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An Analytical Discussion Of Bhasma And Comparative Studies Of Abhrak Bhasma And Amruthballi Powder.

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Abstract
Abhraka Bhasma is a unique and important Bhasma preparation used in Ayurveda therapeutics. There has been a constant surge in the demand for the traditional medicine such as ayurvedic preparations. Abhrak bhasma is a type of ayurvedic preparation prepared from repeated incineration of mica mineral with decoction of various medicinal herbs. Traditionally, it has been used in the treatment of asthma, bronchitis, bleeding disorders, cough, cold, urinary disorders, diabetes, anemia, skin diseases, splenic disorders etc. It has also been considered to have anti-aging as well as anti-infertility properties and therefore used in various rejuvenating preparations. Despite their wide range of applications, these products are rarely validated at par with the modern medicines. There is also a paucity of literature that describes mode of action of these products at physiological and molecular level. In the current study, an attempt has been made to analyze the chemical modifications. With the help of analytical study, presence of elements, compounds, organic and inorganic matter in the Abhrak bhasma can be confirmed. Traditionally Abhrak Bhasma is tested on the basis of organoleptic characteristics and classical Bhasma pariksha. Now a days modern analytical parameters are practiced to characterize Abhrak Bhasma in order to get safety data which can be accepted universally. The analytical study of Abhraka Bhasma was done with classical Bhasma pariksha such as Varitartwa, Rekhapurna, Nishchandratwa etc whereas modern analytical parameters such as XRD, XRF, EDS, SEM, TEM, TGA, UV-Vis-IR, FTIR, DLS and BET were done. These studies confirm physical and chemical characteristics of Abhrak Bhasma by means of its various stages, chemical composition, presence of trace elements and functional groups, particle size reduction especially in Shataputi and Sahastraputi Abhrak Bhasma. This modern sophisticated study also supports classical parameters of Bhasma pariksha which are gold standard in Rasashashtra. So this technique needs to be followed along with classical parameters at various stages of Bhasma preparation. This will help to get more analytical data of Abhrak Bhasma.

Key Words: *Abhrak Bhasma, Shataputi, Sahastraputi, XRD*

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I. Introduction

Ayurveda is the great knowledge in which the holistic ancient Indian system of medicines is recited. Ayurvedic medicines are prepared from plants, animals and metals/minerals origin(1). Rasashastra is a branch of Ayurveda in which detailed knowledge of metals and minerals have been explained. However, due to requirement of higher dosage, non-palatability and less shelf-life, the herbal medicines have their own limitations. To overcome this, *Bhasmas* are the best alternatives as they can be prepared from the natural minerals and metals along with herbs by the process of Bhasmikarana in which toxic compounds are converted into nontoxic and bio-acceptable form. Moreover, they can be easily acceptable, palatable, fast acting and effective in small dosages and have long shelf life without losing their potency(2). *Abhrak Bhasma* is an excellent cellular regenerator and nerve tonic. It is indicated in various chronic diseases such as tuberculosis, COPD and many types of cardiac diseases(3). With the help of analytical study, presence of elements, compounds, organic and inorganic matter in the formulations can be confirmed. Analysis of Abhraka bhasma makes to find easier to understand physicochemical changes occurred after repeated incinerations in the compound. Different steps present in the preparation of Bhasma with the help of analytical study, its formation and breaking of chemical bond, compound, and elements are clearly visualized. Although classical Bhasma pariksha are well defined for the quality control of Abhrak Bhasma, still there needs the modern analytical techniques to ensure the quality of Bhasma so that its toxicity and safety can be ruled out. Hence in the present study, classical and modern analytical techniques have been explored and its importance is been highlighted. In this paper, various modern analytical techniques such as XRD, XRF, EDS, SEM, TEM, TGA, UV-Vis-IR, FTIR, DLS, and BET are discussed.

II. Aim And Objectives

The analytical studies of XRF of Abhraka Bhasma are discussed.

III. Classical Analytical Methods Of Abhraka Bhasma

Sr. No	Organoleptic characteristics	Characteristic
1	Color (Rupa)	Sindurbha
2	Odor (Gandha)	Odorless
3	Taste (Rasa)	Tasteless (Niswadu)
4	Sound (Shabda)	
5	Sparsha (Touch)	Soft smooth powdered form.

Ayurvedic Parameters for Abhraka Bhasma pariksha

The Abhraka Bhasma should be subjected to certain tests in order to assess the standard character as per textual references. If the Bhasma are prepared with different media and different bhavana dravya the characteristic features for Bhasma Pariksha will be the same but the color & therapeutic properties will be different.

The following tests should be performed for Bhasma Pariksha (5)

According to Rasendra Chudamani and Rasa Prakash Sudhakar, Abhraka Bhasma should have the following signs:

1.Nischandratva (Lusterless)

There should be no shining in the Abhraka Bhasma, if shining is present then Marana process should be continued till Nischandratva is chieved. This is the most important sign of Mritabhraka.

