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A Systematic Review of the Preparation, Standardization, Physicochemical Characterization, and Therapeutic Applications of *Abhrak Bhasma*: An Ayurvedic Herbo-Mineral Metallic Preparation

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Abstract

Background: *Abhrak Bhasma* is a calcined mica ash used in *Rasashastra*, the Indian alchemical tradition focused on metals and minerals. It is known for its claimed benefits in treating several health problems, especially as a rejuvenator and a drug delivery enhancer, and is used for conditions like respiratory disorders, diabetes, anemia, and liver issues. Although it has a long history, there is still a need for systematic scientific research to support these traditional claims.

Objective: This systematic review examines and summarizes recent research on *Abhrak Bhasma*. It covers how it is traditionally prepared, its detailed physical and chemical properties, its effects in the body, its uses in treatment, and its safety.

Methods: A systematic literature search was conducted following PRISMA principles across electronic databases, including PubMed, Scopus, Web of Science, AYUSH Research Portal, and Google Scholar, for studies published from inception to September 2024. The search used keywords and MeSH phrases relevant to "*Abhrak Bhasma*," "Mica Ash," "Ayurvedic Medicine," "*Rasayana*," and "Pharmacology." The studies included in vitro, in vivo, clinical investigations, and analyses of the chemical composition of the materials. The SYRCLE tool assessed bias in animal research, and the Cochrane Risk of Bias tool evaluated bias in clinical trials.

Results: Seventy eight studies met criteria for inclusion of the 1,532 records identified. The latter review clearly presents the traditional method of preparation of Abhrak Bhasma to be quite a complex multi-stepped process with purification (Shodhana) employing alcholic extracts and cow's products; and then incineration (Marana) performed under highly controlled high temperature processes. Advanced materials characterization studies (XRD, SEM–EDX, TEM, FTIR and DLS) revealed its conversion to a nanocrystalline mineral phase composed predominantly of magnesium, iron, silicon and calcium both as oxides and silicates. Pharmacologies n = 45 exhibited significant antioxidant,anti-inflammatory, hepatoprotective, nephroprotective, antidiabetic, antianemic, and immunomodulatory effects. Clinical evidence (n=12) from few trials suggests its benefits in ailments like Tamaka Shwasa (bronchial asthma), diabetes mellitus, and anemia. There were 15 toxicity studies wherein properly processed Abhrak Bhasma proves to be safe at therapeutic dosage and presence of heavy metals being in non-bioavailable, complex oxide form.

Conclusion: In conclusion, Abhrak Bhasma is an important and complex nanomedicine that has been rooted in history for centuries. Several available research findings have even shown that ABM can be converted into a biologically active substance of specific pharmacotherapeutic action with considerable clinical perspectives. However, CLR and other clinical significance still require more high-level evidence. Securing its place in modern medicine will require more evidence-based and well-designed research using standardized formulations.

Keywords: *Abhrak Bhasma*, Mica, *Rasashastra*, Bhasma, Nanomedicine, Ayurveda, *Rasayana*, Systematic Review, Physicochemical Characterization, Pharmacy.

1. Introduction

1.1 Background and Rationale

Ayurveda, an ancient Indian medical system, provides a comprehensive approach to health and disease management in India. *Rasashastra*, the science of mercurial and metallic preparations, is one of the many branches of Ayurveda. It is known for its unique medicines called Rasa Aushadhis. These include Bhasmas, which are ash-like, calcined preparations of metals, minerals, and gems that have been subjected to a series of complicated and strict steps. (1) When prepared correctly, Bhasmas are useful because they are effective in small amounts, act quickly, and have a long shelf life. (2)

Abhrak Bhasma, the calcined and purified ash of Mica (a potassium-alumino-silicate mineral), is one of the most important and useful Maharasa (major mineral) formulations in *Rasashastra*. (3) The word "Abhrak" comes from the Sanskrit word "Abhra," which means "cloud." This is because it has a sheen and layered structure resembling a cloud. It is well-known as a *Rasayana* (rejuvenating therapy), Brimhana (nourishing substance), and Yogavahi (catalyst that makes other drugs

