*Journal of Radioanalytical and Nuclear Chemistry, Vol. 270, No.1 (2006) 173–180*

# Availability of essential elements in bhasmas: Analysis of Ayurvedic metallic preparations by INAA

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(Received April 6, 2006)

Twenty bhasmas based on Ca, Fe, Zn, Hg, Ag, K, As, Cu, Sn and gemstones have been analyzed for main constituent elements along with minor (Na, K, Mg, Ca, P), trace (Cr, Mn, Fe, Co, Cu, Zn, Hg) and toxic elements by instrumental neutron activation analysis (INAA) including their C, H, N and S contents. Siddhamakaradhwaja, an Hg preparation and Swet parpati of K were found to be stoichiometrically HgS and $KNO_3$, respectively. K/P varies in a wide range of 0.23 to 12 though for most bhasmas ($n = 12$) it is in a close range of 2.3±1.2. Results for intercomparison studies of Marine Sediment IAEA-433 are included.

## Introduction

Ancient Indian traditional system of medicine called "Ayurveda" ("Ayus" means life and "Veda" means knowledge) is several thousand years old. It advocates the use of herbs and herbal preparations similar to other civilizations of the world. However, metallic preparations are unique in Ayurveda not known anywhere else in the world except the Unani system of medicine, which also recommends metallic-herbal preparations.[1] Bhasmas are intriguing formulations of metals such as Cu, Ag, Au, Fe, Zn, Hg, etc. where these are associated with organic macromolecules derived from the herbal extract making these biologically assimilable. These are prepared by repeated incineration of metals or their salts (preferably oxides) with medicinal herbs or their extracts and taken with honey, milk, butter or ghee (a milk preparation) so as to eliminate their harmful effects.[2–4] Several metals play a vital role in the biochemical processes.[5]

Ayurvedically prepared bhasma is considered to be more powerful than any other healing preparation.[1] It is believed that heavy toxic metals such as Hg and Pb used in traditional medicine system act as a catalyzer, which stimulate activity by their presence in the intestines without ever reaching the blood stream.[6] Being insoluble, bhasma particles are considered as tiny enough (like biologically produced nano-particles) to work into blood circulation and are likely to be biocompatible. Gold bhasma is shown to exist as nano-particles.[7] Also, Siddh Makaradhwaja is reported to initiate stimulant action of Hg ions in highly diluted state.[8]

Earlier, the quality of the herbal preparations was not subjected to review, but it was based on sacred trust between the physician and the patient.[6,9] With technological development the patients or the physicians seek assurance for the quality, safety and efficacy of any medicine, especially for export in the western market. Therefore, quality control for herbal preparations and bhasmas is essential as many of them contain As, Hg and Pb. Many workers have analyzed bhasmas for the characterization of the main constituent elements including trace elements.[10–13] CHOPRA et al.[10] reported first the analysis of indigenous bhasmas of Fe, Sn, Ca, Au and Ag. Recently, LALLA et al.[12] described preparation, characterization of Shankh bhasma and studied its antacid activity. GARG et al.[13] used PIXE for determining trace elements in several bhasmas. PANDIT et al.[14] used AAS for determining trace elements in Lauh bhasma and evaluated its pharmacological action. Such studies play vital role in providing scientific evidences to Ayurvedic physicians and R&D departments of pharmaceutical units to have better standardization and quality control.

In the present study we have employed instrumental neutron activation analysis (INAA) for determining 18 elements besides C, H, N and S in twenty bhasmas. The additional elements do not find any mention in Ayurvedic literature but seem to be useful for maintaining fluid balance and biochemical enzymatic processes.[15] This study points out the importance of quality assurance in Ayurvedic practice vis-à-vis the product utilization in the international market. Also there are presented results on the intercomparison study of the standard reference material (RM) Marine Sediment, IAEA-433.

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*0236–5731/USD 20.00*

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## Experimental

*Sample collection*

Twenty bhasmas in fine powder form were procured from M/s Dabur India Ltd. (Delhi), Baidyanath Ayurved Bhawan Ltd. (Jhansi), Deshrakshak Aushdhalya (Haridwar), Yogi Pharmacy (Haridwar) and local Ayurvedic physicians. Each bhasma has specific use depending on the method of preparation and the way it is prescribed by the physician. Three RMs Peach Leaves (SRM-1547) from the NIST (USA), Mixed Polish Herbs (MPH-2) from the INCT (Poland) and Cabbage (IAEA-331) from the IAEA (Vienna) including synthetic standards were used as comparators. Dr. S. J. DE MORA of Marine Environment Laboratory, Monaco sent 2 bottles of Marine Sediment (IAEA-433).

