Historical Review of Copper-based Ancient Ayurvedic Medicine: Tamra Bhasma

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Abstract:- Copper has been widely used for various purposes since the Vedic periods. It plays a vital role in human physiology and has been used to treat different ailments in its mineral forms. Tamra Bhasma, the oldest medicinal form of copper, has been used in Ayurveda for centuries. In the traditional practice of Ayurvedic pharmacetics, copper is converted into its safe and effective nanomedicine form, Tamra Bhasma. This literature review provides a comprehensive analysis of copper (Tamra), covering its traditional uses, pharmaceutical processes, therapeutic applications, pharmacological activities, safety profiles, and reports on the structural identification of Tamra Bhasma. This examination extends from the Vedic and Samhita periods to recent developments.

Keywords:- Copper, Tamra, Bhasma, Ayurveda, Rasa Shastra

I. INTRODUCTION

Review studies shed light on existing theories and frameworks, revealing gaps, inconsistencies, and areas for future research. These studies also open doors for interdisciplinary approaches to tackle important research problems. By promoting innovative thinking, review studies can pave the way for new research fields and fresh perspectives on existing issues.

The ancient pharmaceutical processes of Rasa Shastra offer valuable insights into traditional methods for preparing therapeutic materials. Today, with advancements in chemistry, physics, and material science, we have the opportunity to comprehend this ancient knowledge using modern scientific terms. By incorporating recent literature, scientific theories, tools, and techniques, we can bridge the gap between traditional and contemporary understanding. A comprehensive review study is crucial for this effort. It assists researchers in establishing a solid theoretical foundation and expanding their thought processes, allowing them to proceed with greater clarity and innovation.

The present literature review offers a thorough analysis of Tamra (Copper). It covers its traditional uses, pharmaceutical processes, and therapeutic applications, as well as safety profiles and reports on the structural identification of Tamra Bhasma. This examination extends from the Vedic and Samhita periods to recent developments.

II. HISTORICAL BACKGROUND OF COPPER (TAMRA) [1, 2]

- Vedic Period: The Vedas, as ancient Indian scriptures, cover diverse topics including religious rituals, philosophy, mathematics, astronomy, and ethics, making them a rich repository of knowledge reflecting the early Indian civilization. Traces of Vedic wisdom can be found in almost all branches of science, highlighting their interdisciplinary nature and enduring significance.

- Rigveda: In the Rigveda, the word "Ayas" (Rigveda 1-11-68) is often mentioned in conjunction with "Tamra," suggesting a reddish metal, likely copper. These references typically relate to various ornaments and decorative items utilized during that era. The use of "Ayas" in association with "Tamra" hints at the early understanding and utilization of copper as a material for crafting ornamental objects, reflecting the technological advancements and cultural practices of the time (Rigveda 5-58-2; 5-53-4; 8-47-15).

- Yajurveda: In the Yajurveda, the term "Tamra" is frequently mentioned (Shatapatha Brahmana 2/3/4/5). However, copper is denoted by the name "Shyamam" due to its characteristic color. Additionally, "Sisam" is used interchangeably with "Tamra" in the Shukla Yajurveda (Shukla Yajurveda 23/37). Originally, both "Tamra" and "Lohitayas" were used to refer to copper, but over time, "Tamra" gained more popularity and became the preferred term.

- Atharva Veda: In the Atharva Veda, the term "Tamra" is indeed prevalent and is also denoted as "Ayas" and "Shyamam" (Atharvaveda 1-34-6; 1-34-7; 20-8-31). Additionally, references to other metals and alloys such as brass and bronze can be found. Iron is symbolically represented as "blood," while copper, denoted as "Shyamam," is likened to "flesh" (Atharvaveda 11-3-74). These symbolic associations indicate the significance attributed to various metals within the cultural and philosophical framework of the Atharva Veda.

- Brahmanas: In the Shatapatha and Gopatha Brahmanas, copper is termed "Lohayasam" (Shatapatha Brahmana 5/4/11/2) for its red hue and was used in arrow-making (Shatapatha Brahmana 2/3/4/5). Mythologically, "Tamra" is said to have originated from...
Lord Indra's umbilicus. The Shatapatha Brahmana mentions Lord Prajapati creating all ores, called "Apakva Dhatu Ayas," within the earth's womb (Shatapatha Brahmana 6/1/11/13). These mythological and symbolic interpretations reflect the reverence and significance attributed to copper in ancient Indian culture and mythology, as well as the understanding of its origins and uses.

- **Purana:** In the Varaha Purana, the origin of Tamra Dhatu is believed to be from Kartikeya's semen falling upon the earth (Varaha Purana, Chaturvarna Diksha, Tamra varnana, 126 Adhyaya 465). It is also described as the derivative of the Rakta (blood) and Meda (body fat) of Gudakesha, who is slain by Lord Vishnu. These mythological narratives from the Puranas provide symbolic interpretations of the origin and nature of copper, associating it with divine beings and cosmic events.