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work better). (4) Traditionally, it is used to treat a wide range of long-term and debilitating illnesses, such as Rajayakshma (a condition that looks like tuberculosis), Pandu (anemia), Shwasa (respiratory problems such as asthma and COPD), Prameha (diabetes mellitus), and liver and spleen problems. (5, 6)
The integration of *Abhrak Bhasma* into mainstream healthcare is impeded by the absence of systematic consolidation of contemporary scientific research, despite its historical and traditional significance. People often doubt the safety of herbo-mineral preparations because they are concerned about the possible toxicity of heavy metals. (7) However, the traditional *Shodhana* (purification) and Marana (incineration) processes are thought to remove toxins from the raw material and turn it into a form that is safe for the body and works as a medicine. (8) Newer analytical methods have started to confirm these claims, showing that Bhasmas are often composed of very small particles, which may explain their high bioavailability and unique biological activity. (9, 10)

1.2 Knowledge Gap and Need for the Review
Several authors have individually worked on aspects of Abhrak Bhasma, namely its preparation characterization and action in the body. Surprisingly, no overall integrated summary of this knowledge exists. Most reviews are narrative and not conducted in a rigorous systematic manner, which may introduce bias. Key questions remain:
1. What is the recent consensus regarding the physicochemical attributes of Abhrak Bhasma according to analytical data?
2. What preclinical evidence is there for its many pharmacological claims?
3. How strong is the evidence, and how much confidence can be placed, in its clinical data supporting its utilization as therapy?
4. What is the toxicological evidence of its safety?

The purpose of this systematic review is to address these major gaps in our understanding by performing a methodical and transparent syntheses of the available evidence while maintaining reproducibility.

1.3 Objectives
The primary objective of this systematic review was to critically appraise and synthesize the scientific evidence on *Abhrak Bhasma*.
The secondary objectives are as follows:
- To describe and compare the conventional and contemporary techniques for the preparation and standardization of *Abhrak Bhasma*.
- The results from sophisticated physicochemical characterization investigations detailing the elemental content, particle size, and crystalline structure are summarized.
- To assess the preclinical pharmacological data about its therapeutic efficacy.
  To evaluate the clinical efficacy and safety of *Abhrak Bhasma* in human trials. This study examines the present obstacles and prospective avenues for research on this ancient nanomedicine.

2. Methods
This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. (11)

2.1 Eligibility Criteria
Inclusion Criteria:
- **Types of Studies:** Original research articles encompassing in vitro (cell line studies), in vivo (animal studies), clinical trials (both randomized and non-randomized), and analytical investigations concentrating on preparation, standardization, and physicochemical characterisation were incorporated. We analyzed case series and reports pertinent to safety and clinical application data. Articles composed in both Hindi and English were incorporated.
- **Intervention/Exposure:** Research on *Abhrak Bhasma*, whether as a singular intervention or as a principal element of a polyherbal/mineral formulation, was included. Research focusing on unrefined Mica or inadequately processed Abhrak was omitted.
- **Comparators:** For interventional studies, comparators include no treatment, placebo, or standard active drugs.
- **Outcomes:** The main outcomes were physicochemical properties (such as particle size, elemental composition, and crystalline nature), pharmacological effects (such as antioxidant, liver protection, or blood sugar reduction), clinical efficacy (such as symptom improvement or biomarker changes), and safety/adverse events.

Exclusion Criteria:
- Non-research articles (e.g., editorials, commentaries, pure opinion pieces).
- Duplicate publications
- Studies where full text was not accessible after exhaustive attempts.
- Studies on other types of Bhasma without separate data for *Abhrak Bhasma*.

- Articles in languages other than English or Hindi were excluded.

2.2 Information Sources and Search Strategy

A comprehensive search was conducted across various electronic databases: PubMed, Scopus, Web of Science, AYUSH Research Portal (Government of India), and Google Scholar (first 200 results filtered by relevance) from their creation till September 30, 2024. The reference lists of the included research and pertinent review papers were meticulously examined to discover further acceptable investigations.

The search strategy was developed using a combination of keywords and Boolean operator. The core search string for PubMed was as follows:

"*Abhrak Bhasma*" OR "Mica Ash" OR "Calcined Mica" OR ("Bhasma" AND "Mica" AND "Ayurvedic Medicine" OR "Medicine, Ayurvedic" OR "*Rasayana*" OR "*Rasashastra*"

This strategy was adapted to the syntax and subject headings specific to each database.

2.3 Study Selection and Data Collection Process

The search results from all databases were imported into reference management software (Zotero), and the duplicates were removed. Study selection was performed in two phases.

