Metallic *Bhasmas*: A Review on Chemical Characterization, Particle Size and Toxicity

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Abstract

Bhasmas are unique metallic-herbal preparations of Indian origin, widely recommended for the treatment of chronic ailments. These intriguing formulations of metals are associated with organic macromolecules derived from the medicinal herbs. *Bhasmas* are often prepared by repeated incineration of metals with herbs and its extracts by alchemic processes and are taken along with honey, milk, butter, or ghee. Besides primary constituent of metals, *bhasmas* also contain other metals as minor constituent or in traces. Commercially available seventeen *bhasmas* based on Ca, Fe, Zn, Hg, Cu, As, Ag and Sn were characterized by instrumental neutron activation analysis (INAA) for up to 20 elements. The technique involves irradiation of the sample with thermal neutrons in a nuclear reactor followed by assay of gamma activity by high-resolution gamma ray spectrometry. Concentrations of major, minor, and trace elements vary in a wide range even in *bhasmas* of the same primary element depending on its preparation method. C, H, and S were also found in significant amounts suggesting the possible presence of organic macromolecules that may act as ligands. Transmission electron microscopy (TEM) studies have shown that the *bhasmas* as available in the market are not really nano particles contrary to claims of some literature reports. Westerners think *bhasmas* to be highly toxic especially those of As, Hg, and Pb, highly toxic elements. Still *bhaasms* of these elements are widely recommended. Clinical evidences suggest that the *bhasmas* taken in small doses are highly beneficial to the body system and do not cause any adverse effects. It is essential to follow quality control in the preparation of *bhasmas*. A review of our earlier work is also presented.

Keywords; *Bhasma*, Chemical characterization, Instrumental Neutron Activation Analyis (INAA), Transmission Electron Microscopy (TEM), Particle size, Toxicity.

Introduction

Ayurveda, the traditional Indian health care system has been in vogue since the Vedic period. It advocates holistic approach to the human health care thus presenting a balance between the physical, mental and spiritual functions of the body and strengthening its immune system. Study of ancient *Ayurvedic* literature indicates the use of metals, minerals and gems since 7th century B.C.[1]. Siddha Nagarjuna considered to be the father of Indian alchemy and *Rasa Shastra,* first suggested the use of precious metals *viz* silver, gold, copper, zinc as medicines and described the preparation of their *bhasmas.* In spite of many processes described for the preparation of *bhasmas,* no scientific process control has been discussed/developed. Many world civilizations such as those of Africa, China, Egypt, and South America have described the use of herbs as medicines but no where metals or metallic-herbal preparations are described. Therefore, Indian system of medicine is unique where the importance of metals in life processes was first recognized.

Bhasma, literally means ash, is unique *Ayurvedic* herbomineral/metallic formulation of nano dimensions and of high potency, recommended for the treatment of chronic ailments. These intriguing formulations of metals are associated with organic macromolecules derived from herbal extracts/juices by alchemic processes making these biologically assimilable with least side effects[2]. *Bhasmas* are often prepared by repeated incineration of metals with medicinal herbs and are taken in small doses along with honey, milk, curd, butter, ghee etc so as to eliminate their harmful effects[3]. Besides primary constituent metal such as Ca, Fe, Zn, Ag, Au, Hg, As these also contain other metals as minor constituents or in trace amounts[4]. The metals are mostly present as oxides, sulfides, and carbonates or as complex with organic ligands derived from the herbs. These additional elements play an important role in the treatment of diseases and hence it is essential to determine for their quality control or toxic effects, if any.
Bhasmas are prepared from precious metals and their naturally occurring salts by calcination process called *putas*. However, before calcination, the metal must go through two main processes, physical purification called *shodhan* and chemical detoxification called *maran,* both terms derived from Sanskrit, an ancient Indian language. The primary steps of preparation method include crushing, boiling and repeated incinerations in earthen crucible at specified temperature that make the minerals ready for human consumption. This purification process is different from chemical purification and is carried out in a special vessel under the earth and

incinerated using cow dung's dry cake[1]. In chemical purification only the foreign matter is eliminated whereas *Ayurvedic* purification is aimed at -

i) Removal of harmful effects from the crude material.

ii) Alteration in undesirable physical properties of the crude material.

iii) Changing some of the characteristics of the crude material.

iv) The enhancement of therapeutic action making it biologically assimilable and maintaining its potency for a long period of time.

When *bhasma* is finally prepared it should be tested to meet following requirements-

a) It should have no metallic luster (*Nishchandrika*).

b) The *bhasma* powder should be fine enough so that when rubbed between the index finger and thumb, it should go into the grooves (*Rekhapurit*).

c) When a small quantity of *bhasma* is sprinkled onto cold water, it should float on the surface (*Varitaram*).

d) The *bhasma* should not revert to its original state (*Apurnabhava*).

In *Ayurveda* minerals remain combined with herbs so as to help in the assimilation and deliver the ingredients to the human body. It is now well established that several metals play a vital role in the biochemical and enzymatic processes as well as in the cure of many chronic diseases. Minerals are essential constituents of the bone, teeth, muscles, blood and nerves and play a vital role to our overall mental and physical wellbeing[5,6]. Whereas proteins, enzymes and vitamins are manufactured in human body by physiological processes, minerals cannot be manufactured in a similar manner but supplemented only. Hence, minerals of Fe, Ca, Mg, Mn, Cu and Zn found in the soil are first absorbed directly in plant roots and then dispersed in different parts. These mineral elements are then supplied to our body through the food chain. Perhaps the metal in *bhasma* bound to carrier macromolecule, acts as a catalyst or alters the membrane fluidity. Apparently, the organic ligands derived from the herb render the metal easily assimilable/bioavailable. Another aspect of *Ayurvedic* preparations is synergism, which is apparently achieved by selectively blending of many plants, minerals and animal products, and thus maintaining the active ingredients at a minimum level and reducing or eliminating its side effects.