*Irradiation and counting*

30–50 mg each of samples and RMs were weighed accurately and packed in alkathene/aluminum foil (Supra pure) for short (5 minutes) and long (7 hours) irradiation, respectively, in APSARA reactor at a thermal flux of ~$6 \cdot 10^{11}$ $n \cdot cm^{-2} \cdot s^{-1}$ at the Bhabha Atomic Research Centre (BARC), Mumbai. Gamma-activity was assayed by high-resolution γ-ray spectrometry using a 40% relative efficiency HPGe detector coupled to 4k-analyzer at the reactor site. Long irradiated samples were brought to Roorkee and counted on HPGe detector in conjunction with 8k analyzer using Genie-2000 software (Canberra, USA). Elemental contents, calculated using different biological RMs as comparators were considered only if values for RMs matched well with the certified values. Phosphorus was determined as described earlier.[16] C, H, N and S were determined by using Elementar Vario-EL III (Germany) after calibration.

## Results and discussion

We have analysed 4 bhasmas each of Ca and Fe, 3 of Zn, 2 each of Hg and gemstones and one each of Ag, As, K, Cu and Sn. Since our values for RMs were in good agreement with the certified values and the standard deviations were small, high degree of accuracy and precision was achieved. Elemental concentrations with ±SD in different bhasmas are listed in Tables 1 and 2. A comparison of our data with the certified values for Marine Sediment (IAEA-433)[17] in Tables 1 and 2 shows that our values for Cr, Cs, Eu, Na, K, and Mn are in excellent agreement (<±5%). However, P data could not be compared but it is presumed to be of high order and could be adopted as a reference value. For other elements, agreement is within ±10% or better. Thus our data for bhasmas should also be reliable within ±5–10%.

*Calcium based bhasmas*

Calcium, a structural element, plays an important role in correcting bone metabolic disorder such as osteoporosis, a skeletal disease characterized by low bone mass, micro structural deterioration of bone tissue leading to enhanced bone fragility.[18] Antacid activity of calcium preparations and enhanced effectiveness of antibiotics have been studied.[19] Analytical studies of Ca based bhasmas derived from pearls/conch/coral have been of interest because of their extensive use as supplement.[11–14] MOTLAG and NATH[20] studied the metabolic role of Praval, Mukta and Shankh bhasmas compared with $CaCO_3$ and calcium lactate and correlated its intake with growth in weight in rats. The dosage prescribed is in the range 65–500 mg/d. Ca content in four bhasmas varies in a wide range (29.5–41.9%) with maximum amount in Shankh bhasma and so are other elements such as Na (3.11–5.91 mg/g), K (0.22–1.26 mg/g) and P (0.29–0.96 mg/g) including Co and Au in <1 μg/g. All the Ca based bhasmas also show C (11.8–15.1%), H (0.25–0.81%) and S (0.12–0.81%) suggesting the presence of carbonate and/or some organic compounds. It has been suggested that Ca supplementation given with hormone replacement therapy (HRT) has an additive effect in the prevention of postmenopausal bone loss.[21] Shankh bhasma is mainly magnesium silicate widely used in the treatment of ulcers, dysentery, dyspepsia and jaundice.[22] Mukta shukti is most enriched in Mn (445±35 μg/g) whereas Shankh has the highest Co (910 ng/g) and Praval Pishti has higher Na (5.91 mg/g) contents. K (1.26 mg/g), P (0.77 mg/g) and Mg (22.1 mg/g) contents. All the 4 bhasmas contain As and Hg in much higher amounts.