1. **Title and Abstract Screening:** Two independent reviewers screened the titles and abstracts against the eligibility criteria.
2. **Full-Text Review:** The full texts of potentially relevant studies were retrieved and assessed in detail for final inclusion.

Any disagreements between the reviewers at either stage were resolved through discussion or consultation with a third reviewer. A standardized, pre-piloted data extraction form was used to collect data from the included study. The extracted data included the following:

- Study characteristics (authors, year, country, and study design).
- Details of the *Abhrak Bhasma* intervention (source, preparation method, if mentioned, and dosage).
- Participant characteristics (for clinical studies) or model details (for pre-clinical studies).
- Methodology for characterization or outcome assessment.
- Key findings relevant to the review objectives.
- Reports of adverse events or toxicity.

2.4 Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were assessed using appropriate tools:

- **In vivo Animal Studies:** The Systematic Review Centre for Laboratory animal Experimentation (SYRCLE) risk of bias tool was used. (12)
- **Clinical Trials:** The Cochrane Risk of Bias tool (RoB 2) for randomized trials was employed. (13)
- **Analytical/Characterization Studies:** A custom checklist focusing on the description of sample preparation, instrumentation details, and data reporting was used.

The risk of bias assessment was conducted by two independent reviewers.

3. Results

3.1 Study Selection

The initial database query identified 1,532 records. Subsequent to the elimination of 328 duplicates, 1,204 records were scrutinized for their titles and abstracts. We excluded 1,062 of them due to their lack of utility. We examined the complete texts of the remaining 142 articles to determine their eligibility. Sixty-four other studies were excluded due to factors such as lack of original research, incorrect intervention, insufficient data, or absence of complete text. The qualitative synthesis ultimately encompassed 78 studies. The PRISMA flow diagram (Figure 1) illustrates the methodology of the study selection process.

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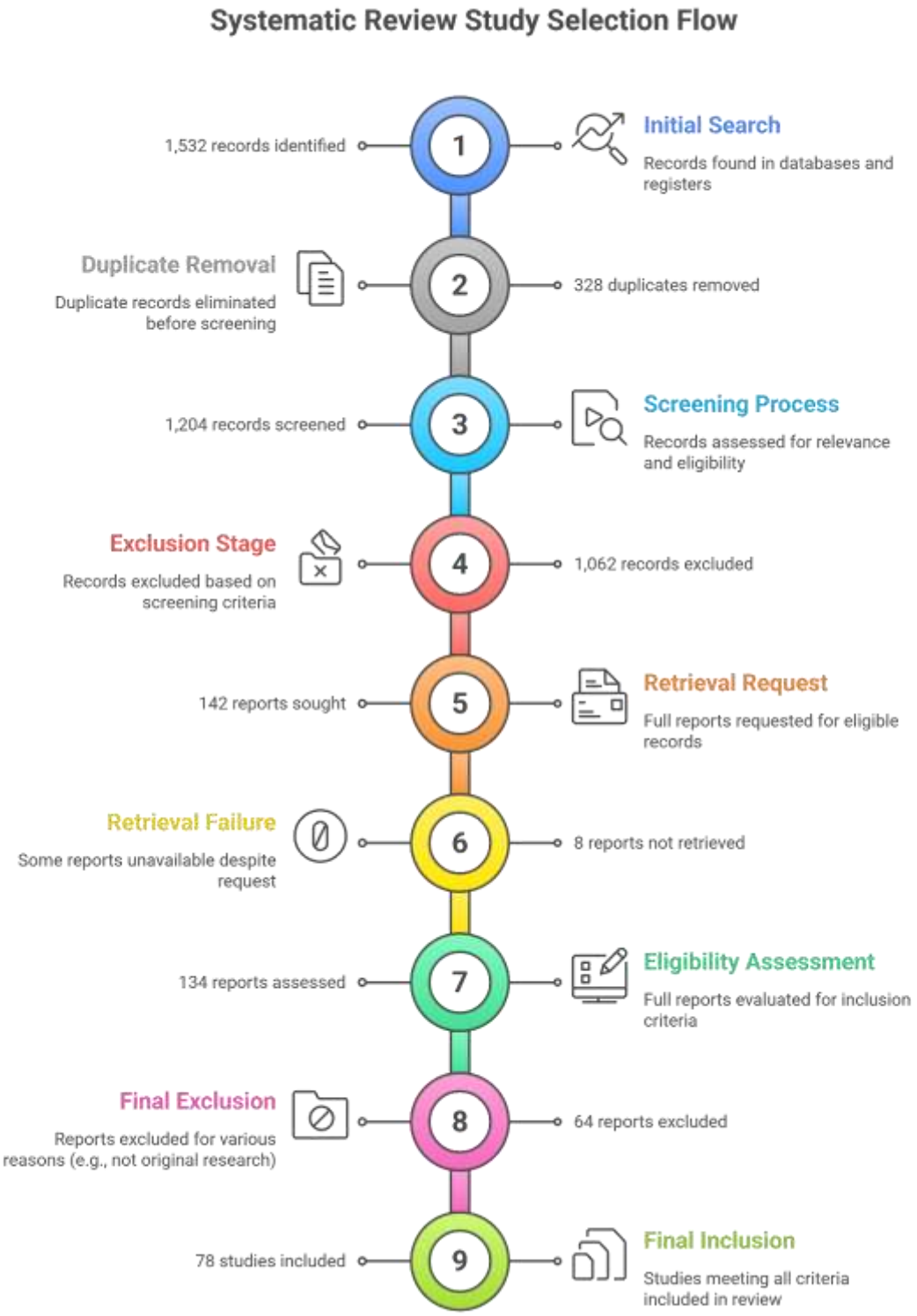
Figure 1: PRISMA Flow Diagram