2. Sindurabh Varnata (Redness)

This is an important sign of Abhraka Bhasma which indicates its color i.e. the Abhraka Bhasma should have red or brick color. This is probably the result of a chemical change which takes place during process (i.e. Oxidation) and formation of compound.

3. Susukshmatwa (Fineness)

This is third important sign which indicates fineness of the particles. Due to the process of levigation & incineration the surface area of Abhrak increases and particle size reduces with the increase of puta till to very fine state. This is important from the point of view of its absorption & assimilation in the body. Ancient *Acharyas* had developed a few tests to measure the fineness of *Bhasma* which are as follows.

i. Varitartva (Floating on water)

According to Rasa Prakash Sudhakar the term "Jalaplava" is also used for this. In this test a perfectly prepared Bhasma powder when sprinkled in a beaker full of water floats upon the surface i.e. the particles are so fine that the surface tension of water cannot be broken with the pressure of their fall.

ii. Lochanjana Sannibhavatva (Collyrium like) (6)

This is another test for measuring the fineness. In this test the few particles of the Bhasma powder are applied to the eyelids just like Anjana. If the Marana is complete and the Bhasma is of good quality the person should not feel any irritation in the mucous membrane of eyelids. This shows that the particles of metal/mineral have attained the desired state of fineness otherwise the process should be continued till the lochanjana sannibhavatva attains & then the Marana process will be considered complete.

4. Unnama (7)

It is the reassessment test of the floating character of Bhasma. A grain should be carefully placed on the film formed on the Varitartwa tests in water to see whether the film can resist the weight of the grain. If the grain remains on the film and does not sink in water, the Bhasma can be considered as excellent.

5. Rekhapurnatva (8)

When a small quantity of Bhasma powder is picked up between the first finger and thumb and on rubbing Bhasma enters into the furrows of fingers it is said to be having Rekhapurnatva property.

6. Nirdhumatvam (9)

If sprinkling on red hot coal, it does not emit smoke, then it can be considered as excellent Bhasma. The emission of fumes indicates the presence of some inorganic substances in the Bhasma.

7. Apunarbhavatva (10)

This test is applicable to metallic Bhasma only. The Bhasma after mixing with Mitra-panchak is subjected to Puta. The intensity of temperature should be same in both i.e. incineration during Bhasma preparation and Bhasma pariksha process. Upon self cooling the product is to be observed for the presence of free metal in the Bhasma. If detected, the bhasma cannot be considered a proper preparation.

8. Niruttha (11)

This test is also meant for detection of the regaining characters of metallic Bhasma. Take a measured quantity of silver and mix it with Bhasma which is to be tested. It is heated in a crucible until the silver melts. After cooling, the silver is weighed. No gain or loss in weight indicates that the Bhasma cannot be converted back into its metallic form, thereby confirming the absence of free metal.

IV. Modern Analytical Methods Of Abhraka Bhasma

(1) XRD study: X-ray diffraction is useful for evaluating minerals, polymers, corrosion products, and unknown materials. Among the most common tests are the identification and quantification of the crystalline phases, determination of the percent crystallinity, and analysis of the crystal structure. A Research on XRD of Abhrak Bhasma with 35 & 37 Puta was observed major diffraction peak which decreases with the process of Shodhan, Dhanya Abhraka Nirmana and Marana. After Amritikarana, there is a slight increase in the crystallite size again to formation of complex with organic moieties from cow ghee(12). In another study of XRD, there is presence FeSO4, Fe2O3 in Bhasma. Also presence of Iron as a major constituent were observed in Ashuddha Abhraka (19.55%),Shuddha Abhraka(17.31%),Abhraka Bhasma (21.16%) (13). XRD analysis on Shatputi Abhraka bhasma observed new structure and molecules as the number of puta increases. Also XRD after Amrutikarana revealed various forms of elements such Diopside, Sylvine, Magnetite, Forsterite & Cristobalite(14).Research on Krishna Vajra Abhrak in which Abhraka bhasma revealed the crystalline nature of Bhasma with mixture of various individual oxides. Intensity of the peaks becomes sharper in the successive phases from Shodhan to each stage of Maran (15).

(2) **SEM analysis**:

Scanning electron microscope (SEM) is one of the common methods for imaging the microstructure and morphology of the materials. In SEM, an electron beam with low energy is radiated to the material and scans the surface of the sample. A research study of Abhrak bhasma in which SEM study observed irregular shape of particle size whereas small particle sediments on larger particle. Particle size found to be from 1 to 200 micron(16). An another study of Abhrak bhasma of two different references by 35 puta and 37 puta were Scanning Electron Microscopy (SEM) study observed particle size was reduced and crystallite increase in Shuddha Abhraka & Dhanyabhraka. In Marana, fibrous structure disappeared & agglomerated clumps of finite particles seen whereas in Amrutikarana, particle shape changes and increased in size, edges were smooth. In method 1 square type particles while in method 2 spherical and rod like particles observed in Scanning Electron Microscopy (SEM) study(17). A Research on Krishna Vajra Abhrak, SEM study observed, square shaped particle size gradually reduces from 174 nm to 87.1 nm from Shuddha to bhasma stage(18).

