxicity or hepatotoxicity, emphasizing the importance of standardization and quality control[21].

7. Mechanistic Insights into Detoxification and Efficacy

7.1 Role of Herbal Media

During Shodhana and Maraṇa, the herbal extracts operate as reducing, capping, and stabilizing agents. Flavonoids and alkaloids are examples of phytochemicals that attach to metal ions and change them into harmless organometallic complexes [22].

7.2 Transformation of Metal Species

For example, mercury can change into mercury sulfide (HgS), a stable, poorly soluble compound with low bioavailability in toxic form. Ferric oxide (Fe_2O_3), a safe and bioassimilable form, is also formed by iron[23].

7.3 Interaction with Biological Systems

Redox balance, immunological response, and cellular signaling pathways are all modulated by nanoscale Bhasmas' interactions with biomolecules such as proteins and enzymes[24].

8. Regulatory and Standardization Perspectives

8.1 Need for Standardization

To guarantee safety, the WHO and Indian Pharmacopeia have established out recommendations for permissible heavy metal levels in herbo-mineral formulations[25]. Standardization entails:
Clinical validation, toxicological evaluation, physicochemical characterization, and raw material authenticity.

8.2 Modern Analytical Validation

To measure trace metals and verify compliance with safety limits, sophisticated methods including ICP-MS, XRF, and AAS are employed[26].

9. Pharmacological Case Studies of Major Herbo-Mineral Drugs

Formulation	**Major Components**	**Pharmacological Activity**
Swarna Bhasma	Gold	Immunomodulatory, Anti-cancer[9,12]
Ras Sindura	Mercury, Sulphur	Antimicrobial, Cytotoxic[11,12]
Lauha Bhasma	Iron	Hematinic, Antioxidant[10,17]
Tamra Bhasma	Copper	Hepatoprotective, Antioxidant[10,18]
Abhraka Bhasma	Mica	Adaptogenic, Immunostimulant[9,19]

10. Toxicity Risk Factors

Formulations that are improperly made or tampered with may cause:
• Hepatotoxicity (from unprocessed lead or mercury)
• Nephrotoxicity (caused by heavy metal buildup)
• Neurological Effects (from inorganic mercury exposure)
Strict adherence to Ayurvedic pharmaceutical principles and contemporary analytical tests are crucial to reducing these dangers[27].

11. Nanomedicine Perspective

Bhasma's nanoscale characteristics serve as a link between conventional and contemporary medicine. The integration of Ayurvedic formulations into nanomedicine research is supported by studies showing that Swarna Bhasma and Ras Sindura nanoparticles function as immune modulators and targeted drug delivery systems[28].

12. Discussion

Properly processed Herbo-mineral formulations are sophisticated organo-mineral complexes rather than just mixes of metals and herbs, as demonstrated by the integration of ancient knowledge with contemporary scientific validation. The conversion of hazardous metals into inert, biocompatible nanoparticles is what makes them safe.

Nevertheless, unregulated production, lack of standardization, and inadequate quality control remain key concerns. To further validate conventional claims and guarantee safe integration into international pharmacotherapy, future research should prioritize mechanistic toxicology, clinical pharmacokinetics, and molecular studies [29].

13. Conclusion

Herbo-mineral formulations, when produced following classical Ayurvedic methods, are pharmacologically potent and safe for therapeutic use. By using organic complexation and nano transformation, the ancient methods of Shodhana and Marana guarantee detoxification and bioavailability. The absence of harmful free metals is confirmed by scientific validation using contemporary methods like TEM, XRD, and ICP-MS, which also emphasizes their distinct pharmacological activities, such as immunomodulation, antioxidation, and anticancer potential.

To prevent toxicity, standardization, quality control, and understanding of the significance of correct manufacturing are still essential. Ayurvedic pharmaceutics and contemporary nanoscience can be combined to create safe, efficient, and scientifically supported natural medicines in the future.

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