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Review Article

SIGNIFICANCE OF *SHODHANA DRAVYAS* USED IN THE PURIFICATION OF *MAHARASA, UPRASA, SADHARANA RASA* AND *DHATU VARGA*

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ABSTRACT

Rasashastra is the Iatrochemistry of Ayurveda which deals with the various pharmaceutical processes of *Shodhana* (purification/potentiation), *Marana* (incineration/calcination), Jarana (polling) and other detailed descriptions of metals, minerals, poisonous plants and animal products which are of therapeutic importance in Ayurveda. A series of pharmaceutical procedures that converts a metal/mineral into a therapeutically effective form is termed as *Shodhana*. Various methods along with different media are being used for the purification of metals/minerals. Failure to subject certain metals/minerals to the process of *Shodhana* can have a detrimental impact on the efficacy of the preparations. It is quite interesting to understand the role of media in the purification of *Maharasa, Uprasa, Sadharna Rasa* and *Dhatu Varga.*

INTRODUCTION

Shodhana is a procedure of elimination of *Dosha* (impurity/toxicity/flaw) from the drug. The term *Dosha* indicates not only impurities but also all that makes the drug unsuitable for further process or therapeutic use. In the case of metals and minerals, it is a physicochemical and therapeutic transformation of a substance making it feasible for the next process (*Marana*) or directly for therapeutic use. It is a mandatory process of metals and minerals that help to expose maximum surface area of drug for chemical reactions and also in impregnation of organic materials and their properties into the drug. This makes the mineral brittle and helps in particle size reduction.

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MATERIAL AND METHOD

The review of role of media in the purification of *Maharasa, Uprasa, Sadharna Rasa* and *Dhatu Varga* is done from various Ayurvedic classics, published papers and web sources i.e., PubMed, Scirus, Science Direct and Scopus.

Maharasa: *Maharasa* are eight in number i.e., *Abhraka* (mica), *Vaikranta* (tourmaline), *Makshika* (chalco pyrite), *Vimala* (iron pyrite), *Shilajitu* (asphaltum panjabinum), *Sasyaka* (copper sulphate), *Chapala* (bismuth), *Rasaka* (calamine).

Table 1: *Maharasa* and media used for their *Shodhana* process

S.no.	*Maharasa*	Media used for *Shodhana*
1.	*Abhraka* (Mica)	*Kanji*/cow urine/ *Triphala Kwatha*/ cow milk/ *Kulatha Kwatha*/ *Takra*/ *Bhringraja Swarasa*/ *Badar Kwatha*
2.	*Vaikranta* (Tourmaline)	*Kanji Amla Dravyas, Asav Mutra, Kulatha Kwatha, Kodo Kwatha, Kadli kanda Swarasa, Sajji Kshara, Yava Kshara, Tankana*

3.	*Makshika* (Chalcopyrite)	*Eranda Taila* and *Matulunga Swarasa/Kadli kanda Swarasa, Gomutra, Takra, Kulatha Kwatha, Triphala Kwatha*
4.	*Vimala* (Iron pyrite)	*Vasa Swarasa, Meshshringi Swarasa, Jambiri Nimbu Swarasa*
5.	*Shilajatu* (Asphaltum Panjabinum)	*Kshara, Amla Varga,* cow urine, cow milk*, Guggulu, Kanji*
6.	*Sasyaka* (Copper sulphate)	*Nimbu Swarasa, Kusumbha, Khadir, Laksha, Manjistha*
7.	*Chapala* (Bismuth)	*Jambhiri Nimbu, Bandhya karkoti* and *Adraka* *Jambhiri Nimbu, Bandhya karkoti* and *Adraka Swarasa*
8.	*Rasaka* (Calamine)	*Bijpur Nimbu Swarasa / Kanji/ Takra/* Human urine/ sheep urine

***Abhraka* (Mica):** *Nirvapa* technique (heating the material to red hot and then quenching in liquid media) is used commonly in *Abhraka Shodhana* (purification). *Abhraka* is heated to a red-hot state because at this stage elements present in the biotite are converted into oxide form on the surface of *Abhraka* flakes by reacting with atmospheric oxygen. After heating it is instantly quenched into the liquid media. Instant quenching is important because repeated immediate cooling after heating disrupts compression–tension equilibrium leading to cracks on the flake surface thus breaking the material i.e., reduction in particle size. After each *Nirvapa*, the crammed structure of *Abhraka* is destroyed to form small pieces due to increased brittleness. At the early stage of *Shodhana* cracks are seen at the surface of *Abhraka* flakes and finally, these become coarse powder. In the last stage of the *Shodhana*, fine *Abhraka* particles start floating in the air and travel a long distance as compared to the initial steps due to a significant size reduction. Different liquid media are used for quenching such as Kanji, *Triphala kwatha,* cow's milk, cow's urine etc. *Kanji* dissolves the acid-soluble impurity, cow's urine removes base soluble impurities from *Abhraka* and cow's milk dissolves lipid soluble impurities. Cow's milk and *Triphala* act like a *Vishaghna Dravya. Nirvapa* process is repeated seven to twenty-one times for *Abhraka Shodhana* which causes a marked reduction in hardness and also imposes the properties of various media in the *Abhraka.*[1]