(3) FEG-SEM (Field Emission Gun – Scanning Electron Microscope)

It b provides the very highest resolution imaging compared to regular SEM. It guarantees high brightness, crisp images and stable beam current. One Research study of Sahasraputi Abhraka bhasma (100 Putas)) FEG-SEM (Field Emission Gun, Scanning Electron Microscopy) , particle size noticed was unevenly arranged (heterogeneous) present between 29nm and 88nm and irregular shape ranging from spherical to obligated(19). Another research on Shatputi Abhraka bhasma FEG-SEM study shown that if the no. of puta increases, particle size decreases i.e. particle size after 20 puta was from 30 to 398nm, after 50 puta it was 30 to 85 nm and after 100 puta it reduces again to 24 to 50 nm(20).

(4) XRF (X-ray fluorescence) study

It is a non-destructive analytical technique used to determine the elemental composition of materials. A research on analytical evaluation of Abhrak Bhasma (Babita Bhatia & Purushottam G Kale, 2013) observed presence of elements in oxidized form in ED-XRF. The phase analysis revealed the presence of Fe (22%) as a major element and Ca, K and Si in low concentrations, their concentration being 11%, 8% and 13% separately. Mg (4%), Al (2%) and Ti (1%) were present as minor elements. No carbon present in it indicates the absence of any natural organic Matter (21).

(5) FTIR (**Fourier Transform Infrared) Study**

FTIR Spectroscopy, is an analytical technique used to identify organic, polymeric, and, in some cases, inorganic materials. A Research on Abhraka bhasma of 2 different methods after 35 and a 37 puta in which Fourier Transform Infrared (FTIR) study observed, various bonds of different functional groups indicate organo-metallic nature of sample shows O-H bond was prominent from Shodhana to Amrutikarana stages. In method 1 strongest sharp bond of O=C=O stretching bond was observed increasing from Shodhana to Marana whereas in method 2 decreasing from Shodhana to Marana. Si-O group sharp bond observed in both methods indicates elimination of Sulphur and Silicon(22). Wele et al (2020)done research on Synthesis & Characterization of Krishna Vajra Abhraka in which FTIR study revealed organic functional group such as hydroxyl group, carbonate group and presence of carbon indicating bio-inorganic nature of the Bhasma(23).

(6) **EDS or EDAX (Energy Dispersive X-Ray Analysis)**

It is used to determine which chemical elements are present in a sample, and can be used to estimate their relative abundance. EDS also helps to measure multi-layer coating thickness of metallic coatings and analysis of various alloys. A Research on Sahasraputi Abhraka Bhasma (100Puta) in which EDS study shown higher percentage elements such as O (41%), Si (16%), K (13%) and Fe (13%) and the minor elements presence i.e. Al (6%), Mg (5%), Ca (4%) and Cl (1%)(**24)** Another Research Study on Abhraka Bhasma by 2 different methods after 35 and a 37 Puta in which EDX study shown that after Shodhan Si, Al increases while Fe, Mg and C decreases whereas after Marana Fe, Mg increases, Si, C decreases and after Amrutikarana Si, Fe, C increases, Al, Mg decrease which indicates detoxification of Abhrak Bhasma. Also presence of carbon suggests formation of organometallic compound(25). Wele et al (2020) observed in EDAX study of Krishna Vajra Abhrak decrease tendency of harmful elements and increase useful elements such as Fe, Ca, and Na which highlights importance of Ayurvedic processing which is beneficial for its therapeutic use(26).

(7) TEM (Transmission electron microscopy)

It is an analytical technique used to visualize the smallest structures in matter. A Research Study on Abhraka bhasma of 2 different methods after 35 and a 37 puta. (Kantak et al, 2019) observed in TEM study the particles of different sizes and shapes ranging from 50 nm to 1 mm with change in the method of preparation. All the prepared products show agglomerated structures(27). In TEM study of Shatputi Abhraka bhasma, morphology of Abhraka bhasma were in Polygonal shape and the Particles were present in agglomerates shape and structure(28).

(8) BET (Brauner Emmet Teller)

It is mostly used for analyzing the fineness of cement and concrete, the adsorption capability of activated carbon, catalyst characterization, adsorption performance of gas purifiers, and for studying nanomaterials. Kantak et al (2019) observed in BET study high surface area of Bhasma along with higher porosity(29).