In earlier days, the physicians called *Vaidyas* were preparing these *bhasmas* and other herbal preparations according to well laid procedures described in old texts. Hence, the quality of these preparations was not subjected to any review but was based on the sacred faith between the physician and the patient. However, in modern times these are manufactured by pharmaceutical firms who may or may not be following the exact procedure. Therefore, a

physician or a patient seeks assurance for the quality, safety and efficacy of any herbal *Ayurvedic* medicine more so because of Government regulations especially for export in the western market. Hence, any *bhasma* or other herbal preparation needs quality control as many of them have been found to contain toxic substances. In recent years many reports from USA, Canada and other western countries have banned Indian herbal preparations because of toxic element contents[7]. In view of these reports, it has become essential to standardize these herbal formulations and maintain quality control. Ingredients and uses of seventeen metal based *bhasmas* analyzed in this study are listed in Table 1.

Several workers have analyzed *bhasmas* of various metals, alloys and minerals, for major, minor and trace elements by employing a variety of classical and instrumental analytical methods *viz* flame photometry, atomic absorption spectrophotometry (AAS), inductively coupled plasma-atomic emission spectrometry (ICP-AES), particle induced X-ray emission (PIXE), X-ray diffraction[8-14]. Earlier in our laboratory, we have extensively employed INAA for major, minor and trace element of a large number of commercial *bhasmas*[15,16]. In continuation, we present here a review of our earlier work and report data on C, H, and S contents that may be present as minor constituents. Toxicity of some elements is discussed because of prevailing controversy. Also our results on particle size by transmission electron microscopy (TEM) are presented for the first time.

Experimental

Sample collection and reactor irradiation All the seventeen *bhasmas* analyzed in this study were procured commercially from M/s Dabur India Ltd (Delhi), Baidyanath Ayurved Bhawan Ltd (Jhanshi), Deshrakshak Aushdhalaya (Haridwar), and local Ayurvedic physicians in Roorkee. Names of all the bhasmas, its ingredients and their uses as described in literature are listed in Table 1. Two Reference Materials Peach Leaves (SRM 1547) and Mixed Polish Herbs (MPH 2), used as comparator standards, were procured from NIST, USA and INCT, Poland respectively. All the samples and RMs were stirred well and dried at 80 ºC in oven for 2h before use. 30-50 mg each of the sample and RMs were weighed accurately, and packed in Alkathene/aluminum foil for

short and long irradiations respectively in APSARA/ CIRUS reactor at BARC, Mumbai. Other details are the same as described earlier [15,16].

Activity measurements After suitable cooling, samples were unwrapped, swiped with acetone for decontamination and mounted on a Perspex sheet. Gamma activity was assayed by using high resolution gamma spectrometry at different intervals of time. Other details of experimental setup and counting schedule are same as reported earlier [15,16].

Main constituent of the metallic *bhasma* was analyzed by conventional classical methods. C, H, N, and S were determined by using Elementar Vario-EL III (Germany) after prior calibration. N content was also analyzed but found in insignificant amounts and hence not reported.

Results and discussion

Elemental concentrations are calculated by comparator method using RMs with certified elemental contents. NAA has the unique advantage of being multielemental, nondestructive and higher sensitivity requiring small sample size only. Main constituent of the *bhasmas* analyzed in this study was found at % level whereas other nutrient and toxic elements were found at minor and trace level. All the elemental contents of major, minor and trace constituents are listed in Tables 2 and 3. Multiple *bhasmas* of the same element such as that of Ca (4), Fe (4), Zn (3) and Hg (3) were analyzed as each one differs in preparation methodology and so also these have different medicinal importance. Significance of variation in elemental contents of these is discussed here briefly.

Calcium based *bhasmas*: Calcium forms >1% of the total body content and Ca along with P are considered structural elements playing an important role in correcting bone metabolic disorders[5]. With increasing industrialization, skeletal disease of osteoporosis characterized by low bone mass and micro structural deterioration of bone tissue leading to enhanced bone fragility, has become a major health problem. In *Ayurveda*, several Ca preparations from natural/sea sources are recommended for supplementing its deficiency to growing children and ladies especially after 50 years of age. All the *bhasmas* were prepared by repeated incineration/calcination of pearls, oyster or conch shell in a covered vessel under reducing atmosphere. Four preparations analyzed in this study show a varying content of 29.5 - 41.9% Ca, 2.73 - 22.1 mg/g Mg, 0.29 - 0.96 mg/g P and a number of other elements such as Na, K,

and Fe which all play a vital role in life processes[5,6]. Variation in range and mean elemental concentrations of these elements along with As and Hg, the two toxic elements are illustrated in Fig. 1. Several workers have reported antacid activity of these preparations and studied their role in enhancing effectiveness of antibiotics [17,18]. Surprisingly, all the Ca-based *bhasmas* showed high C (11.8 – 15.1 %), H (0.25 – 0.81 %) and S (0.12 – 0.81 %) suggesting the possible presence of carbonate and sulfate[8]. Interestingly all the four *bhasmas* contain higher amounts of As and Hg than permissible limits that may possibly be attributed to polluted marine environment.