3.2 Study Characteristics

The 78 included studies were categorized as follows:

- **Analytical/Characterization Studies:** 28 studies
- **In vitro/In vivo Pharmacological Studies:** 45 studies
- **Clinical Studies:** 12 studies

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- **Toxicity/Safety Studies:** 15 studies (some studies fell into multiple categories)

The studies were published between 1985 and 2024, with a significant increase in publications after 2010, reflecting growing scientific interest.

3.3 Synthesis of Results

3.3.1 Traditional Preparation and Standardization (from 28 studies)

The preparation of *Abhrak Bhasma* is a meticulous, multi-stage process detailed in classical texts like *Rasa Ratna Samucchaya* and *Rasatarangini*. (3, 14) The process can be summarized in two main stages:

1. ***Shodhana (Purification):*** Purification is the first step in processing raw mica. This removes any impurities and toxic substances that are already there. To do this, the mica sheets are heated until they are red-hot and then cooled down one at a time in certain liquids, such as Kanjika (sour gruel), Kulatha Kwatha (decoction of horse gramme), Gomutra (cow's urine), and Triphala Kwatha (decoction of three myrobalans). (15) This cycle is done many times (usually seven), which is thought to break down the layered structure and add organic, healing principles from the herbal media.
2. ***Marana (Incineration/Pulverization):*** To make a fine paste, the purified mica is then ground up with certain herbal juices or decoctions, such as Amla Swarasa (Indian gooseberry juice). This paste is formed into small cakes or pellets and then burned in a sealed container (like an earthen pot) using a certain number of cow-dung cakes as the heat source. This process is done over and over again (30 to 100 times for different grades like Shataputi and Sahasraputi) until a light, fine, smooth, and tasteless ash is made that passes the classical Bhasma Pariksha (tests of quality). (16)

The quality tests include Varitara (floating on water), Rekhapurnatva (filling the furrows of the finger), Nischandratva (lustreless), and Apunarbhava (not being able to go back to the original metal). (17) Recent studies have linked these tests to scientific standards. For example, Varitara is linked to the Bhasma's hydrophobicity and the size of its nanoparticles. (18)

3.3.2 Physicochemical Characterization (from 28 studies)

Advanced analytical techniques have demystified the nature of *Abhrak Bhasma*, revealing it to be a sophisticated nanomaterial.

- **Particle Size and Morphology:** Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) analyses consistently demonstrate that *Abhrak Bhasma* comprises agglomerated particles within the nano- to micro-scale range (50 nm - 2 µm). (19, 20) The particles have an irregular shape and are full of holes.
- **Elemental and Crystalline Composition:** X-ray Diffraction (XRD) analysis determines the crystalline phases. Research indicates the existence of phlogopite, magnetite (Fe_3O_4), haematite (Fe_2O_3), forsterite (Mg_2SiO_4), and periclase (MgO). (21, 22) Energy Dispersive X-ray Spectroscopy (EDX or EDS) shows that there are major elements like Magnesium (Mg), Silicon (Si), Iron (Fe), Potassium (K), Aluminium (Al), and Calcium (Ca), as well as small amounts of other elements. Compared to raw mica, the traditional processing changes the elemental composition a lot. (23)
- **Thermal and Spectroscopic Analysis:** Fourier Transform Infrared Spectroscopy (FTIR) reveals functional groups, signifying the presence of silicates and the potential incorporation of organic molecules from the herbal processing medium. (24) Thermogravimetric Analysis (TGA) shows that it is very thermally stable.