- **Sutras:** In the Gauhya Sutras, bronze and copper are extensively utilized in the preparation of Yantras, indicating their significance in sacred practices and rituals. Acharya Gautama emphasized the superiority of utensils made of Tamra (copper) for holy rituals, underscoring its revered status in religious practices in Dharma Sutras. Tamra was regarded as inherently pure, underscoring its importance not only in religious ceremonies but also in other areas due to its enduring qualities.

- **Smritis:** In the Smritis, Tamra (copper) was extensively utilized and revered as a symbol of purity. It was employed in various contexts, including for detrimental punishment, coinage, and the creation of sacred pitchers, which were cleansed using acids and alkalis (Yagya Valka Smriti Vyavhar Page.562/365) Manusmruti provides detailed descriptions of metal extraction procedures, including those for Tamra, along with other metals (Manusmruti 5/113-114). Additionally, Manusmruti advises the purification (Shodhana) of metals, including Tamra, through the use of Kshara (alkali), Amla (acid), and Jala (water).

**Sambhita Period, Sangraha Granthas and Nighantush:**

During the period of the Sambhitas, the therapeutic use of metals began. In the Charaka Samhita, Tamra (copper) is listed among the six metals (Ch. Su. 1/71), recognized for its poisonous nature (Ch. Su. 1/132) yet prescribed in the treatment of various ailments. Tamra Churna (powder) is used as a Rasayana in the Bhrahma Rasayana Kalpa and for various ailments (Ch. Chi. 1/3-46). Utensils made of Tamra are suggested for skin diseases like Sidhma and Kilasa (Ch. Chi. 7/117-118). Tamra powder is utilized in treating conditions such as Hikka, Shwasa, and Kasa. Anjana (collyrium) prepared in Tamra pots is used for treating Abhishyanda and Timira (Ch. Chi. 17/125). Tamra, along with other Dhatu like gold, is employed in treating conditions like Visarpa and Gulma (Ch. Chi. 21/131). Furthermore, Anjana, Shankh Varti, and Drustiprada Varti are prepared using Tamra powder and other medicinal substances to treat various eye diseases and enhance vision. Tamra is also used in crafting medical instruments such as the nozzles of Basti (enema) and tongue cleaners (Jihva nirlekhaka) (Ch. Si. 3/7). Tamra Churna is utilized to eliminate unabsorbed poison from the Koshta (stomach and intestines) (Ch. Chi. 23/239). These references from the Samhitas highlight the early understanding and utilization of metals, including copper, in therapeutic practices within ancient Indian medicine.

In the Sushruta Samhita, numerous references regarding the therapeutic use of Tamra (copper) for both external and internal applications can be found in various sections. Tamra is classified under the main heading 'Trapvadi Gana' (Su. Su. 38/62), and its pharmacological actions are also mentioned (Su. Su. 46/326), Tamra is used for treating conditions such as Krimi, Pandu, and Prameha.

Water stored in Tamra pots (Su. Su. 45/13) is said to become free from all toxic effects and is considered beneficial in the treatment of Paaitika disorders (Su. Ut. 42/105). Sushruta also describes the use of Tamra powder combined with other Dhatus (metals) and Kashayas (decocations) of drugs from the Salsaradi Gana in the treatment of Prameha (Su. Chi. 12/10). Copper powder, along with other metals, is utilized as an external plaster in cases of Kaphaja Arbuda (Su. Chi. 18/38). Additionally, Tamra powder, combined with herbal powders, is applied to wounds in Upadamsha (Su. Chi. 16/47). Tamra pots are recommended for fermentative preparations such as Soma (Su. Chi. 26/13). Copper is indicated in the preparation of medical instruments like Basti Netra (Su. Chi. 35/12) Further, it is used in Shirovirechana in pot form, in treating Shleshmaja and Rakta abhishyanda with Anjana (collyrium) (Su.Chi. 40/45; Su. Ut. 11/7; 12/13; 12/46; 12/26; 12/50; 12/46; 12/51), and in curing Praklimnavartma (Su. Ut. 12/53). Other eye diseases like boils and pterygium are also treated with copper-based therapies (Su Ut. 15/26). In the Sushruta Samhita, the Shalakas (probes) prepared by using Tamra Dhatu are preferred for eye procedures (Su. Ut. 18/61). Collyrium made from Tamra is also indicated for treating Timira to improve eyesight (Su. Ut. 18/105; 18/101), eye stability (Su. Ut. 18/85), and in case of paediatric eye diseases (Su. Ut. 16/14) Various external applications of Tamra preparations are recommended for treating eye diseases, but internal use is not indicated.