Iron based *bhasmas*: Iron is an essential trace element, that nourishes blood, enhances vigour and its astringency prevents blood from becoming too hot or too fluid[4]. Pandit et al[19] evaluated chemical and pharmacological action of different Ayurvedic preparations in iron deficient anemic patients. These *bhasmas* are mostly prepared from pure iron filings/ferric oxide or magnetic iron incinerated with decoction of *Trifala, ghritkumari ras*, vinegar and sesame oil. Iron content varies in a much wider range of 5.31 - 56.9% with least amount in *Trifala yog lauh* and highest in *Vanaspati yog lauh*. Other minor constituents are Na, K, Mn and P besides trace amounts of Co, Cu and Zn including toxic elements (As and Hg). Ranges and mean elemental contents in 4 *bhasmas* analyzed in this study are shown in Fig. 2. Treatment of iron deficiency anaemia with iron salts like ferrous sulfate results in gastrointestinal irritation, cardiovascular collapse, damage to brain and liver. A perusal of C, H and S data in small amounts (Table 1) suggests the possible presence of organic macromolecules that may act as ligands. Jani et al[20] have detected trace amounts of polycyclic aromatic hydrocarbons (PAH) by HPLC in *Ayurvedic* preparations.

Zinc based *bhasmas*: Zinc is an essential constituent of many enzymes in the human body as more than hundred metalloenzymes are known. Its deficiency may cause reduction in cell division resulting in failure of growth, weight loss impairment of tissue repair[5,6]. Out of three zinc based *bhasmas* analyzed in this study, its content varies in a wide range of 0.012 - 60.0% and these contain higher amounts of iron (3.87 – 22.8 mg/g), besides K and P. Even two *yashad* bhasmas procured from different pharmaceutical firms differ in their elemental contents significantly. *Kharpar* is primarily $ZnCO_3$ though it also has Ca (23.9%) and C (8.4%) suggesting that some $CaCO_3$ may have been added. Khosa and Dixit[21] have shown *yashad bhasma* to increase virility and intelligence. Also Puri et al[22] have suggested its role in the treatment of myopia. An elemental variation plot of zinc based *bhasmas* is shown in Fig. 3. It is observed that high amounts of Mn (117 - 334 µg/g) along with significant amount of S (0.257 – 0.436 %) seem to be always associated in these *bhasmas*. Several zinc based wound healing

ointments and eye drops (Zincorin and Occulus contain ~0.1 5 % $ZnSO_4$) are being marketed by various pharmaceutical firms.

Mercury based *bhasmas*: Mercury is an industrial hazard and occurs in environment as heavy metal contaminant. Any form of mercury (inorganic or organic) is considered to be highly toxic, causing *Minimata* disease[23,24]. If inhaled in trace amounts, it exhibits purgative effect. However, in *Ayurveda* its preparation especially *Makaradhwaja* is considered as a marvel drug[25] that can cure all diseases if properly prepared and used. However, if improperly prepared then it may cause all kinds of diseases[26]. In our study, we have found *Siddha makaradhwaj* to be stoichiometrically pure HgS with no other element including gold being found even in traces except trace amounts of C (0.06%) and H (0.03%). In another brand of *Makaradhwaja gutika* with swarnakalp marketed by Dhootpaeshwar Ltd, Mumbai, only trace amounts of Hg (168 μg/g) but significant amount of Au (462 μg/g) was found. We presume it is not real or a duplicate sample may have been sold as a branded product.

Other metal *Bhasmas*: We also analyzed one each of Ag, Cu, Sn and As based *bhasmas.* Of these As is highly toxic. Copper, silver and gold have long been known as coinage metals but these are also considered for medicinal purposes. *Rajat bhasma* is recommended for epilepsy, neuropsychobehavioural effects, and tuberculosis[27]. Besides 23.4% Ag, *rajat bhasma* also contained As (14.2 %), P (5.14%) and Na (1.28%) as major constituents along with trace amounts of Mn (183 μg/g) and Au (140 ng/g). Arsenic is considered to be the king of poisons but it is also known to be a possible essential element in *Unani* system of medicine with analgesic activity and proconvulsant effects[28]. Arsenic based *kushta khas* shows As (3.65 %) along with Ca (30.1 %) and S (21.1%) as major components. It also contains Na (0.83 mg/g), K (2.42 mg/g), P (1.06 mg/g) and Cl (0.20 mg/g) as minor constituents along with Mn and La in trace amounts. Thus As might be present as sulfide (As_2S_3). Copper is an integral part of several enzymes influencing our immune system. It also acts as antioxidant and plays an important role in scavenging superoxides[29]. Sample of *tamra bhasma* contained Cu (44.1%), Fe (7.12%), P (1.09%) and K (2.37%) as major constituents and As (~20), Mn (134) and Zn (358) in μg/g amounts. Higher amount of S (22.0%) may be indicative of presence of CuS. Tin based *vanga bhasma* contained Sn (43.8%) and Ca (7.35%) as major constituents besides Fe (0.3%) and K (0.88%) as minor constituents and P (720), Mn (257), Zn (67) including In (17.1) in μg/g amounts. Chopra et al[30] first reported synthesis of tin based *bhasma* in 1936. In *Ayurvedic* literature, tin based *bhasma* has been recommended for diabetes, semen disorder, skin disease and syphilis[3].