*Table 1.* Elemental concentrations in calcium (4), iron (4) and mercury (3) based bhasmas

| Element | Calcium | | | | Iron | | | | Mercury | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mukta Moti | Mukta Shukti | Praval Pishti | Shankh | Vanaspati Yog Lauh | Kant Lauh | Triphala yog Lauh | Mandoor | Siddha Makardhwaja | Parad |
| 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 | ND | 0.53 ± 0.12 |
| 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 | ND | ND |
| 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 | ND | 247 ± 5 |
| 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 | ND | ND |
| Co, ng/g | 123 ± 12 | 27 ± 2 | 147 ± 15 | 910 ± 100 | 416 ± 40 | 340 ± 25 | 610 ± 45 | 510 ± 40 | ND | ND |
| Cu, µg/g | ND | ND | 1.52 ± 0.15 | ND | 1.08 ± 0.12 | 15.0 ± 0.3 | 16.9 ± 0.5 | ND | 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%** | ND | ND |
| 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 | **85.3 ± 7.0%** | **0.018 ± 0.002%** |
| 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 | ND | ND |
| 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 | 65.8 ± 7.2 |
| 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*** | ND | 252 ± 23 |
| 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 | ND | ND |
| 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 | ND | 0.97 ± 0.04 |
| Zn, µg/g | 176 ± 20 | ND | 125 ± 10 | ND | ND | 61.2 ± 4.5 | 79.9 ± 1.0 | 135 ± 24 | ND | ND |
| C, % | 11.8 | 12.1 | 11.9 | 15.1 | 1.22 | 0.11 | 0.12 | 0.07 | 0.064 | 13.4 |
| H, % | 0.364 | 0.245 | 0.299 | 0.81 | 0.01 | 0.04 | 0.02 | 0.01 | 0.034 | 0.030 |
| N, % | ND | 0.005 | 0.04 | ND | ND | ND | ND | ND | ND | ND |
| S, % | 0.39 | 0.12 | 0.38 | 0.81 | 0.12 | 0.05 | 0.03 | 0.16 | 14.2 | 0.04 |
| Marine | As, µg/g | Br, µg/g | Ce, µg/g | Co, µg/g | Cr, µg/g | Cs, µg/g | Eu, µg/g | Fe, mg/g | K, mg/g | Mn, µg/g |
| Sediment | 19.8 ± 1.3 | 83.9 ± 8.8 | 71.5 ± 0.4 | 14.5 ± 0.7 | 137 ± 2 | 6.32 ± 0.65 | 1.24 ± 0.02 | 42.9 ± 1.5 | 16.4 ± 1.9 | 318 ± 18 |
| (IAEA-433) | (18.9 ± 1.8) | (67.0 ± 16.0) | [64.5 ± 2.8] | (12.9 ± 1.2) | (136 ± 10) | (6.40 ± 0.44) | [1.18 ± 0.07] | (40.8 ± 1.9) | (16.6 ± 3.2) | (316 ± 16) |

ND: Not detected.
In parentheses ( ) and brackets [ ] are the certified and information values, respectively.

*Table 2.* Elemental concentrations in zinc (3), silver (1), potassium (1), arsenic (1), copper (1), tin (1) and gemstone (2) based bhasmas