(9) DLS (Dynamic light scattering)

It is also known as photon correlation spectroscopy (PCS), is a very powerful tool for studying the diffusion behavior of macromolecules in solution. Kantak et al(2019) observed in DLS study bimodal distribution of particles of Abhrak Bhasma in Nano range(50-500 nm) in both Method 1 (50%) & Method 2 (90%)(30). A Research on Abhraka Krishna Vajra Abhraka: Synthesis & Characterisation by Wele et al (2020) observed in DLS study, 98 percent particles are unimodal distribution(31).

(10) TGA (Thermo gravimetric analysis)

TGA is useful in determining purity and composition of materials, drying and ignition temperatures of materials and knowing the stability temperatures of compounds. Kantak et al (2019) witnessed presence of weight loss (0.2-0.3) at~100oC in TGA study which was due to adsorbed moisture on the surface of Abhrak bhasma indicates presence of moisture and decomposition of organic moieties(32).Tamhankar et al(2020)

observed that when Bhasma heated gradually with rise in temperature indicates melting, decomposition, and recrystallization and observed new molecules formed with different molecular weights in TGA study (33).

(11) UV-Vis-IR (Ultraviolet-visible-infrared Spectroscopy)

UV-Vis and UV-Vis-NIR instruments measure the light absorbed, transmitted, or reflected by the sample across a certain wavelength range. Tamhankar et al(2020)(34) revealed changes in Shataputi Abhrak Bhasma at various stages by Ultraviolet-visible-infrared Spectroscopy where order of reflectance observed that 20 puta of Abhraka bhasma passes most part of spectrum in the sunlight reflected comparable to 50 & 100 puta which highlights importance of Nishchandratwa of Abhrak Bhasma with successive puta.

V. Observation And Discussion

Abhrak Bhasma Pariksha like Nischandratva, Sindurabh Varnata, Susukshmatwa, Unnama Rekhapurnatva, Nirdhumatvam, Apunarbhavatva, Niruttha has been described in detail as per Rasashashtra classics. Hundreds to thousands of incinerations are performed during the preparation of Abhrak bhasma for various therapeutic uses and Rasayan karma.The modifications made to physico-chemical processes are emphasized by the significance of their various modern analytical techniques which has been carried out for this purpose. According to an XRF study, Abhraka contains more iron than other elements, particularly when it is in its raw state. However, silica content lowers when Abhraka undergoes the processes of Shodhana, Dhany Abhraka nirmana, and Marana. This indicates importance of Marana process & Bhasma pariksha which is specific to Abhraka Bhasma such as Nischandratva. Particle size distribution of Abhraka is irregular, ranging from spherical to oblongated, according to a FEG-SEM study. O, Fe, and Si are the three main elements found in EDS. A TEM study reveals that the size and form of the particles vary from 50 nm to 1 mm. increased surface area correlates with increased porosity, according to BET study, while a bimodal and unimodal particle distribution is shown in DLS study. Repeated incineration & lavigation process helps to form a nanosize particles of Abhraka Bhasma(35) which is supported by SEM& TEM study. According to a TGA examination, weight loss is caused by moisture and the disintegration of organic materials. Repeated lavigation process followed by subsequent incineration process helps Abhrak has the elemental content of the sample and the conditions of its preparation determine the X-ray diffraction line's intensity in X-ray diffraction (XRD). Abhraka shown the crystalline substance as a prominent diffraction peak. A significant quantity of Fe is seen in the monoclinic structure of KMg3(Si3Al) O10(OH) form various compound formation according to XRD. Changes in the form of Bhasma & its Composition can be revealed with XRD study(36). Organic compounds with distinct functional groups of the O-H band, O=C=O stretching band, Si-O group sharp band, and C-Br band are shown by FTIR analysis(37). FTIR analyzes the functional group that detects a compound's absorption of light in the electromagnetic spectrum, but it only interacts with the spectrum in relation to a polar molecular band present functional group in Bhasma indicate presence of various Bhavana dravya. The porosity of the particles in the BET analysis indicates their strength, permeability, and whether or not porous used in molecules dissolve in organic solvents. Higher surface area & porosity indicates high rate of absorption Bhasma. In DLS, the particle specially in shatputi & *Shatraputi* Abhraka Bhasma size distribution and colloidal data demonstrate that the solar spectrum is reflected at a discrete 330 nm peak, with low levels of reflected light at 100 Puta. All these analytical tests highlight the importance of various stages of Bhasma preparation and its scientific importance.

ICPMS Study Of Abhraka Bhasma

Introduction

Abhraka Bhasma

ICPMS OF Abrhak Bhasma-ICP-MS (Inductively Coupled Plasma Mass Spectrometry) analysis of Abhrak Bhasma (calcined mica) usually shows that it is mainly a combination of silicon, iron, magnesium, aluminum, and potassium(38), along with some organic matter left from the processing of herbs. It is a nano-crystalline, non-toxic substance that works as a metallic calx, with sizes ranging from 19-88 nanometers.