Particle Size Studies

A *bhasma* is suitable for drug use if it has no metallic luster. It must be extremely fine powder such that the particles are smaller than skin ridges of the index finger and the thumb, float on cold water, does not revert to metallic form, maintains its potency indefinitely and manifests no toxicity[3]. The processing technology during the preparation of *bhasma* is very complex and specific according to ancient literature. It has been observed that micro cracks are developed at the grain boundaries during thermal cycling. It is supposed that microfine medicinal product has easy digestive power and quick reaction with the bile juices. Some workers have suggested *bhasmas* as biologically produced nano particles. Prakash[1] has reproduced some photographs showing microstructures of gold, zinc and lead *bhasmas*. However, no experimental measurements have been reported confirming the nano-sized particles. In order to confirm these literature claims, TEM photographs were recorded for a few *bhasmas* of *shankh* (Ca)*, yashad* (Zn)*, vanga* (Sn), and *Vanaspati Yog Lauh* (Fe) shown in Fig. 4. It is observed from the photographs that the particle size of *yashad* (Zn) was found to be 520 nm and those for *shankh* (Ca) and Fe these correspond to 260 nm. *Vanga* containing Sn showed a much bigger particle size of 2 μm. Thus, our experimental observations do not clearly show the *bhasma* to be of really nano particle size (< 100 nm) but as somewhat of larger particle size.

Bhowmick et al[12] have reported physicochemical characterization of *yashad* (Zn) *bhasma* and detected nanoparticles containing nonstoichiometric zinc oxide with irregular shape and 15-25 nm size by TEM. Paul and Sharma[31] have prepared nano size (~15 nm) particles of *swarna* (Au) *bhasma* and studied its blood compatibility to evaluate cytotoxicity. In a recent study Kantak et al[13] have prepared *Abhraka bhasma* and shown crystalline nature of different sizes and shapes ranging from 50 nm to 1 μm. It may be mentioned that our *bhasma* samples were not freshly prepared and these being old, aggregation might have occurred. It is suggested that more thorough experimental evidence using high resolution TEM is required to confirm the nano particle size of *bhasmas* of freshly prepared samples.

Toxicity of *bhasmas*

Sometime back a bunch of Ayurvedic medicines including *bhasmas* were sampled from an Indian store in New York and analyzed. Subsequently a report was published by Saper et al[7] in the Journal of the American Medical Association (JAMA) which created a whirlwind of controversy that wreaked havoc on the export market of *Ayurvedic* medicines from India. The

study was carried out in the context of toxicity of As, Hg and Pb that remain associated with the use of herbal medicines. Unlike many trace elements required by the body as minerals, toxic heavy metals do not play any role in the metabolic processes in human body[5]. In fact these toxic elements tend to accumulate in tissue causing toxicity, damaging the body organs. Several diseases such as *Minamata, Itai-Itai* etc are known to be caused by these toxic elements[5]. Yet, metals are the starting point of *bhasmas*. It is argued that toxicity can arise only from a particular metallic species and not all forms are toxic. However, a *bhasma* prepared according to the classical methods never contains a free metal. Since metallic preparations have been in use since ages and no toxicological studies are reported, it is assumed these are safe to consume in small doses. Of course, along with their dose and mode of administration, dietary restrictions are also very important. A *bhasma* is always consumed with honey, milk, curd, butter milk, butter or ghee whereby their harmful effects may be neutralized. It seems that due to commercialization, some manufacturers may not be following the recommended procedure (good practices) in the preparation of these medicines[32]. Therefore, it is essential to have quality control and provide analytical data for all the herbal preparations so as to ensure that no toxicity due to metals is added to herbo-mineral preparations. In this regard, Chan[32] has emphasized the essentiality of following good agricultural practices (GAP), good laboratory practices (GLP), good manufacturing practices (GMP) and good supply practices (GSP). Recently Department of AYUSH, Ministry of Health & Welfare, Government of India has come out with a notification with permissible limits for As, Pb, Hg and Cd[33]. Nagarajan et al[34] have reported the preparation and characterization of lead based *Naga bhasma* whereby they have emphasized that repeated calcination leads to the formation of nano crystalline lead sulfide. Though lead is heaviest of all toxic metals but it is still recommended as *Ayurvedic* medicine in minute amounts. Recently Liu et al[35] have studied a number of metallic *bhasmas* of Tibetian origin and reviewed their therapeutic effects and toxicity aspects. It has been emphasized that chemical form of the metal in *bhasma* plays a role in risk assessment for its disposition, efficacy and toxicity.

A cursory look of data in Tables 2 and 3 including Figs 1 to3, it is clear that most *bhasmas* analyzed in this study contain significant amounts of As and Hg both of which are highly toxic but their dosage taken with honey as recommended in old texts are useful. Our composition data show the need for quality control of *Ayurvedic* preparations manufactured by pharmaceutical companies with state of art R&D laboratory. In order to derive benefit from such preparations, it is imperative to prepare *bhasmas* as per recommended procedure and

subject them to toxicity testing thus ensuring their efficacy and safety. Following motto must always be remembered:

"When processed properly and used under the expert guidance of a trained clinician, bhasmas are safe"