| Element | Zinc | | | Silver | Potassium | Arsenic | Copper | Tin | Gemstone | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yashad #1 Baidyanath | Yashad #2 Deshrakshak | Kharphar | Rajat | Shwet Parpati | Kushta Khas | Tamra | Vanga | Jahar Mohra Khatai | Vaikrant Mani |
| Al, mg/g | 3.03 ± 0.14 | 1.02 ± 0.05 | 1.70 ± 0.02 | 7.08 ± 0.5 | 0.02 ± 0.01 | 0.71 ± 0.08 | ND | 0.13 ± 0.01 | 3.17 ± 0.04 | 0.79 ± 0.01 |
| As, µg/g | 15.3 ± 1.4 | 89.6 ± 13.5 | 269 ± 30 | 142 ± 19* | ND | **3.65 ± 0.6%** | 19.7 ± 1.0 | 24.1 ± 6.4 | 53.9 ± 5.5 | 231 ± 44 |
| Ca, mg/g | ND | 193 ± 5.5 | 239 ± 20 | ND | ND | 301 ± 2 | ND | 73.5 ± 2.9 | ND | 15.8 ± 1.3 |
| Cl, mg/g | ND | 0.21 ± 0.03 | 0.59 ± 0.15 | ND | 4.09 ± 0.66 | 0.20 ± 0.02 | ND | 0.24 ± 0.03 | 0.45 ± 0.01 | 0.13 ± 0.01 |
| Co, ng/g | 188 ± 10 | 205 ± 20 | 310 ± 25 | 387 ± 24 | ND | ND | 810 ± 55 | 880 ± 40 | 335 ± 25 | 285 ± 10 |
| Cu, µg/g | 5.05 ± 0.8 | 9.03 ± 0.78 | 23.7 ± 1.8 | ND | 12.3 ± 0.9 | ND | **44.1 ± 3.0%** | ND | 10.6 ± 0.3 | 21.5 ± 0.6 |
| Fe, mg/g | 22.8 ± 2.4 | 3.87 ± 0.24 | 7.14 ± 0.45 | ND | ND | ND | 71.2 ± 3.1 | 1.34 ± 0.06 | 32.6 ± 0.2 | 2.95 ± 0.18 |
| Hg, µg/g | ND | 0.75 ± 0.03 | 0.17 ± 0.01 | ND | 0.07 ± 0.01 | ND | 0.23 ± 0.01 | 0.97 ± 0.08 | 1.01 ± 0.50 | 0.18 ± 0.02 |
| K, mg/g | 0.59 ± 0.02 | 2.22 ± 0.16 | 3.59 ± 0.09 | ND | **39.3 ± 3.5%** | 2.42 ± 0.05 | 23.7 ± 2.0 | 0.26 ± 0.03 | 0.33 ± 0.02 | 8.79 ± 0.82 |
| Mg, mg/g | ND | 67.2 ± 5.6 | ND | ND | ND | ND | ND | ND | 3.25 ± 0.24 | 1.06 ± 0.09 |
| Mn, µg/g | 116 ± 13 | 334 ± 13 | 288 ± 12 | 183 ± 18 | 2.70 ± 0.01 | 84.0 ± 1.0 | 134 ± 12 | 257 ± 25 | 319 ± 33 | 89.2 ± 6.7 |
| Na, mg/g | 0.21 ± 0.02 | 0.57 ± 0.02 | 0.37 ± 0.08 | 12.8 ± 0.1 | 0.08 ± 0.01 | 0.83 ± 0.08 | 0.25 ± 0.01 | 0.47 ± 0.01 | 0.36 ± 0.02 | 3.75 ± 0.42 |
| P, mg/g | 2.19 ± 0.06 | 0.92 ± 0.04 | 0.65 ± 0.03 | 51.4 ± 1.5 | 0.09 ± 0.01 | 1.06 ± 0.04 | 10.9 ± 0.2 | 0.72 ± 0.01 | 0.21 ± 0.01 | 0.73 ± 0.03 |
| Zn, µg/g | **60.0 ± 7.0%** | **13.4 ± 2.4%** | **0.012%** | ND | 54.3 ± 4.0 | ND | 358 ± 26 | 67.0 ± 4.9 | 308 ± 4 | 94.8 ± 1.2 |
| C, % | 0.087 | 7.13 | 8.37 | 0.631 | 0.022 | 0.242 | 0.088 | 4.15 | 0.676 | 0.060 |
| H, % | 0.039 | 0.424 | 0.214 | 0.252 | 0.034 | 0.049 | 0.511 | 0.640 | 1.30 | 0.027 |
| N, % | ND | 0.027 | ND | ND | 13.7 | ND | ND | ND | ND | ND |
| S, % | 0.436 | 0.257 | 0.383 | 19.9 | ND | 21.1 | 22.0 | 0.152 | 0.561 | 0.132 |
| Marine | Na, mg/g | P, mg/g | Rb, µg/g | Sb, µg/g | Sc, µg/g | Sr, µg/g | Tb, µg/g | Th, µg/g | Ba, µg/g | La, µg/g |
| Sediment | 13.0 ± 1.1 | 1.22 ± 0.09 | 120 ± 1.5 | 2.15 ± 0.09 | 15.8 ± 0.8 | 320 ± 24 | 0.71 ± 0.06 | 10.4 ± 0.57 | 313 ± 5 | 36.9 ± 0.4 |
| (IAEA-433) | [13.5 ± 1.5] | {-} | (99.9 ± 14.2) | (1.96 ± 0.18) | [14.6 ± 1.1] | (302 ± 20) | [0.70 ± 0.09] | (9.78 ± 0.57) | (268 ± 32) | (33.7 ± 2.7) |

ND: Not detected. In Vanga bhasma, Sn and In contents were found to be 43.8±2.4% and 17.1±0.7 µg/g, respectively.
* In Rajat Bhasma. Ag was found to be 23.4±2.5%.
In parentheses ( ) and brackets [ ] are the certified and information values, respectively, and for {–} no data are available.