In the Ashtanga Sangraha, properties of Tamra (copper) and its alloys are detailed, including their use in storing medicines (A. S. Su. 12/14). The pharmacological actions of Tamra are also described within this text (A. S. Chi. 21/101). Moreover, Tamra is part of the Saptadhatus mentioned in the Sharanagardhara Samhita (Sha. Sam. M.K. 11/1) and Bhava Prakasha Nighantu (Bh. P. Ni. Dhatuvarga), along with descriptions of its purification and incineration processes. In the Raja Nighantu (Ra. Ni. Suvarnadivarga 1/6-12) and Dhavanatari Nighantu (Dha. Ni. Sshhashavarga 1/6-12), Tamra is ranked third among the group of seven metals, and these texts detail their therapeutic properties as well as any potential toxic effects. Additionally, the therapeutic uses and the pharmacological actions of Tamra are described in the Madhava Dravya Guna (Madhava Dravya Guna 158-164) and Madanpala Nighantu (Ma. Ni. 4/7).
The Kautilya Arthashastra contains various references concerning copper ores. These detailed descriptions indicate the importance of copper in ancient Indian economy and industry, as well as the sophistication of metallurgical knowledge during that time (Kautilya Arthashastra 2/18).

A review of Tantric literature indeed suggests that the copper was known for its possible uses during that period, but it was veiled in strict confidentiality similar to mantras. However, this secrecy surrounding the use of metals was eventually lifted by Nagarjuna, who advocated for their use openly in his Rasa texts. Nagarjuna’s contributions marked a significant shift, bringing an end to the secrecy surrounding the utilization of Dhatus and Updishatus (metals and minerals) in various forms.

The Rasa Hridaya Tantra provides a comprehensive description of Dhatus, including various types of Tamra, while the Rasendra Chudamani is credited with first describing the method of preparing Somanathi Tamra Bhasma. This text also delves into the pharmaceutical processes of Tamra and its therapeutic uses in conditions such as anemia, piles, and different eye diseases (Ra. Chu. 14/61-62). Similarly, the Rasa Prakasha Sudhakara from the 13th century offers insights into the varieties of Tamra (R. P. S. 4/40-43), methods Shodhana (R.R.S. 4/36-39; 40-43) Marana, and therapeutic applications (R.P.S. 4/45). The Rasa Ratna Samuchchaya discusses the distinctions between good and bad quality Tamra, alongside various purification (R.R.S. 5/49-51) and incineration (R.R.S. 5/53-54; 56-58) methods, including a special process for preparing Somnathi Tamra Bhasma (R.R.S. 5/65-67). Shri Dhundhika Natha, the author of Rasendra Chintamani in the 14th century, describes the method of Amritikarana (making nectar-like) of Tamra. Additionally, the Rasa Chintamani outlines special methods for preparing white-colored Tamra Bhasma (Ra. Chi. 10/26-32). Furthermore, the Rasa Padhatti details the preparation method of Tamra Bhasma without mercury and its therapeutic utility (R.P. 24/28). Texts from the 17th century onwards in the field of Rasa Shastra continue to provide detailed information about Tamra Bhasmas (R.P.S. 5/77) enriching our understanding of its preparation, properties, and applications in traditional Indian medicine.

### III. SYNONYMS OF COPPER IN ANCIENT TIMES

Copper has many synonyms and few of them are describing its mythological relations and few are related to its ap

<table>
<thead>
<tr>
<th>Ancient Types of Copper</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ancient varieties of copper along with their descriptions and qualities have been mentioned in Table 2</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: List of Synonyms of Copper Available in Different Texts.

<table>
<thead>
<tr>
<th>Variety of Tamra</th>
<th>Description</th>
<th>Quality</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepalaka</td>
<td>Very smooth and ductile with heaviness and also free from defects.</td>
<td>Best quality</td>
<td>As a Medicine in the form of its Bhasma.</td>
</tr>
<tr>
<td>Mlechchha</td>
<td>White or blackish in appearance with highly emetic property.</td>
<td>Inferior</td>
<td>Not useful as a medicinal.</td>
</tr>
<tr>
<td>Rakta Tamra</td>
<td>Red in color</td>
<td>Best quality</td>
<td>Medicinal use</td>
</tr>
<tr>
<td>Krishna Tamra</td>
<td>Black in color</td>
<td>Inferior compared to Rakta Tamra</td>
<td>Not specified.</td>
</tr>
</tbody>
</table>

### IV. PHYSICAL PROPERTIES OF TWO ANCIENT VARIETIES

#### Nepalaka Variety of Copper:

It is esteemed for its superior quality, boasts several distinguishing characteristics outlined in Rasashastra texts. It is described as slimy to the touch (Srisngidham), soft in nature (Mridu), and exhibits a striking copper-red color (Shonam or Japakusuma Varna). Notably, it possesses the unique property of being malleable enough to be fashioned into sheets without breaking (Ghanaaghatakshama). Additionally, it is characterized by its heaviness (Gara) and purity, being free from impurities (Nirviskara or Vikara rahita) [4,5].
**Mlechhcha Variety of Copper:**

It is characterized by its inferior quality, presents several distinctive traits delineated in Rasashastra texts. It exhibits various colors such as white (Sita), black (Krishna), and reddish (Aruna Varna) due to its propensity to tarnish. Notably, its consumption can induce severe vomiting (Ativami). Moreover, Mlechhcha Tamra is described as hard in nature (Kathora) and contains impurities such as iron and lead (Lohanagayaktam). It is brittle and tends to break upon impact with a hard object (Ghanaasaham). Additionally, despite proper washing, it retains its black color (Kshalita cha punah Krishna) [4, 5].