Conclusion

Bhasmas of metals, alloys and minerals have been known in Indian subcontinent since ages and widely used for treatment of many chronic diseases. Seventeen metal based *bhasmas* of Ca, Fe, Zn, Hg, Cu, Ag, Sn and As were analyzed for major, minor and trace constituents by INAA. Presence of significant amounts of C, H and S suggests that some organic molecules may possibly be acting as ligands or involve in compound formation. Concentrations of elements in different *bhasmas* of the same element vary in a wide range depending on the method of preparation. Particle size of *bhasmas* is likely to be of nano size but more studies are required to confirm it. These are consumed in small doses and with honey, milk, curd, ghee etc so that harmful effects are likely to be avoided. Toxicity aspects of elements such as As, Hg, Pb as major/minor or trace constituent is discussed. Presumably chemical form of metal plays an important role in toxicity of a *bhasma.*

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Figures:

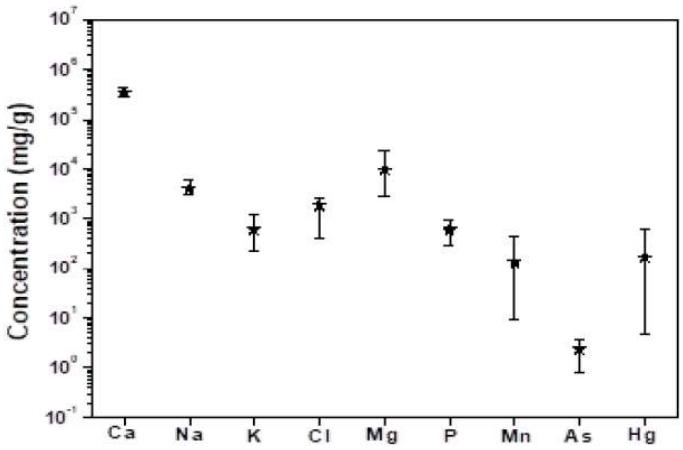

Fig. 1 Range and Mean Elemental Contents in Ca based *bhasmas* (n=4)

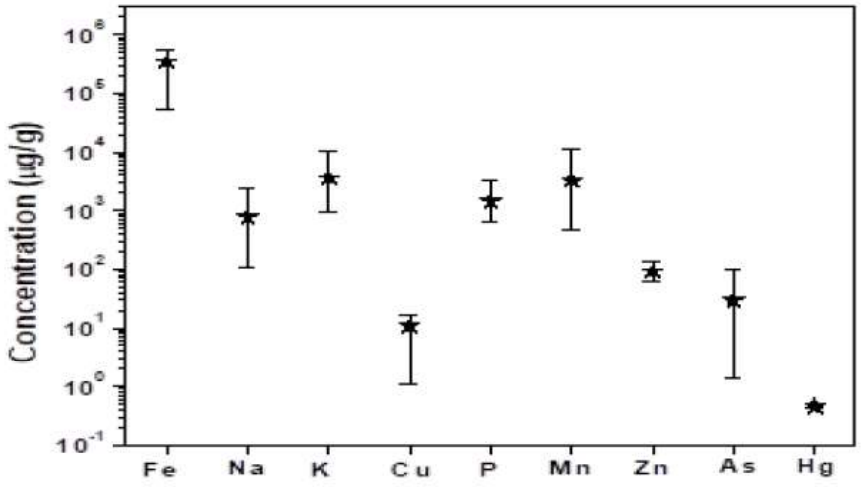

Fig. 2 Range and Mean Elemental Contents in Fe based *bhasmas* (n=4)

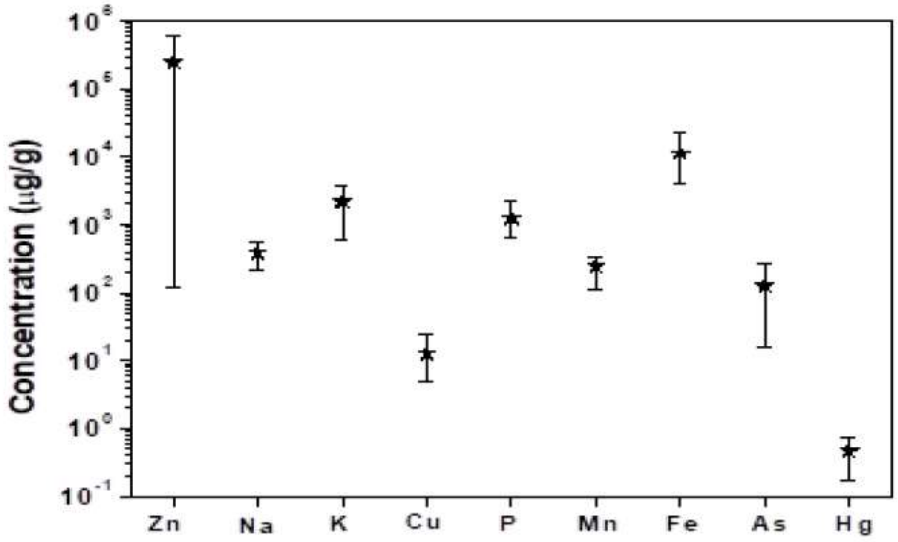

Fig. 3 Range and Mean Elemental Contents in Zn based *bhasmas* (n=3)