*Iron based bhasma*

Iron nourishes blood, enhances vigour and its astringency prevents blood from becoming too hot or too fluid. It is an essential element, a part of hemoglobin playing an important role in oxygen transport.[5] Out of four bhasmas analyzed in this study, Fe content varies in a wide range, from 5.31% (Trifalayog Lauh) to 56.9% (Vanaspatiyog Lauh). Na, K, Mn and P were minor constituents besides traces of As, Co, Cu and Zn. Lauh bhasma (calxes of Fe) is used in anaemia similar to iron tablets/capsules/syrup prescribed as iron supplementation in allopathy. These bhasmas are prepared from purified iron filings/ferric oxide or magnetic iron incinerated with decoction of Trifala, Ghritkumari ras, vinegar and sesame oil. KANASE et al.[23] studied curative effects of Mandoor bhasma on liver and kidney of albino rats and noticed total recovery in two weeks. Our studies have shown Mn, P and K in mg/g amounts and traces of As, Co, Cu, Zn, and Hg, all derived from herbs. Iron bhasmas are prescribed in the dosage of 125–750 mg/d and taken along with honey. Vanaspatiyog Lauh bhasma contains the highest amount of Fe (56.9%) along with Al, K, Mn, Na, and V at minor or trace level. Though Trifalayog Lauh, contains the least amount of Fe (5.31%) but it is more potent because of fine particles of iron by C from Trifala extract.[1] It is also found to contain Mg, K, P, Al in mg/g amounts besides As, Cu, Mn and Zn in traces. Though Lauh bhasma has a bit higher C (1.22%) content but other three bhasmas contain only ~0.1% C and all the four contain very little amounts of S (<0.2%) and H (<0.04%). JANI et al.[24] have detected ppm level polycyclic aromatic hydrocarbons (PAH) in Ayurvedic medicinal preparations.

*Zinc based bhasmas*

Zinc plays a vital role as a constituent of many enzymes in the human body. More than hundred zinc metalloenzymes are needed in almost all stages of nucleic acid and protein synthesis.[5] Total dietary Zn intake is 10–15 mg/d, which comes through diet. Out of three zinc based bhasmas analyzed here Yashad #1 and #2, procured from Baidyanath and Deshrakshak Aushdhalaya, contained 60.0 and 13.4% Zn, respectively, whereas Kharpar contained 123 µg/g Zn only. All three Zn based bhasmas contain K, P and Fe in mg/g amounts whereas As, Al, Mn and Cu were found at µg/g level. Though Yashad # 1 contained significant amounts of Al (0.30%), Fe (2.28%) and P (0.22%) but no Ca whereas # 2 showed Mg (6.7%), Ca (19.3%), K (0.22%) and Mn (0.03%). Kharpar is primarily $ZnCO_3$[28] though it also contains Ca (23.9%) and C (8.4%) suggesting $CaCO_3$. Zinc salts help in eye disease, diabetes, and skin disease, fever, as memory enhancer, chronic pyrexia, cough, boils, and urinary tract infections.[25] KHOSA and DIXIT[26] have shown Yashad bhasma to increase virility and intelligence.

*Mercury based bhasmas*

Mercury is primarily an environmental contaminant and industrial hazard known for its toxicity causing Minimata disease.[5] It is said to be highly toxic though in Ayurveda it is considered a marvel drug as a nervine tonic and for restoring normalcy to collapsing patients.[27] SUBRAMANIAN et al.[28] used $^{203}Hg$ tracer to study the pharmaco-kinetics and bio-distribution of Kajali but did not observe any ill effects including brain in Wistar rats. According to Ayurveda, its toxic effects are neutralized in presence of sulfur.[9] VOHORA et al.[8] studied its CNS and adaptogenic effects and found it to be growth promoting, rejuvenating and facilitating learning process in small doses of 15 mg/kg. Makaradhwaja, the most renowned of all mercury preparations, acts as a rejuvenator. Our sample of Siddha Makaradhwaja from Baidyanath, contained 85.3% Hg and 14.2% S totaling to 99.5% corresponding to perfect stoichiometry of HgS with negligible amounts of C and H. Not even traces of gold could be detected as reported.[4,29] Parad, another Hg based bhasma procured from a local physician showed only 0.02% Hg and 0.04% S with high amounts of Ca (24.7%) and Mg (6.58%) besides trace amounts of Mn, Al and P.