**Ancient Sources of Copper (Tamra):** [6-13]

Tamra, or copper, is available from mineral sources like Tuttha (copper sulphate) and Swarna Makshika (chalcopyrite), mentioned in texts like Rasa Prakasha Sudhakara and Rasatarangini. Additionally, animal sources such as Mayura Puchcha (peacock feathers) and Bhunaga (earthworms) are described in Rasatarangini for obtaining Tamra as Sattva.

V. **ANCIENT METHOD OF PREPARATION OF COPPER NANOPARTICLES IN THE FORM OF TAMRA BHASMA**

Shodhana of Tamra is essential during pharmaceutical procedures to eliminate impurities and potential toxins. Tamra, if not purified properly, can cause adverse effects such as changes in complexion, vomiting, emaciation, purgation, and sedation. Shodhana ensures the safety of Tamra-based formulations, mitigating health risks and enhancing therapeutic efficacy.

There are two Methods of Shodhana used for Dhatu Shodhana:

- **Samanya Shodhana:** This refers to general purification methods applicable to all Dhatus. It involves heating and quenching the metal successively in various liquid medias to remove impurities and enhance its therapeutic properties.

  Various methods of Samanya Shodhana applicable to Dhatus in classical texts can also be applied to Tamra. Some of these methods include:

  - Heating and quenching the Dhatus for 7 times successively in Tila Taila (oil), Takra (buttermilk), Gomutra (cow urine), Aranala (fermented gruel), and Kulattha Kwatha (horse gram decoction) [14].
  - Heating and quenching the Dhatus for 7 times successively in Takra, Kanji, Gomutra, Tila Taila, and Kulattha Kwatha [15].
  - Heating and quenching the Dhatus for 7 times successively in Taila, Takra, Gomutra, Kanji, and Arkadughdha (latex of Calotropis procera L.) [16].
  - Heating and quenching the Dhatus for 7 times in Kadimoola Swarasa (banana stem juice) [17].
  - Heating and quenching the Dhatus for 3 times successively in the order of Kanji (sour gruel), Takra, Kulattha Kwatha, Gomutra, and Tila Taila (sesame oil) [18].
  - Heating and quenching the Dhatus for 3 times successively in Tila Taila, Takra, Kanji, Gomutra, and Kulattha Kwatha [19].

**Vishesha Shodhana:** This refers to specific purification methods tailored to individual metals based on their characteristics and impurities. It may involve additional steps or specific substances to achieve thorough purification. Many Acharyas in Ayurveda agree that while Samanya Shodhana is essential for metals, it may not be sufficient to completely eliminate all impurities and enhance potency. Therefore, they advocate for Vishesha Shodhana (specific purification) to further refine the metal and maximize its therapeutic benefits.

Ayurveda Prakasha specifically highlights the necessity of Vishesha Shodhana for Tamra, emphasizing that Samanya Shodhana alone may not be adequate to address all the Doshas associated with Tamra. Table 3 likely enumerates various methods of Vishesha Shodhana (specific purification) elucidated in classical texts.

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**Table 3: Details of Various Vishesha Shodhana Methods as Per Different Texts**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Drugs used</th>
<th>Procedure</th>
<th>Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rasaratna Samucchaya 5/49</td>
<td>Ksharamala</td>
<td>Nirvapana (7 times)</td>
<td>Mahisha Takra</td>
</tr>
<tr>
<td>Rasaratna Samucchaya 5/51</td>
<td>Saindhava Lavana and Nimbu Rasa – Lepa.</td>
<td>Nirvapana</td>
<td>Nirgundi Swarasas</td>
</tr>
<tr>
<td>Rasaratna Samucchaya 5/52</td>
<td>Gomutra</td>
<td>Swedana (1 Yama period)</td>
<td>Gomutra</td>
</tr>
<tr>
<td>Rasaratna Samucchaya 1/280</td>
<td>Gomutra</td>
<td>Swedana (1 Yama period)</td>
<td>Gomutra</td>
</tr>
<tr>
<td>Rasaratna Samucchaya 1/279</td>
<td>Saindhava Lavana and Arka Dugdha – Lepa</td>
<td>Nirvapana</td>
<td>Nirgundi Swarasas</td>
</tr>
</tbody>
</table>

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digestible, absorbable, and assimilated by the body, the material becomes homogeneous, making it easily palatable and reduces particle size. The resulting nanoparticles. This enhances the metal bioacceptability, based on different use in Ayurvedic medicine.