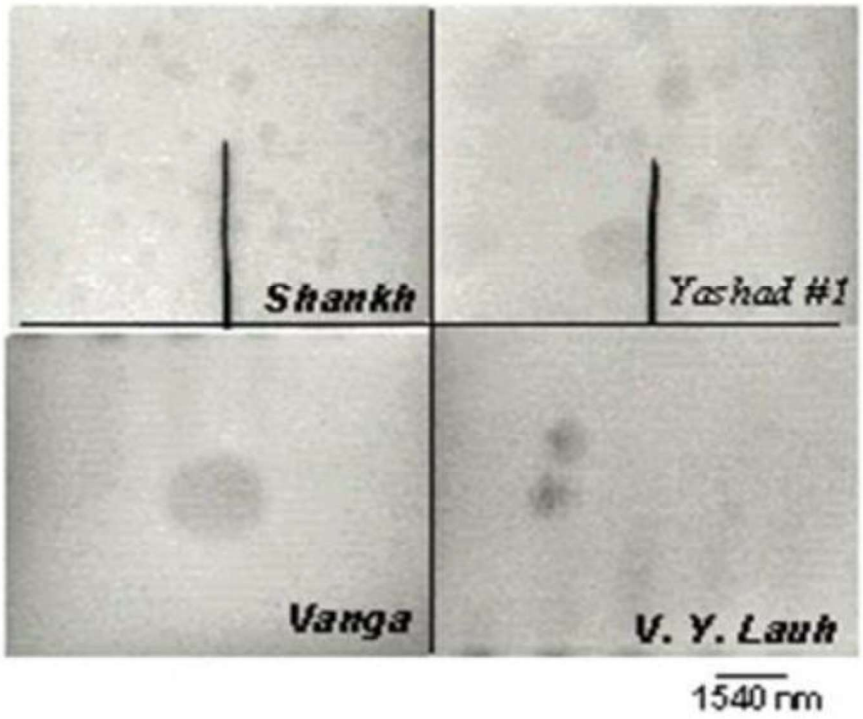

Fig 4 Transmission electron micrographs of some bhasmas; Shankh (Ca), Yashad (Zn), Vanga (Sn) and Lauh (Fe)

Table 1 Metal *Bhasmas*, their ingredients and uses.

Bhasma (Metal)	Ingredient/ Description	Uses
CALCIUM (Ca) BASED		
1. Mukta Moti	*Pearls and Ghee (milk preparation)*	Cough, impotency, eye disorders, tuberculosis, sprue, nervine sedative, used in hyperacidity, asthma, cough and nervous excitement in growing children and pregnant women.
2. Mukta Shukti	Pearls and Rose water	Respiration, cough, heart diseases, stomach, liver, intestine
3. Praval Pishti	Pearls	Antacid, used in cough, phthisis, scrofulous, affections, spermatorrhoes, pulmonary hemorrhage and calcium deficiency.
4. Shankh	Conch shell	Antiperodic, carminative and analgesic, used in colic flatulence and tympanites.
IRON (Fe) BASED		
5. Vanaspati Yog Lauh	Magnetic iron (purified)	Sprue, stomach disorders, anaemia, diabetes, blood disorders, restorative, haematinic, astringent, jaundice, disorders of liver and spleen
6. Kant Lauh	Magnetic iron (purified), Ash of incinerated magnetic iron	Ant rheumatic, haematinic and used in anaemia
7. Mandoor	Ash of incinerated purified ferric oxide	Alterative, haematinic, diuretic, used in anaemia, oedema, chlorosis, rickets and jaundice.
8. Trifala Yog Lauh	Ferrum (purified), incinerated and potentiated, rubbed with Trifala decoction	Strengthening the body, deficiency of iron, anaemia, indigestion
ZINC (Zn) BASED		
9. Yashad	Zinc/ Shudh Yashad	Dysentery, sweating, phthisis, tuberculosis, diabetes, hypoglycemic, astringent, used in urinary disorders
10. Baidyanath Deshrakshak Kharpar	Zinc carbonate/ash of incinerated purified zinc carbonate	Antacid, Bone strengthening,
MERCURY (Hg) BASED		
11. Sidhmakardhwaja	Mercury	Physical disorders, strengthening the body, fever, malaria, asthma
12. Parad	Mercury	Syphilis, genital disorders, rejuvenation
SIVER (Ag) BASED 13.Rajat	Silver	Wasting, nerve disorders, brain functions, eye disorders, tuberculosis
ARSENIC (As) BASED 14.Khushta **khas**	Arsenic	Nervine tonic, Asthma, leucoderma, paralysis and impotency
COPPER (Cu) BASED 15. Tamra	Ash of incinerated purified copper	Acidity, ascites, jaundice, piles, leprosy, leucoderma, asthma, tuberculosis, cough, skin diseases, obesity, chronic bloating, spleen and liver enlargement, cirrhosis.
TIN (Sn) BASED 16.Vanga	Tin	Asthma, cough, sweating, blood disorders, diabetes, diuretic and urinary antiseptic, semen disorder, syphilis and gonorrhea

.Table 2. Elemental concentrations in calcium (4) iron (4) and tin based *bhasmas*