*Gemstone based bhasmas*

Gemstones have long been used in Ayurveda since alchemy days. Most minerals require 5, 7 or 11 incinerations for purification called shodhan. We analyzed Vaikrant and Jahar Mohara Khatai Pishti, which are tourmaline (black stone with hexagonal crystal) and serpentine orephite based respectively (procured from Deshrakshak). These contain many nutrient elements including K, Mg, P, Mn, Fe, Cu, and Zn. Vaikrant alleviates excess Vata-Pitta-Kapha, increases vitality and can be used as a substitute of diamond bhasma. Jahar Mohara is a mineral stone, supposedly magnesium silicate green in color.[25] It is commonly used to neutralize poisonous effects of snakebite causing vomiting and is also used for heart palpitation and depression.

*Other bhasmas*

Gold and silver utensils have long been used in India for storing water by the upper class society. Its tiny particles/thin foils are used for covering the eatables including sweets. NADEEM et al.[30] investigated silver preparations for analgesic activity, neuropsycho-behavioral effects and attributed its therapeutic ability in

CNS diseases including epilepsy. Rajat bhasma, based on Ag, acts on the brain and nervous system through nutritive mechanism. In lower doses it acts as anxiolytic but in higher doses (10–20 mg/kg) it reduces behavioral despair. Rajat bhasma contained 23.4% Ag besides As (14.2%), S (19.9%), P (5.14%) and Na (1.28%), with Mn (183 μg/g) and Au (140 ng/g) in traces suggesting the possibility of $Ag_2S$ or $As_2S_5$.

Though As is considered as the king of poisons, it is now known to be a possible essential element in Unani medicine with analgesic activity and proconvulsant effects.[31] As preparations have been shown to have no acute toxicity but a wide therapeutic index. As based Kushta khas shows 3.65% As along with major components of Ca (30.1%) and S (21.1%) besides mg/g amounts of Na, K, P, Cl and traces of Mn. Thus, As may be present as $As_2S_3$/$As_2S_5$ besides some organic impurities. Cu is an integral part of several enzymes and influences the immune system. Its vessels are considered as auspicious in Indian household and water boiled in these vessels is prescribed for many ailments.[4] It is reported to act as antioxidant and plays role in scavenging superoxides.[32] Its role is known in lipid peroxidation with no detectable adverse effects. Tamra bhasma contained 44.1% Cu besides Fe (7.12%), P (1.09%), K (2.37%) and As (~20), Mn (134) and Zn (358) in μg/g amounts. It is useful in jaundice, piles, leprosy, leukoderma, asthma, tuberculosis, sluggish and fatty liver, and skin disease.[25]

Vanga bhasma prepared by incineration of Sn in an iron pot till red hot and mixed with Aparmaga (*Achyranthes aspera*) and Ghritkumari (*Aloe barbadensis*)[30] contained 43.8% Sn besides Ca (7.35%), Fe (0.3%) and K (0.88%) and trace amounts of P, Mn, Zn including In, a rare element present in stannite. It also contained C (4.2%), H (0.64%) and S (0.15%) suggesting the presence of some organo-sulfur compounds, which may remain chelated. It is recommended in diabetes, semen disorder, impotency, skin disease, syphilis and gonorrhea[25] and also prescribed for asthma, cough and blood disorders.[2] Potassium based Swet parpati, commonly known as Kalami Sora, is prepared by melting in an earthen pot and then in a ceramic pot till flakes are formed. It contained 39.3% K and 13.7% N corresponding to the stoichiometry of $KNO_3$ (>99%). Besides, some KCl may also be present in ~1% amount. Also μg/g amounts of Na (80), P (90), Cu (12.3), Mn (2.7) and Zn (54.3) were observed. Its powder with cold water/coconut water is recommended for urinary tract infection, enlargement of prostate gland and acidity.[25]