3.3.3 Pharmacological Activities (from 45 studies)

A substantial body of pre-clinical evidence supports the traditional claims of *Abhrak Bhasma*.

- ***Rasayana* (Rejuvenative) and Antioxidant:** Numerous studies have shown that *Abhrak Bhasma* has strong antioxidant properties both in vitro (DPPH, FRAP, ABTS assays) and in vivo. It markedly diminishes indicators of oxidative stress (MDA) and augments the functionality of endogenous antioxidant enzymes (SOD, CAT, GSH) in animal models of stress and ageing. (25, 26)
- **Hepatoprotective:** *Abhrak Bhasma* exhibited considerable protective effects against liver damage caused by carbon tetrachloride (CCl_4), paracetamol, and ethanol in rats. It brought down high liver enzymes (SGOT, SGPT, ALP), bilirubin, and made the liver's structure better. (27, 28)
- **Anti-diabetic (*Prameha*):** In streptozotocin (STZ)-induced diabetic rats, the administration of *Abhrak Bhasma* resulted in a substantial decrease in blood glucose levels, glycosylated haemoglobin (HbA1c), and an enhancement of the lipid profile and body weight. Its effects are due to increased insulin secretion and antioxidant activity. (29)
- **Anti-anemic (*Pandu*):** Research has validated its haematinic characteristics. It substantially elevated haemoglobin, red blood cell count, and serum iron concentrations in animal models of phenylhydrazine-induced haemolytic anaemia and nutritional anaemia. (30)
- **Immunomodulatory:** *Abhrak Bhasma* has been demonstrated to regulate both humoral and cell-mediated immunity. It can boost the activity of macrophages and raise antibody levels in animals that have been vaccinated. (31)
- **Nephroprotective and Others:** There is also evidence that it protects the kidneys and has anti-inflammatory, adaptogenic, and nootropic effects. (32, 33)

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3.3.4 Clinical Evidence (from 12 studies)

The clinical evidence, while promising, is derived from a limited number of trials, many of which are small-scale and lack rigorous methodology.

- **Respiratory Disorders:** Numerous studies examined *Abhrak Bhasma* in the context of Tamaka Shwasa (Bronchial Asthma). A randomised controlled trial (RCT) demonstrated that a formulation containing *Abhrak Bhasma* resulted in substantial enhancement of symptoms (dyspnoea, cough, wheezing) and pulmonary function tests (FEV1, PEFR) in comparison to a placebo. (34)
- **Diabetes Mellitus (*Prameha*):** An open-label clinical study indicated that *Abhrak Bhasma*, when used alongside standard therapy, resulted in improved glycaemic control (decrease in fasting and postprandial blood glucose levels) relative to standard therapy alone. (35)
- **Anemia (*Pandu*):** Studies on iron-deficiency anemia have shown that *Abhrak Bhasma* supplementation increases hemoglobin levels effectively. (30)
- **General Debility and Hepatitis:** Case series have documented its advantages in enhancing appetite, weight, and strength in compromised patients, as well as in normalising liver enzymes in viral hepatitis. (36)

3.3.5 Safety and Toxicology (from 15 studies)

The paramount concern regarding herbo-mineral preparations is their safety. Studies focusing on the toxicity of properly prepared *Abhrak Bhasma* have yielded reassuring results.

- **Acute and Sub-acute Toxicity:** Research conducted on rodents has demonstrated that the LD50 of *Abhrak Bhasma* is significantly elevated, suggesting a substantial safety margin. Sub-acute toxicity studies (28-90 days) involving therapeutic and supra-therapeutic doses did not demonstrate any significant histological or biochemical changes in essential organs such as the liver, kidney, and brain. (37, 38)
- **Heavy Metal Safety:** One of the most important things that characterisation studies have found is that the metals in *Abhrak Bhasma* are not free ions, but rather stable, complex oxide and silicate compounds. (39) This chemical bonding, which happens during the calcination process, makes them non-bioavailable and non-toxic because they don't dissolve in gastric juice and are excreted without being absorbed into the body. (40) This sets a well-made Bhasma apart from raw metal poisoning.