Element	Calcium				Iron				Tin
	Mukta Moti	Mukta Shukti	Vanga	Shankh	Vanasp-ati Yog Lauh	Kant Lauh	Triphala yog Lauh	Mandoor	Vanga
Al (mg/g)	0.13±0.01	0.70±0.03	1.62±0.15	0.30±0.04	2.44±0.05	2.50±0.27	3.52±0.04	ND	0.13±0.01
As (μg/g)	1.29±0.18	0.82±0.04	3.61±0.03	3.67±0.40	1.39±0.15	10.6±1.0	97.3±16.8	9.59±1.0	24.1±6.4
Ca (mg/g)	31.0±2.6 %	33.6±2.4 %	29.5±2.0 %	41.9±4.0 %	ND	2.37±0.25	ND	ND	73.5±2.9
Cl (mg/g)	2.66±0.35	0.40±0.06	2.08±0.30	2.27±0.18	ND	0.24±0.03	0.22±0.03	0.21±0.03	0.24±0.03
Co (ng/g)	123±12	27±2	147±15	910±100	416±40	340±25	610±45	510±40	880±40
Cu (μg/g)	ND	ND	1.52±0.15	ND	1.08±0.12	15.0±0.3	16.9±0.5	ND	ND
Fe (mg/g)	ND	1.28±0.12	2.83±0.19	ND	56.9±5.6%	42.9±0.5%	5.31±0.53%	35.1±5.4%	1.34±0.06
Hg (μg/g)	19.0±2.0	4.75±0.55	627±20	14.3±1.2	ND	0.49±0.04	0.42±0.03	0.45±0.04	0.97±0.08
K (mg/g)	0.22±0.02	0.59±0.01	1.26±0.07	0.35±0.01	1.83±0.07	1.18±0.11	0.93±0.04	10.3±1.6	0.26±0.03
Mg(mg/g)	3.45±0.29	ND	22.1±4.3	2.73±0.21	ND	1.26±0.11	0.96±0.05	ND	ND
Mn (μg/g)	28.0±0.6	445±35	49.4±3.8	9.35±1.25	596±47	467±25	465±30	11.4±0.4*	257±25
Na(mg/g)	3.80±0.39	3.13±0.29	5.91±0.51	3.11±0.03	0.41±0.04	0.11±0.01	0.21±0.02	2.33±0.11	0.47±0.01
P (mg/g)	0.96±0.03	0.29±0.01	0.77±0.02	0.38±0.01	0.62±0.02	0.96±0.01	0.86±0.04	3.26±0.04	0.72±0.01
Zn (μg/g)	176±20	ND	125±10	ND	ND	61.2±4.5	79.9±1.0	135±24	67.0±4.9
C (%)	11.8	12.1	11.9	15.1	1.22	0.11	0.12	0.07	4.15
H (%)	0.364	0.245	0.299	0.81	0.01	0.04	0.02	0.01	0.64
S (%)	0.39	0.12	0.38	0.81	0.12	0.05	0.03	0.16	0.152

ND = Not detected, * = Concentration in mg/g, In Vanga bhasma, Sn and In contents were found to be 43.8±2.4 % and 17.1±0.7 μg/g respectively

Table 3. Elemental concentrations in zinc (3), silver (1), arsenic (1), copper (1), and Mercury (3) based *bhasma*

	Zinc			Silver	Arsenic	Copper	Mercury		
Element	Yashad #1	Yashad #2	Kharphar	Rajat	Kushta Khas	Siddha Makardhwaja	Siddha Makardhwaja	Parad	Makaradhwaja
	Baidyanath	Deshrakshak							Gutika with Swarnakalp
Al (mg/g)	3.03±0.14	1.02±0.05	1.70±0.02	7.08±0.5	0.71±0.08	ND	ND	0.53±0.12	ND
As (μg/g)	15.3±1.4	89.6±13.5	269±30	142±19*	3.65±0.6%	19.7±1.0	ND	ND	0.40±0.01
Ca (mg/g)	ND	193±5.5	239±20	ND	301±2	ND	ND	247±5	ND
Cl (mg/g)	ND	0.21±0.03	0.59±0.15	ND	0.20±0.02	ND	ND	ND	ND
Co (ng/g)	188±10	205±20	310±25	387±24	ND	810±55	ND	ND	30.5± 1..2
Cu (μg/g)	5.05±0.8	9.03±0.78	23.7±1.8	ND	ND	44.1±3.0%	ND	ND	17.9 ± 1..3
Fe (mg/g)	22.8±2.4	3.87±0.24	7.14±0.45	ND	ND	71.2±3.1	ND	ND	6.68± 0.30
Hg (μg/g)	ND	0.75±0.03	0.17±0.01	ND	ND	0.23±0.01	85.3±7.0%	0.018±0.002%	168±11
K (mg/g)	0.59±0.02	2.22±0.16	3.59±0.09	ND	2.42±0.05	23.7±2.0	ND	ND	4.47± 0.12
Mg(mg/g)	ND	67.2±5.6	ND	ND	ND	ND	ND	65.8±7.2	ND
Mn (μg/g)	116±13	334±13	288±12	183±18	84.0±1.0	134±12	ND	252±23	ND
Na (mg/g)	0.21±0.02	0.57±0.02	0.37±0.08	12.8±0.1	0.83±0.08	0.25±0.01	ND	ND	3.15±0.17
P (mg/g)	2.19±0.06	0.92±0.04	0.65±0.03	51.4±1.5	1.06±0.04	10.9±0.2	ND	0.97±0.04	ND
Zn (μg/g)	60.0±7.0%	13.4±2.4%	0.01%	ND	ND	358±26	ND	ND	86.4±2.2
C (%)	0.087	7.13	8.37	0.631	0.242	0.088	0.064	13.4	ND
H (%)	0.039	0.424	0.214	0.252	0.049	0.511	0.034	0.03	ND
S (%)	0.436	0.257	0.383	19.9	21.1	22	14.2	0.04	ND

ND = Not detected, In Rajat *Bhasma* Ag was found to be 23.4 ± 2.5 %, * concentration in mg/g