- Tamra Marana (incineration of copper): After the Shodhana process, Tamra (copper) undergoes Marana (incineration) to prepare it for internal use in Ayurvedic medicine. Marana categorizes the process based on different media used to prepare Bhasma (copper nanoparticles). This enhances the metal bioacceptability, palatability, and reduces particle size. The resulting material becomes homogeneous, making it easily digestible, absorbable, and assimilated by the body, transforming it from a heterogeneous to a homogeneous form. Total 53 methods of Marana processes have been described in ancient texts of Ayurveda.

- Amritikaran of Tamra Bhasma
  After the Marana process, possible impurities may still remain in Tamra Bhasma. To remove these impurities, a specialized procedure known as Amritikaran is recommended. While this procedure is advised for all Bhasmas, it's particularly crucial for Tamra Bhasma to eliminate its Utklesha, Vanti, and Bhranti Doshas, ensuring the purity and safety of the final product [20].

### Table 4: Various Methods of Amritikaran Explained in Different Rasa Shashtra Classics

<table>
<thead>
<tr>
<th>Reference</th>
<th>Drug used</th>
<th>Method of preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rasa Tarangini</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Tamra Bhasma 1 part</td>
<td>By mixing a and b together.</td>
<td></td>
</tr>
<tr>
<td>b. Shuddha Gandhaka ½ part</td>
<td>Performing mardana along with c.</td>
<td></td>
</tr>
<tr>
<td>c. Pancamrita</td>
<td>Subjecting the mixture to Gajaputa, which is then repeated three times.</td>
<td></td>
</tr>
<tr>
<td>a. Tamra Bhasma 1 part</td>
<td>By mixing a and b together.</td>
<td></td>
</tr>
<tr>
<td>b. Shuddha Gandhaka ½ part</td>
<td>Performing mardana along with c. Goraka is kept inside Surana Kanda. After Kapadmitti, Gajaputa is given.</td>
<td></td>
</tr>
<tr>
<td>c. Nimbu Swarasa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Tamra Bhasma 1 part</td>
<td>By giving bhavana of substance b to substance a.</td>
<td></td>
</tr>
<tr>
<td>b. Kumari Swarasa</td>
<td>Subjecting the mixture to Vaara Putha after drying.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Repeating the entire process seven times.</td>
<td></td>
</tr>
</tbody>
</table>
Rasamritam
- a. Tamra Bhasma 1 part
- b. Nimbu Swarasa

By giving bhavana of substance b to substance a.
Keeping the mixture in Surana Kanda. Subjecting the mixture to Gaja Pata.
Repeating the entire process seven times.

Rasayanasara
- a. Tamra Bhasma 1 part
- b. Panchamrita

Giving bhavana of substance b to substance a.
Performing Sharava Sampata. Subjecting the mixture to Gaja Pata after drying.
Repeating the entire process three times.

Ancient Sources of Copper (Tamra):6-13
According to different texts of Rasa Shastra, the range of dose of Tamra Bhasma for internal administration is between 1/8th Ratti – 1 Masha (15 mg-1g). However, it is used in clinical practices with a dose of ½ Ratti – 1 Ratti (60-120 mg), depending on the status of the patient [21].

VI. PHARMACOLOGICAL ACTIONS OF TAMRA BHASMA AND COPPER

Tamra Bhasma has many pharmacological actions and they have depicted in Fig. 1.

- Vital Roles of Copper in the Human Body:
Copper plays a vital role in human physiology [22]. All the functions of the copper have been depicted in Fig. 2.
Functions as a part of various enzymes
Assists the proper thyroid functioning in hormone balance and regulation
Aids in the absorption of iron
Boosts level of body energy
Helps to carry oxygen in the bloodstream and its supply to tissues
A brain stimulant and antagonizes manganese ions
Required for the adrenaline synthesis
Supports proper functioning of nervous system
Aids in the absorption of iron
Crucial for the production of RBCs and acts as a pigmentsing factor along with tyrosine
Fig 2: Role of Copper in Human Physiology

VII. TOXICOLOGICAL HAZARDS OF TAMRA BHASMA AND COPPER AND THEIR MANAGEMENT

Tamra Bhasma if not prepared well or compromised pharmaceutical processing leads to many noxious events [23, 24] as mentioned in Table 4.