Most bhasmas are mixed with cardamom, cinnamon, ghee and honey and taken orally in small doses. In clinical practice as reported in old scriptures, bhasma is not reported to have any serious untoward effects.[1] Honey is considered as highly nutritious with elements such as Li. Na, K, Rb, Mg, Fe, Mn, Cu and Zn.[33]

Our compositional data have shown the need for strict quality control to provide quality Indian Ayurvedic preparations manufactured by pharmaceutical companies, which need to have R&D laboratory with modern instrumentation. Use of metals in medicine is often associated with toxicity.[34] Studies have shown these to be non-toxic and exhibiting free radical scavenging activity due to their antioxidant property.[2,4] The bhasmas are associated with organic macro-molecules, show increased superoxide dismutase and catalase activity, which reduce free radical concentration.

### *Inter-elemental correlations*

Despite the fact that all the bhasmas have one constituent as a primary metal, some interesting inter-elemental correlations have been observed. The most important of these is the K/P ratio in all the bhasmas, which varies in a wide range of 0.23 (Mukta moti) to 12 (Vaikrant). For a majority of bhasmas ($n = 9$), it is in a close range of 0.9–2.4 with only two bhasmas (Kharpar and Vaikrant*)* showing K/P>5.5. In our extensive study of K/P ratio in various medicinal herbs, least ratio (~2) is observed in bhasmas (Fig. 1). However, order of magnitude in bark, fruits and roots remains the same (~12) but becomes <10 for leaves and seeds. Four Ca-based bhasmas show the lowest K/Na≤0.2 whereas for Tamra bhasma it is the highest (95). For most other bhasmas, K/Na ($n = 9$) is in a small range of 2 to 10. Further, Fe/Mn ratio in 9 non-iron containing bhasmas lies in a large range of 2.9 to 530, but it is linearly correlated ($r = 0.96$) with Fe content.[34] Since all these elements have been derived from the herbs, inter-element correlations seem to be real.

Metallic herbal preparations offer advantages over plant drugs by virtue of their stability over a period, lower dosage, easy storability and sustained availability. The bhasmas need to be thoroughly investigated with regard to its elemental contents, speciation and organic constituents including clinical studies so as to develop understanding about their therapeutic effects.

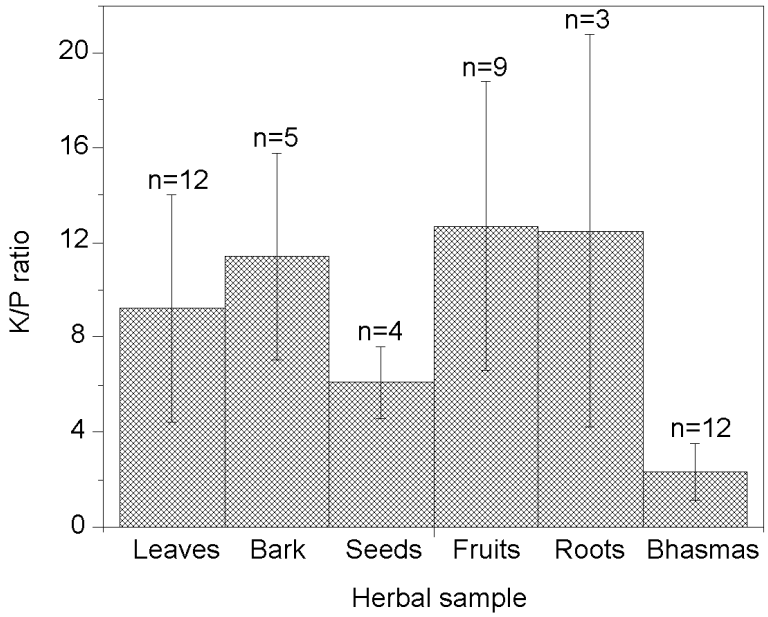


*Fig. 1.* Correlation of K/P ratio with various plant parts used as medicinal herbs where the bars represent standard deviation

*

Grateful thanks are due to Board of Research in Nuclear Sciences (BRNS), Government of India for financial assistance under Grant No. 2000/37/5/BRNS. Sincere thanks are due to Dr. R. MAHATYAGI (Australia) for providing authentic samples and useful discussions. Thanks are due to Drs. J. Y. DEOPUJARI (Nagpur) and R. BELGE (Nashik) for providing authentic literature.

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