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REFERENCES

1. B. Prakash, Indian J. History Sci., 32, 1, 1997.
2. S. S. Savrikar, Proc. Seminar on Metals in Medicine*;* Ayurvedic and Modern View, Parbhani (India), pp. 16, 2004.
3. N. G. Patel, Ayurveda: The Traditional Medicine of India in *Folk Medicine; The Art and the Science*, Steiner, R. P. (Ed.), American Chemical Society, Washington, DC, pp. 41, 1986

4. R. E. Suoboda, *Prakriti;* Your Ayurvedic Constitution, 2nd Edn., Sadhana Publications, Bellingham, USA, pp. 169, 1998.
5. B. L. O'Dell, and R. A. Sunde, Handbook of Nutritionally Essential Mineral Elements, Marcell Dekker Inc., New York, pp.692, 1997.
6. A. S. Prasad, Essential and Toxic Elements in Human Health and Disease: An Update, Wiley-Liss, New York, pp.391, 1993.
7. R. B. Saper, N. K. Stefanos, P. Janet, M. J. Burns, D. M. Eisenberg, R. B.Davis, and .R. S. Phillips, J. Am. Med. Assoc., 292, 2868, 2004.
8. R. N. Chopra, S. Ghosh and A. T. Dutt, Indian J. Med. Res., 24, 517, 1936.
9. R. Dixit and G. C. Shivhare, J.Indian Chem. Soc., 65, 747, 1988.
10. S. M. Sondhi, V K Shama, R. P. Verma, Indian Drugs, 33, 67, 1996.
11. R. R. Garg, M. L. Garg , F. Hennrich, H. Himmsen, H. Mommsen, N. Singh, P. C. Mangal and P. N. Trehan, Indian J. Phys., 67B, 581, 1993.
12. T. K. Bhowmick, A. K. Suresh, S. G. Kane, A. C. Joshi, and J. R. Bellare, J Nanopart. Res., 11, 655, 2009.
13. S. Kantak, N. Rajurkar and P Adhyapak, J Ayurveda Integr. Med., 11, 236, 2020.
14. A. Ashwini and B. R. Kerur, Asian J. Pharm. Clin. Res. 12, 545, 2019.
15. A. Kumar, A. G. C. Nair A.G.C., A. V. R. Reddy and A. N. Garg, J. Radioanal. Nucl. Chem., 270, 173, 2006.
16. A. Kumar, A. G. C. Nair, A. V. R. Reddy and A. N. Garg, Biol. Trace Elem. Res., 109, 231,2006
17. A. J. Baxi, and S. A. Vasavada, Indian J. Pharmacy, 27, 227, 1965.
18. M. Kulkarni, J. M. Deopujari, and H. J. Purohit, India J. Exptl. Biol., 40, 831,2002.
19. S. Pandit, T. K. Biswas, P. K. Debnath, A. V. Saha, U. Chowdhury, B. P.Shaw, S. Sen, and B. Mukherjee, B., J. Ethnopharmacology, 65, 149,1999.
20. J P Jani, C. V. Raiyani, J. S. Mistry, and S. K. Kashyap, Hum Exp. Toxicol., 10, 347, 1991.
21. Khosa, R.L. and Dixit, S.N., J. Res. Indian Med., 6, 222, 1971.
22. Puri, R.N., Thakur, V. and Neema, H.V., Indian J. Ophthalmology, 31 Suppl., 816, 1983.
23. Merian, E., Metals and their Compounds in the Environment; Occurrence, Analysis and Biological Relevance, VCH, Weinheim pp.1438, 1991.
24. Mercury-Environmental Aspects, Environmental Health Criteria 86, World Health Organization, Geneva, pp.115, 1989.

25. Vohora, S.B., Kim, H.S., Shah, S. A., Khanna T. and Dandiya, P.C., CNS and Adaptogenic effects of *Siddh Makaradhwaja*: An Ayurvedic Mercury Preparation, in *Trace and toxic Elements in Nutrition and Health*, Abdulla, M., Vohora, S.B. and Athar, M. (Eds.) Wiley Eastern Ltd. New Delhi, pp. 73, 1993.
26. M. N. Pal, Role of mercury in Ayurvedic drugs in Proc. First Internat. Conf. Elements in Health and Disease, Eds., R. B. Arora, S. B. Vohora, and M. S. Y. Khan, WHO and Institute of History of Medicine and Medical Research, New Delhi, pp. 269, 1984.
27. A. Nadeem, T. Khanna, and S. B. Vohora, Indian J. Pharmacol. 31, 214, 1999.
28. Siddiqui, R. and Vohora, S. B., Indian Drugs, 37, 274, 2000.
29. S. D. Kahalekar, *Tamra bhasma* induces superoxide dismutase, Proc. Seminar Metals in Medicine; Ayurvedic and Modern View, Parbhani, pp. 65, Sept 2004.
30. R. N. Chopra, S. Ghosh and A. T. Dutt, Indian J Med. Res., 24, 257, 1936.
31. W. Paul and C. P. Sharma, Int. J Ayurvedic Res., 2, 14, 2011.
32. K. Chan, Chemospere, 52, 1361, 2003.
33. F.No.K-11020/5/97/DCC, Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and H omeopathy, Ministry of Health and Family Welfare, Govt. of India, 2005.
34. S. Nagarajan, S. Krishnaswamy, B. Pemiah, K. S. Rajan, U. Krishnan, and S. Sethuraman, Indian J. Pharm. Sci, 76, 38, 2014.
35. J. Liu, F. Zhang, R. Velagapudi, O. A. Olajide, C. Li, L-X Wei, Evidence Based Compl. Alt. Med. ID 1697804, 13 p, 2019