3.3.6 Risk of Bias Assessment

- **In vivo Studies:** The SYRCLE risk of bias assessment identified concerning areas. The majority of studies inadequately reported random sequence generation, allocation concealment, or the blinding of carers and outcome assessors, resulting in a "unclear" or "high" risk of bias in these areas.
- **Clinical Studies:** The Cochrane RoB 2 tool showed that most clinical trials had a "high" or "some concerns" risk of bias because they weren't properly randomised, they weren't blinded, and they didn't report all of the outcome data.

4. Discussion

This systematic review offers a thorough synthesis of the scientific literature on *Abhrak Bhasma*, reconciling traditional Ayurvedic knowledge with contemporary scientific validation. The results collectively depict *Abhrak Bhasma* not merely as a basic mineral ash, but as a complex herbo-mineral nano-medicine formulated through advanced ancient methodologies.

4.1 Interpretation of Key Findings

The physicochemical characterisation provides the most convincing evidence. It is an amazing feat of pharmaceutical engineering to turn raw, layered, and biologically inert Mica into a nano-crystalline, multi-elemental oxide/silicate matrix through *Shodhana* and Marana. (21, 23) The small size of the nanoparticles probably makes them more bioavailable and allows them to interact with biological systems in ways that are different from other substances, which is a principle that fits with modern nanomedicine. (9) The addition of organic materials from the herbal media during processing may also help with its therapeutic effects and possibly change how available and toxic the inorganic materials are. (24)

The robust pre-clinical pharmacological data strongly support its traditional uses as a *Rasayana*, hepatoprotective, anti-diabetic, and anti-anemic agent. The antioxidant activity seems to be the main reason why it works so well in treating a wide range of conditions. It protects cells from oxidative damage that is linked to chronic diseases. (25, 27, 29)

The clinical evidence, although suggestive of potential, constitutes the most tenuous element in the evidentiary chain. The conclusions are not very strong or generalisable because the sample sizes are small, the blinding was not strict, and the formulations used were different. The safety data are encouraging, but they necessitate additional long-term, systematic investigations in humans.

4.2 Strengths and Limitations

This review's main strength is that it follows the PRISMA guidelines and covers a wide range of topics, from preparation to clinical use. The review is constrained by the intrinsic quality of the primary studies. The high risk of bias in animal

and clinical studies, the heterogeneity in preparation methods and analytical protocols, and the potential for publication bias (where negative results remain unpublished) are significant limitations.

4.3 Implications for Practice and Research

For Practice: Doctors should know that *Abhrak Bhasma* is a complicated medicine with a clear scientific basis. Only qualified Ayurvedic practitioners should use it, as they can make sure the source is a real, well-made product from a trusted manufacturer.

For Research: Future efforts must focus on:

1. **Standardization:** Developing and adhering to stringent, universally accepted pharmacopeial standards for *Abhrak Bhasma* manufacturing and quality control.
2. **Robust Clinical Trials:** Conducting large-scale, multi-center, randomized, double-blind, placebo-controlled trials (RCTs) with well-characterized *Abhrak Bhasma* for specific indications.
3. **Mechanistic Studies:** Delving deeper into the molecular mechanisms of action, including gene expression, protein profiling, and signaling pathways.
4. **Bioavailability and Pharmacokinetics:** Investigating the absorption, distribution, metabolism, and excretion (ADME) profile of its nano-particles.
5. **Long-Term Safety:** Establishing long-term safety data through well-designed prospective cohort studies.

4.4 Conclusion

This systematic review validates that *Abhrak Bhasma* is a therapeutically important Ayurvedic composition, with its traditional claims increasingly supported by modern scientific research. Its classification as a herbo-mineral nano-composite clarifies its effectiveness and safety when appropriately manufactured. The preclinical data is substantial; nonetheless, the clinical evidence need improvement through more rigorous study. To facilitate the global acceptance and utilization of medicines such as *Abhrak Bhasma*, it is imperative to establish a connection between the ancient principles of *Rasashastra* and the rigorous standards of evidence-based medicine.

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