Amruthaballi Powder

ICP-MS analysis has been used to determine the presence of major trace elements and macro-minerals in Tinospora cordifolia. The analysis has revealed the presence of elements such as Calcium, Potassium, Magnesium, Iron, Copper, Zinc, and Manganese.

The analysis has revealed the presence of elements such as Calcium, Potassium, Magnesium, Iron, Copper, Zinc, and Manganese.

Screening of Heavy Metal Contamination: Owing to the possibility of environmental contamination in herbal powders, ICP-MS analysis is used to determine the presence of toxic heavy metals such as Lead (Pb),

Cadmium (Cd), Mercury (Hg), and Arsenic (As). The analysis has revealed that although these metals are present, they are safe within permissible limits.

Quantitative Analysis: In a specific study, ICP-MS analysis was used to determine the presence of twenty elements such as Fe, Cu, Zn, and Mn in ppm (parts per million) to determine the nutritional value of the herb.

Details of Study

Elements of ABHRAKA BHASMA

Reactive Dilution	Element	Wavelength(nm)	Label	Type	Internal Standard	Background Correction	Pixels	Calibration Fit	Condition Set
N/A	Cu	327.395	Cu(327.395 nm)	Analyte		Fitted	2	Weighted Linear Through None	
N/A	Fe	238.204	Fe(238.204 nm)	Analyte		Fitted	2	Weighted Linear Through None	
N/A	Mn	257.610	Mn(257.610 nm)	Analyte		Fitted	2	Weighted Linear Through None	
N/A	Zn	213.857	Zn(213.857 nm)	Analyte		Fitted	2	Weighted Linear Through None	

Elements of **AMRUTHABALLI POWDER**

Reactive Dilution	Element	Wavelength (nm)	Label	Type	Internal Standard	Background Correction	Pixels	Calibration Fit	Condition Set
N/A	Cu	327.395	Cu (327.395nm)	Analyte		Fitted	2	Weighted Linear Through None	1
N/A	Fe	238.204	Fe (238.204nm)	Analyte		Fitted	2	Weighted Linear Through None	1
N/A	Mn	257.610	Mn (257.610nm)	Analyte		Fitted	2	Weighted Linear Through None	1
N/A	Zn	213.857	Zn (213.857nm)	Analyte		Fitted	2	Weighted Linear Through None	1

Calibrations: ABHRAKA BHASMA

Standard Concentrations By Element

Solution Label	Dilution Factor	Stock standard	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Blanck-1	N/A		0.00	0.00	0.00	0.00
Standard 1	N/A		2.00	2.00	2.00	2.00
Standard 2	N/A		4.00	4.00	4.00	4.00
Standard 3	N/A		6.00	6.00	6.00	6.00

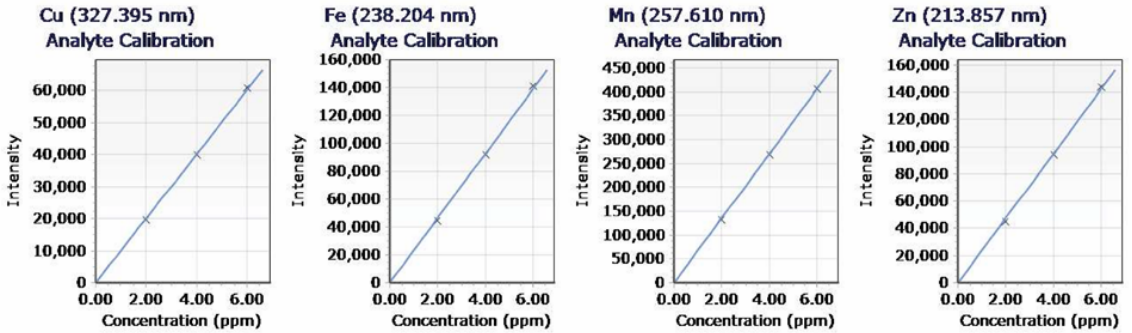
Calibration Parameters

Label (wavelength nm)	Calibration Fit	Minimum Concentration	Maximum Cocentration	Calibration Error	Excess Curvature	Upward Curvature	%RSE Limit
Cu (327.395 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			
Fe (238.204 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			

Mn (257.610 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			
Zn (213.857 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			

Summary Calibration Results

Element and wavelength	Type	Units	Equation	Correlation Coefficient	%RSE
Mn(257.610nm)	Analyte	Ppm	67416.03978410*Concentration+112.47660607	0.99996	1.75120203
Zn(213.857nm)	Analyte	Ppm	23645.88097253*Concentration+128.35957579	0.99970	4.70281317
Fe(238.204nm)	Analyte	Ppm	23049.68121234*Concentration+393.87496982	0.99970	4.67080660
Cu(327.395nm)	Analyte	Ppm	10036.08343104*Concentration+50.49693110	0.99994	2.06451311