Table 5: List of all Doshas of Improperly Prepared Tamra Bhasma.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Doshas</th>
<th>Modern Terminology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Aadhmana</td>
<td>Distension due to flatus</td>
</tr>
<tr>
<td>2.</td>
<td>Aruchi</td>
<td>Anorexia</td>
</tr>
<tr>
<td>3.</td>
<td>Ayuraghnam</td>
<td>Reduce life longevity</td>
</tr>
<tr>
<td>4.</td>
<td>Balapahatva</td>
<td>Loss of physical strength</td>
</tr>
<tr>
<td>5.</td>
<td>Bhrama</td>
<td>Dizziness</td>
</tr>
<tr>
<td>6.</td>
<td>Bhranti</td>
<td>Vertigo</td>
</tr>
<tr>
<td>7.</td>
<td>Chittasantap</td>
<td>Perplexed mind</td>
</tr>
<tr>
<td>8.</td>
<td>Chittatapa</td>
<td>Perplexed mind</td>
</tr>
<tr>
<td>9.</td>
<td>Daha</td>
<td>Burning sensation</td>
</tr>
<tr>
<td>10.</td>
<td>Dhatushosha</td>
<td>Debility</td>
</tr>
<tr>
<td>11.</td>
<td>Gatratapa</td>
<td>Warmness in the body</td>
</tr>
<tr>
<td>12.</td>
<td>Kantighnatva</td>
<td>Reduced skin texture</td>
</tr>
<tr>
<td>13.</td>
<td>Kledanam</td>
<td>Moistened body</td>
</tr>
<tr>
<td>14.</td>
<td>Krimi</td>
<td>Worm infestation</td>
</tr>
<tr>
<td>15.</td>
<td>Kushtham</td>
<td>Skin diseases</td>
</tr>
<tr>
<td>16.</td>
<td>Mudah</td>
<td>Intoxication</td>
</tr>
<tr>
<td>17.</td>
<td>Moha</td>
<td>Disoriented mind and body</td>
</tr>
</tbody>
</table>
In cases of copper sulfate poisoning, vomiting typically occurs within 5-10 minutes after ingestion. Therefore, emetics are not required. Instead, a gastric wash should be administered using a 1% potassium ferrocyanide solution, which forms insoluble cupric ferrocyanide. White bulk of egg or cold milk that contain albumin will form insoluble copper albuminate and act as an antidote. Intramuscular injection of B.A.L. (British Anti-Lewisite) is advised at a dose of 2.5 mg/kg/body weight. Castor oil can also remove the poison from the intestine. Symptomatic treatment includes administering morphine hydrochloride to relieve pain and maintaining electrolyte and fluid balance [26, 27].

### Management:

First step is to find out the cause and remove it as soon as possible. Do massage and take a bath with warm water. The patient should be rehabilitated in fresh air. Attend to his diet and dyspepsia [27, 28].

### Clinical Presentation:

In chronic Cu poisoning, symptoms look like those of lead poisoning. Common signs include gums with a green or purple line, a persistent coppery taste in the mouth, headache, nausea & vomiting, giddiness, dyspepsia, diarrhoea, colicky pain, laryngitis & bronchitis, renal damage, anaemia, peripheral neuritis, muscle atrophy, jaundice, and greenish urine, perspiration and hair. Eyes may experience inflammation of the conjunctiva and ulceration of the cornea due to copper dust exposure. Direct skin contact with copper may lead to dermatitis or eczematous lesions. Chronic copper poisoning can also result in a symptom complex known by various names such as hemochromatosis, bronzed diabetes, and pigment cirrhosis, as described by Mallory [26, 27, 28].

### Antidote to Manage Copper Poisoning [25]

- Juice of *Munivrihi* mixed with *Sita*
- Juice or infusion of *Dhanyak* mixed with *Sita*
- Use of *Mukta Bhasma*

#### VIII. COPPER POISONING

Copper is a reddish heavy metal that is generally non-toxic in its pure form. However, when alloyed and converted into fine powder, it can become poisonous if ingested or inhaled. Common copper salts include copper sulfate (blue vitriol) and copper acetate (verdigris or zangal), both of which can be toxic in certain forms and concentrations. While copper is essential in small amounts for human health, excessive exposure to its compounds can lead to various health issues [26].

### Acute Poisoning:

Copper sulfate, also known as blue vitriol or tuttha (CuSO4.5H2O), is used medicinally in small doses as an astringent or emetic. However, in larger amounts, it can become an irritant poison.

Acute poisoning from copper salts typically begins within 15-30 minutes of ingestion. Symptoms include a metallic taste, increased salivation, and a burning pain in the mouth, nausea, vomiting with blue or green vomitus, thirst, diarrhoea, oliguria, haematuria, albuminuria, uraemia, jaundice, cramps or spasms, convulsions, frontal headache, circulatory collapse, limbs paralysis, drowsiness, insensibility, and coma leading to death [26, 27].

### Fatal Period:

The usual fatal period is 1-3 days, but it can be prolonged for several days [26, 27].

### Management:

In cases of copper sulfate poisoning, vomiting typically occurs within 5-10 minutes after ingestion. Therefore, emetics are not required. Instead, a gastric wash should be administered using a 1% potassium ferrocyanide solution, which forms insoluble cupric ferrocyanide. White bulk of egg or cold milk that contain albumin will form insoluble copper albuminate and act as an antidote. Intramuscular injection of B.A.L. (British Anti-Lewisite) is advised at a dose of 2.5 mg/kg/body weight. Castor oil can also remove the poison from the intestine. Symptomatic treatment includes administering morphine hydrochloride to relieve pain and maintaining electrolyte and fluid balance [26, 27].