***Shodhana* of *Abhraka* using cow milk:** During *Shodhana* of *Abhraka* using cow milk as liquid media, a study revealed that during the quenching process, the temperature of cow milk was suddenly enhanced and reached at boiling stage due to the transfer of heat from *Abhraka* and the color of cow milk turned to a grey tinge. The pH and solid content of cow milk was increased from 12.1 to 12.7and 6.2 to 6.5 respectively after *Shodhana* due to the reaction with *Abhraka* which was alkaline in nature. It was noticed that during heating *Abhraka* produces fumes that had the smell of ghee due to the burning of fatty material of cow milk. Its color was also changed to blackish brown.[2]

Using cow milk as a liquid media, ions like K^+ are replaced by Ca^{++}, Mg^+ etc. from milk on the cracked surfaces of the layers. Also, there is a possibility of adsorption of metal-binding, soluble enzymes and immunoglobulins from milk within the mica layers.[3]

***Vaikranta* (Tourmaline):** *Hayamootra, Kulatha Kwatha, Kodrava, Kshara, Gomutra* etc., are the different *Drava Dravyas* described in the classics. *Kulatha kwatha* can effectively reduce the hardness of *Vaikranta* as it possesses *Bhedhana* property.[4]

***Makshika* (Chalcopyrite)**

Makshika Shodhana* using *Triphala Kwatha

Swarna Makshika (SM) was heated to red hot stage and quenching was done in *Triphala Kwatha* for seven times. While performing *Nirvapa*, strong sulphur smell was observed from first to fourth cycle of quenching which was due to sulphur dioxide (SO2) vaporization and oxidation of Swarna Makshika. From the fifth cycle onward, the intensity of the odour was reduced and by the seventh cycle, no odour was observed.

$2CuFeS_2 + 7.5O_2 - 2CuSO_4 + Fe_2O_3 + 2SO_2$

$2CuFeS_2$-CuS + 2FeS + S

Repeated heating and cooling of SM flakes causes disruption in compression tension equilibrium and leads to crack on the flake surface (stress corrosion theory). During red hot state, different compounds such as pyrrhotite (Fe1-xS), pyrite (FeS2), bornite (Cu5FeS4) and chalcocite (Cu_2S) will be formed on the surface of SM flakes. Repeated heating leads to the breaking of SM flakes from coarse powder to fine powder, thus converting copper and iron to oxide form by reacting with atmospheric oxygen. Raw SM is often found with a variety of other trace elements such as cobalt (Co), nickel (Ni), manganese (Mn), Zinc (Zn) and tin (Sn) substituting for copper and iron (Fe), selenium (Se) and arsenic (As) substitute for sulphur and trace amount of silver (Ag), gold (Au), platinum (Pt), lead (Pb), vanadium (V), chromium (Cr), indium (In), aluminium (Al) and antimony (Sb).

During the process of red hot in an iron pan at high temperature, chemical impurities such as extra sulfur in the form of sulfur dioxide (SO_2) and arsenic may be get vaporized while other get oxidized and after heating, it was instantly quenched in the *Triphala*

Kwatha. It facilitates the media to enter inside the drug easily by which the remaining blemishes will get separated or dissolved in the liquid media as well as the therapeutic property of *Triphala Kwatha* will be introduced into *Swarna Makshik*. Instant quenching is important because repeated immediate cooling after heating leads to breaking of the material. Yellowish and golden shining of SM was lost completely after *Shodhana* process and turned into dark black coarse powder.

Triphala mainly consists of tannins, gallic acid, chebulinic acid, ascorbic acid (Vitamin C) and phenolics. Ascorbate has been known to antagonize the intestinal absorption of copper. More recent studies have characterized a post-absorption role for ascorbate in the transfer of copper ions into cells. The vitamin reacts directly or indirectly with ceruloplasmin, a serum copper protein, specifically stabilizing the bound copper atoms and facilitating their cross-membrane transport. Ascorbate at physiological levels and above impedes the intracellular binding of copper to Cu, Zn and superoxide dismutase. The mechanism is unclear but nonetheless suggests both positive and negative regulatory functions for ascorbate in copper metabolism. Ascorbic acid increases the bioavailability of Fe by converting Fe+3 to Fe+2, while phenolics can reduce the bioavailability of Fe by binding, for example, tannins. Excess of ascorbic acid and a lack of dietary tannins have both been suggested as contributing to clinical/pathological Fe storage disease. *Triphala* is a mild laxative and thereby counteracts the constipating property of iron and copper. Thus, it is mentioned in the maximum *Shodhana* procedures of various metals and minerals.[5]