Sequence

Rack:Tube	Sample Label	Dilution List	Measurement	Weight (g)	Volume (mL)	**Dilution**	**Autodilution** Factor
	Blank	N/A	Measurement 7	1	1	1	N/A
	Standard 1	N/A	Measurement 7	1	1	1	N/A
	Standard 2	N/A	Measurement 7	1	1	1	N/A
	Standard 3	N/A	Measurement 7	1	1	1	N/A
	Sample 1	N/A	Measurement 2	1	1	1	N/A
	Sample 2	N/A	Original	1	1	1	N/A
	Sample 3	N/A	Original	1	1	1	N/A
	Sample 4	N/A	Original	1	1	1	N/A
	Sample 5	N/A	Original	1	1	1	N/A
	Sample 6	N/A	Original	1	1	1	N/A
	Sample 7	N/A	Original	1	1	1	N/A
	Sample 8	N/A	Original	1	1	1	N/A
	Sample 9	N/A	Original	1	1	1	N/A
	Sample 10	N/A	Original	1	1	1	N/A
	Sample 11	N/A	Original	1	1	1	N/A
	Sample 12	N/A	Original	1	1	1	N/A
	Sample 13	N/A	Original	1	1	1	N/A
	Sample 14	N/A	Original	1	1	1	N/A
	Sample 15	N/A	Original	1	1	1	N/A
	Sample 16	N/A	Original	1	1	1	N/A
	Sample 17	N/A	Original	1	1	1	N/A
	Sample 18	N/A	Original	1	1	1	N/A
	Sample 19	N/A	Original	1	1	1	N/A
	Sample 20	N/A	Original	1	1	1	N/A
	Sample 21	N/A	Original	1	1	1	N/A
	Sample 22	N/A	Original	1	1	1	N/A
	Sample 23	N/A	Original	1	1	1	N/A
	Sample 24	N/A	Original	1	1	1	N/A
	Sample 25	N/A	Original	1	1	1	N/A
	Sample 26	N/A	Original	1	1	1	N/A
	Sample 27	N/A	Original	1	1	1	N/A
	Sample 28	N/A	Original	1	1	1	N/A
	Sample 29	N/A	Original	1	1	1	N/A

	Sample 30	N/A	Original	1	1	1	N/A
	Sample 31	N/A	Original	1	1	1	N/A
	Sample 32	N/A	Original	1	1	1	N/A
	Sample 33	N/A	Original	1	1	1	N/A
	Sample 34	N/A	Original	1	1	1	N/A
	Sample 35	N/A	Original	1	1	1	N/A
	Sample 36	N/A	Original	1	1	1	N/A
	Sample 37	N/A	Original	1	1	1	N/A

Rack:Tube	Sample Label	Dilution List	Measurement	Weight (g)	Volume (mL)	**Dilution**	**Autodilution** Factor
	Sample 38	N/A	Original	1	1	1	N/A
	Sample 39	N/A	Summary	1	1	1	N/A
	Sample 40	N/A	Summary	1	1	1	N/A
	Sample 41	N/A	Summary	1	1	1	N/A
	Sample 42	N/A	Original	1	1	1	N/A
	Sample 43	N/A	Original	1	1	1	N/A
	Sample 44	N/A	Original	1	1	1	N/A
	Sample 45	N/A	Original	1	1	1	N/A
	Sample 46	N/A	Original	1	1	1	N/A
	Sample 47	N/A	Original	1	1	1	N/A
	Sample 48	N/A	Original	1	1	1	N/A
	Sample 49	N/A	Original	1	1	1	N/A
	Sample 50	N/A	Original	1	1	1	N/A
	Sample 51	N/A	Original	1	1	1	N/A
	Sample 52	N/A	Original	1	1	1	N/A
	Sample 53	N/A	Original	1	1	1	N/A
	Sample 54	N/A	Original	1	1	1	N/A
	Sample 55	N/A	Original	1	1	1	N/A
	Sample 56	N/A	Original	1	1	1	N/A
	Sample 57	N/A	Original	1	1	1	N/A

Rack:Tube	Sample Label	Dilution List	Measurement	Weight (g)	Volume (mL)	**Dilution**	**Autodilution** Factor
	Sample 58	N/A	Original	1	1	1	N/A
	Sample 59	N/A	Original	1	1	1	N/A
	Sample 60	N/A	Original	1	1	1	N/A
	Sample 61	N/A	Original	1	1	1	N/A
	Sample 62	N/A	Original	1	1	1	N/A
	Sample 63	N/A	Original	1	1	1	N/A
	Sample 64	N/A	Original	1	1	1	N/A
	Sample 65	N/A	Original	1	1	1	N/A
	Sample 66	N/A	Original	1	1	1	N/A
	Sample 67	N/A	Original	1	1	1	N/A
	Sample 68	N/A	Original	1	1	1	N/A
	Sample 69	N/A	Original	1	1	1	N/A
	Sample 70	N/A	Original	1	1	1	N/A
	Sample 71	N/A	Original	1	1	1	N/A
	Sample 72	N/A	Original	1	1	1	N/A