### Chronic Poisoning:

Chronic poisoning from copper typically occurs among workers in copper factories or individuals exposed to copper dust over time. This exposure can happen through inhalation of copper dust in the workplace or using dirty copper vessels for food preparation. Dust can be absorbed through the alimentary canal, lungs, and partly through the skin during the handling of Cu metal and related salts [26, 27].

### Clinical Presentation:

In chronic Cu poisoning, symptoms look like those of lead poisoning. Common signs include gums with a green or purple line, a persistent coppery taste in the mouth, headache, nausea & vomiting, giddiness, dyspepsia, diarrhoea, colicky pain, laryngitis & bronchitis, renal damage, anaemia, peripheral neuritis, muscle atrophy, jaundice, and greenish urine, perspiration and hair. Eyes may experience inflammation of the conjunctiva and ulceration of the cornea due to copper dust exposure. Direct skin contact with copper may lead to dermatitis or eczematous lesions. Chronic copper poisoning can also result in a symptom complex known by various names such as hemochromatosis, bronzed diabetes, and pigment cirrhosis, as described by Mallory [26, 27, 28].

<table>
<thead>
<tr>
<th>Classical Antidote to Manage Copper Poisoning [25]</th>
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<tr>
<td>- Juice of <em>Munivrihi</em> mixed with <em>Sita</em></td>
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<tr>
<td>- Use of <em>Mukta Bhasma</em></td>
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#### Table 6: Toxicity Studies on *Tamra Bhasma*.

| Chronic toxicity study: *Tamra Bhasma* to albino Wistar rats. TED of 5.5 mg/kg, 5× TED, and 10× TED. Significant decreases in body weight in 5× TED, and 10× TED. The TED showed non-toxic effects. However, 5×TED, and 10×TED |
were found to have a toxic effect [29].

2. **Genotoxicity study:** TB, prepared with and without *Amritikaran* to Swiss albino mice at 7.8 mg/kg body weight for 14 days. All treated groups showed significant body weight gain compared to the cyclophosphamide (CP) group. No structural deformities compared to the CP group [30].

3. **TB made from shodhita and ashodhita Tamra,** examined for toxicity study in albino rats at 5.5, 27.5, and 55 mg/kg for 45 days. Histopathological results indicated that TB prepared from *shodhita Tamra* was safe even at 5x TED. However, TB prepared from *ashodhita Tamra* showed toxicity even at TED [31].

4. In a chronic toxicity study in albino Wistar rats, at dose levels of 2.25 mg/200 gm and 4.5 mg/200 gm rat (2xTED) for 90 days. The study found no toxicity [32].

5. TB prepared with and without *Amritikaran* administered for 28 days at 5.5, 27.5, and 55.5 mg/kg in albino Wistar rats to evaluate acute and subacute toxicity. Mild toxicity affecting the liver, kidney, heart, and thymus observed at the 55.5 mg/kg dose level only. The sample prepared without *Amritikaran* exhibited a greater extent of toxicity [33].

6. In a toxicity study of TB in Albino rats (Charles Foster strain), the calculated LD50 dose was found to be 480 mg/100 gm in rats. Dose levels of 1000 mg/kg (3 days), 2 mg/kg (30 days), and 5 mg/kg (90 days) did not result in toxicity. However, at 100 mg/kg for 15 days, slight increases in all these enzymes observed [34].

**Pharmacological Activities of Tamra Bhasma**

Different types of pharmacological activities of Tamra Bhasma have been summarized in Table 6.