Results

Solution Label	Dilution Test	Measurements	Cu (327.395nm)	Fe(238.204 nm)	Mn (257.610nm)	Zn (213.857nm)
Sample 41	N/A	Summary	0.20(ppm)	8.80 (ppm)	2.21 (ppm)	1.28 (ppm)

Calibrations: Amrutballi Powder
Standard Concentrations By Element

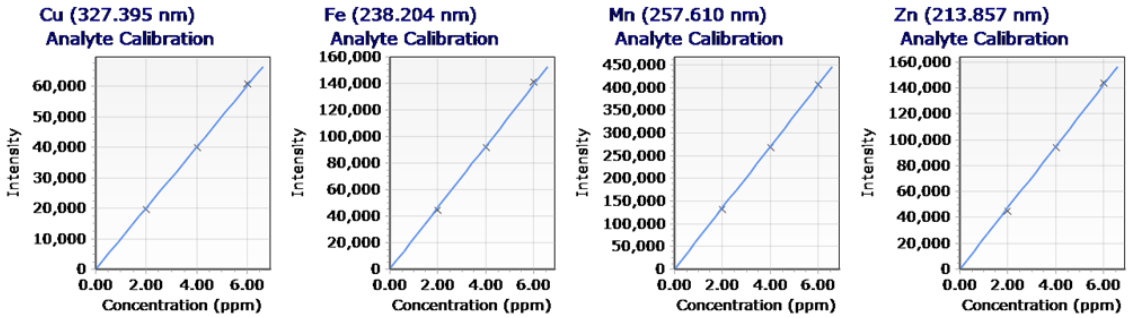
Solution Label	Dilution Factor	Stock standard	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Blanck-1	N/A		0.00	0.00	0.00	0.00
Standard 1	N/A		2.00	2.00	2.00	2.00
Standard 2	N/A		4.00	4.00	4.00	4.00
Standard 3	N/A		6.00	6.00	6.00	6.00

Calibration Parameters

Label (wavelength nm)	Calibration Fit	Minimum Concentration	Maximum Cocentration	Calibration Error	Excess Curvature	Upward Curvature	%RSE Limit
Cu (327.395 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			
Fe (238.204 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			
Mn (257.610 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			
Zn (213.857 nm)	Weighted Linear Through None	0.00 ppm	6.60 ppm	10 %			

Summary Calibration Results

Element and wavelength	Type	Units	Equation	Correlation Coefficient	%RSE
Mn(257.610nm)	Analyte	Ppm	67416.03978410*Concentration+112.47660607	0.99996	1.75120203
Zn(213.857nm)	Analyte	Ppm	23645.88097253*Concentration+128.35957579	0.99970	4.70281317
Fe(238.204nm)	Analyte	Ppm	23049.68121234*Concentration+393.87496982	0.99970	4.67080660
Cu(327.395nm)	Analyte	Ppm	10036.08343104*Concentration+50.49693110	0.99994	2.06451311



Sequence

Rack:Tube	Sample Label	Dilution List	Measurement	Weight (g)	Volume (mL)	Dilution	Autodilution Factor
	Blank	N/A	Measurement 7	1	1	1	N/A
	Standard 1	N/A	Measurement 7	1	1	1	N/A
	Standard 2	N/A	Measurement 7	1	1	1	N/A
	Standard 3	N/A	Measurement 7	1	1	1	N/A
	Sample 1	N/A	Measurement 2	1	1	1	N/A
	Sample 2	N/A	Original	1	1	1	N/A
	Sample 3	N/A	Original	1	1	1	N/A
	Sample 4	N/A	Original	1	1	1	N/A
	Sample 5	N/A	Original	1	1	1	N/A
	Sample 6	N/A	Original	1	1	1	N/A
	Sample 7	N/A	Original	1	1	1	N/A
	Sample 8	N/A	Original	1	1	1	N/A
	Sample 9	N/A	Original	1	1	1	N/A
	Sample 10	N/A	Original	1	1	1	N/A

	Sample 11	N/A	Original	1	1	1	N/A
	Sample 12	N/A	Original	1	1	1	N/A
	Sample 13	N/A	Original	1	1	1	N/A
	Sample 14	N/A	Original	1	1	1	N/A
	Sample 15	N/A	Original	1	1	1	N/A
	Sample 16	N/A	Original	1	1	1	N/A
	Sample 17	N/A	Original	1	1	1	N/A
	Sample 18	N/A	Original	1	1	1	N/A
	Sample 19	N/A	Original	1	1	1	N/A
	Sample 20	N/A	Original	1	1	1	N/A
	Sample 21	N/A	Original	1	1	1	N/A
	Sample 22	N/A	Original	1	1	1	N/A
	Sample 23	N/A	Original	1	1	1	N/A
	Sample 24	N/A	Original	1	1	1	N/A
	Sample 25	N/A	Original	1	1	1	N/A
	Sample 26	N/A	Original	1	1	1	N/A
	Sample 27	N/A	Original	1	1	1	N/A
	Sample 28	N/A	Original	1	1	1	N/A
	Sample 29	N/A	Original	1	1	1	N/A
	Sample 30	N/A	Original	1	1	1	N/A
	Sample 31	N/A	Original	1	1	1	N/A
	Sample 32	N/A	Original	1	1	1	N/A
	Sample 33	N/A	Original	1	1	1	N/A
	Sample 34	N/A	Original	1	1	1	N/A
	Sample 35	N/A	Original	1	1	1	N/A
	Sample 36	N/A	Original	1	1	1	N/A
	Sample 37	N/A	Original	1	1	1	N/A
	Sample 38	N/A	Original	1	1	1	N/A
	Sample 39	N/A	Summary	1	1	1	N/A
	Sample 40	N/A	Summary	1	1	1	N/A
	Sample 41	N/A	Summary	1	1	1	N/A
	Sample 42	N/A	Original	1	1	1	N/A
	Sample 43	N/A	Original	1	1	1	N/A
	Sample 44	N/A	Original	1	1	1	N/A
	Sample 45	N/A	Original	1	1	1	N/A
	Sample 46	N/A	Original	1	1	1	N/A
	Sample 47	N/A	Original	1	1	1	N/A
	Sample 48	N/A	Original	1	1	1	N/A
	Sample 49	N/A	Original	1	1	1	N/A
	Sample 50	N/A	Original	1	1	1	N/A
	Sample 51	N/A	Original	1	1	1	N/A
	Sample 52	N/A	Original	1	1	1	N/A
	Sample 53	N/A	Original	1	1	1	N/A
	Sample 54	N/A	Original	1	1	1	N/A
	Sample 55	N/A	Original	1	1	1	N/A
	Sample 56	N/A	Original	1	1	1	N/A
	Sample 57	N/A	Original	1	1	1	N/A
	Sample 58	N/A	Original	1	1	1	N/A
	Sample 59	N/A	Original	1	1	1	N/A
	Sample 60	N/A	Original	1	1	1	N/A
	Sample 61	N/A	Original	1	1	1	N/A
	Sample 62	N/A	Original	1	1	1	N/A
	Sample 63	N/A	Original	1	1	1	N/A
	Sample 64	N/A	Original	1	1	1	N/A
	Sample 65	N/A	Original	1	1	1	N/A
	Sample 66	N/A	Original	1	1	1	N/A
	Sample 67	N/A	Original	1	1	1	N/A
	Sample 68	N/A	Original	1	1	1	N/A
	Sample 69	N/A	Original	1	1	1	N/A
	Sample 70	N/A	Original	1	1	1	N/A
	Sample 71	N/A	Original	1	1	1	N/A
	Sample 72	N/A	Original	1	1	1	N/A

Results

Solution Label	Dilution List	Measurements	Cu (327.395 nm)	Fe (238.204 nm)	Mn (257.610 nm)	Zn (213.857 nm)
Sample 37	N/A	Original	0.18 (ppm)	26.24 (ppm)	1.09 (ppm)	0.38 (ppm)

Results

After measuring all parameters related to Abhrak bhasma and Amrutballi powder these are the few points mentioned below indicating the similarities and differences between Abhrak Bhasma and Amrutballi powder.

Similarities between Abhrak Bhasma and Amruthballi Powder.

Aspect	Abhrak Bhasma	Amruthballi Powder
Common Elements	Cu, Fe, Mn, Zn	Cu, Fe, Mn, Zn
Calibration Range	0.00 – 6.60 ppm	0.00 – 6.60 ppm
Calibration Fit	Weighted Linear Through None	Weighted Linear Through None
Heavy Metal Safety	Pb, Cd, Hg, As within permissible limits	Pb, Cd, Hg, As within permissible limits

Differences between Abhrak Bhasma and Amruthballi Powder.

Aspect	Abhrak Bhasma	Amruthballi Powder
Primary Composition	Silicon, Iron, Magnesium, Aluminum, Potassium	Calcium, Potassium, Magnesium, Iron, Copper, Zinc, Manganese
Nature	Mineral-based (calcined mica, metallic calx)	Plant-based (herbal powder)
Organic Matter	Minimal, residual from herbal processing	Naturally rich in organic compounds
Particle Size	Nano-crystalline (19–88 nm)	Coarse plant powder, no nano-crystalline structure

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