<table>
<thead>
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<th>Table 7: Studies on Tamra Bhasma for Validation by Pharmacological Activities.</th>
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<tr>
<td><strong>1.</strong> Antioxidant study- Lipid Peroxidation (LPO) and reduced Glutathione (RGSH) levels were evaluated for antioxidant study. Both the activities showed statistically significant decrease in TB at 5 x TED and 10 x TED dose as compared to control group. Significant decreased CK-MB activity, LDH activity and ALP level were seen at 5 x TED and 10 x TED doses. Significant increase in ASE and ALT activities was seen in TED, TED x 5 and TED x 10 dose levels [29].</td>
</tr>
<tr>
<td><strong>2.</strong> Comparative anti-hyperlipidaemic activity: <em>Shuddha Tamra Bhasma</em> (STB) demonstrated significant anti-hyperlipidemic activity, while <em>Ashuddha Tamra Bhasma</em> (ATB) lacked such effect [35].</td>
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<td><strong>3.</strong> Anti hyperlipidaemic activity: Study concludes that lipid lowering capacity of TB was more in TB prepared using Mulika and followed by Kajjali. TB prepared using sulphur was not effective [36].</td>
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<tr>
<td><strong>4.</strong> Anti-oxidant potential: Findings suggested that <em>Tamra Bhasma</em> is a potent antioxidant medication and can be considered for managing lipid peroxidation without any detectable adverse effects [37].</td>
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<tr>
<td><strong>5.</strong> <em>Tamra Bhasma</em> and <em>Somnathi Tamra Bhasma</em> subjected to albino Wistar rats. Insignificant changes were seen in BSL, serum cholesterol, triglycerides as well as in all other biochemical parameters when compared to control group. This reveals the safety of these formulations [38].</td>
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<td><strong>6.</strong> The antioxidant activity of <em>Tamra Bhasma</em> was studied in albino rats across three parameters: Lipid Peroxidation: Normal at doses up to 7.5 mg/kg, but increased at higher doses. Aerial Oxidation of GSH: Maintained at 5 mg/kg, but rapidly increased at higher doses. SOD Activity: Initially decreased at doses up to 5 mg/kg, then gradually increased at higher doses, accompanied by increased lipid peroxidation and rapid GSH oxidation. In summary, <em>Tamra Bhasma</em> showed antioxidant effects at lower doses but induced oxidative stress at higher doses, with a complex impact on antioxidant enzyme activity [34].</td>
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**IX. PHARMACOTHERAPEUTICS OF COPPER COMPOUNDS**

Copper plays a crucial role in iron absorption from the gastrointestinal tract (GIT) and regulates or activates iron from its storage tissues by its catalytic activities. It helps in the haemoglobin formation, with a requirement of 3 mg/day daily for the hematopoietic purposes. The highest percentage of copper in the blood is found in haemoglobin. A combination of copper with iron results in faster recovery in anaemic children compared to iron alone.

Oral administration of copper sulfate at 1-3 mg/day, along with milk or fruit juice, is found effective for children [39]. Bacteriostatic and bactericidal action of copper is well reported. Historically, copper salts were used to induce vomiting due to their irritant effects on the gastrointestinal tract. However, excessive absorption of copper can lead to toxic symptoms, although prompt vomiting due to copper's irritant properties helps mitigate this risk [40].

B.L. Pandey *et al.* studied on the action of Tamra Bhasma on experimental gastric ulcers and secretions, discovering an anti-ulcerogenic effect on experimental animals [41]. They observed a reduction in the content of sugars of mucosa glycoproteins and found that the drug's effect was prolonged and increased gastric mucosal thickening [42]. Researchers suggest that copper powder may have an additional mechanism of action, possibly involving the enhancement of prostaglandin secretion. The role of prostaglandins in cytoprotection of the gastric mucosa and the action of proteolytic enzyme activity by copper have been explored by Moddox J. S *et al.* in 1993 and Menguy R. Masters *et al.* in 1965 [43, 44].

In 1977, Oster G and Salgo *et al.* reported that copper reduces carbonic anhydrase activity [45]. Singh PP and Das PK *et al.* found in 1978 that a single dose of copper inhibits the development of tolerance to certain nervous system effects of cannabis in rats after 7 days [46]. Additionally, in 1982, Sanyal *et al.* reported the effect of copper in reducing
peptic activity [47]. Furthermore, Leung et al. (1992) suggested cupric ions as a potential chemotherapy treatment for human lung tumours [48].

Scientific Reports Addressing Chemical Identity of Tamra Bhasma

- Wadekar et. Al. (2005) reported that Tamra Bhasma is composed of cupric oxide (cuo), and it is present as a crystalline material having a crystallite size of 32.2 nm. The crystallite size of Tamra Bhasma was greater than that of lab-prepared cupric oxide nanoparticles (23.6 nm) [49].
- The findings of Singh et. Al. (2019) also report the same findings of Wadekar et. Al. (2005) [50].
- Dr. Lalit Mohan Sah (2005) in his M.D. thesis (submitted to Banaras Hindu University, Varanasi) reported that the Tamra Bhasma prepared by using Kajjali has phases of cus and Tamra Bhasma prepared with Gandhaka has dominant phases of cus with a few phases of cuo. Whereas, Tamra Bhasma prepared with Tilparni swarasa has phases of cuo only [51].
- Reddy et. Al. (2006), Jagtap et. Al. (2012), and Chaudhary et. Al. (2013) reported that Tamra Bhasma is copper sulfide as a crystalline material [52-54].

X. CONCLUSION

Copper (Tamra) has been used for various purposes since Vedic period. The use of Tamra Bhasma to treat different ailments is evidenced in different classical texts of Ayurveda. Copper has many vital functions in the body and plays a crucial role in human physiology, Tamra Bhasma is a safe and effective bioavailable form of copper, if prepared and used in a judicious way. It is concluded that copper is used in the form of Tamra Bhasma by converting it to a best bioavailable nanomedicine with the help of ancient pharmaceutical techniques. It is well established that Tamra Bhasma is a safe and ancient nanomedicine form of copper.

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