***Shodhana* of *Swarna Makshika* using lemon juice**

The *Shodhana* of *Swarna Makshika* was done by *Bharjana* (roasting and frying) in lemon media. Before *Shodhana* process raw *Swarna Makshika* was powdered and evolution of fumes was observed in the initial two hours during *Bharjana* (Roasting and frying) process and then fumes subsided. *Makshika* turned into a fine powder and brown in color with shining particles. Sulphur odor was observed when *Swarna Makshika* was heated. On heating up to five hours colour changed to brick red. The temperature of system observed through pyrometer was 800°C and the temperature of upper surface of pan was around 650°C. Loss was observed due to evaporation of Sulphur. Lemon juice was added as per the requirement during the intermediate procedure. The whole process was on mild heat and stirring was done constantly while roasting.

In the roasting and frying phase there is some kind of electrostatic attraction or surface creation of citrate complexes with copper pyrites. The positive charge of metallic ions is decreased by citric acid, thereby suggesting the adsorption on positively charged sites. Unpurified *Swarna Makshika* may contain physical impurities, such as undesirable rock or gangue minerals, standard silicates or oxides. The thermal expansion principle indicates that expansion ranges from metal and mineral to heating materials. The expansion of the compound is generally smaller than that of metal. Consequently, continuous heating leads to the splitting of rough to fine powder. By reacting with ambient oxygen, copper and iron are converted to oxide form at a red-hot condition.[6]

***Tuttha* (Copper Sulphate)**

***Shodhana* of *Tuttha* using lemon juice:** During the process of *Shodhana,* copper sulphate is triturated with lemon juice and it converts to copper citrate. The bright blue color in crude form converts to a green or bluish-green crystalline powder after purification.[7]

Uprasa: *Uprasa* are eight in number i.e., *Gandhaka* (Sulphur), *Gairika* (Ochre), *Kasisa* (blue vitriol), *Sphatika* (Potash Alum), *Hartala* (Orpiment), *Manahshila* (Realgar), *Kankushta* (Ruhbarb).

Table 2: *Uparasa* and media used for their *Shodhana* process

Sr.no.	*Uprasa*	Media used
1.	*Gandhaka* (Sulphur)	*Go-ghrita, Godugdha, Bhringraj Swarasa*
2.	*Gairika* (Ochre)	*Go-ghrita, Godugdha*
3.	*Kasisa* (blue vitriol)	*Bhringraj Swarasa, Jambiri Nimbu Swarasa*
4.	*Sphatika* (Potash Alum)	*Kanji*
5.	*Hartala* (Orpiment)	*Kushmanda Swarasa, Tila Kshara, Churnodaka, Kanji, Triphala Kwatha*
6.	*Manahshila* (Realgar)	*Agastya Swarasa, Adraka Swarasa, Jyanti Swarasa, Bhringraj Swarasa, Nimbu Swarasa, Churnodaka*
7.	*Anjana* (Collyrium)	*Bhringraj Swarasa, Jambiri Nimbu Swarasa, Triphala Kwatha*
8.	*Kankushta* (Ruhbarb)	*Shunthi Kwatha*

***Gandhaka* (Sulphur):** *Gandhaka* (S) itself is extremely hot in potency and if ingested without proper purification can cause burning micturition. Whereas, cow ghee and cow milk are cool in potency, hence used for *Gandhaka* purification which limits the hot potency of *Gandhaka* (S). Milk contains proteins which are good chelating agents for transition of metal cations. Cow ghee may contain free fatty acid which may form Na, K, Ca salts and remove them from *Gandhaka*.[8]

***Shodhana* of *Gandhaka* using *Goghrita* (clarified butter) and *Godugdha* (cow milk)**

During purification of sulphur it was powdered because it increases effective surface area which facilitates quick melting. Crystalline sulphur after purification turned to amorphous nature. Loss of its translucency and lustre represent its amorphous nature. The repeated heating, melting and sudden cooling of sulphur by pouring it into liquid media may cause the loosening of the bonds between the molecules, making it amorphous in nature. This loosening of the bonds may be helpful in dissolving the impurities in the media thus separating it from the sulphur, making it pure. With each procedure it changes from orange colour to bright yellow colour suggesting removal of impurities. Also, during heating the sulphur until it melts some of the impurities might have removed through oxidation process.

During the purification of *Gandhaka,* it is powdered because it increases the effective surface area which facilitates quick melting. Crystalline sulphur after purification turned to an amorphous nature. The loss of its translucency and lustre represents its amorphous nature. The repeated heating, melting and sudden cooling of sulphur by pouring it into liquid media may cause the loosening of the bonds between the molecules, making it amorphous in nature. This loosening of the bonds may help in dissolving the impurities in the media thus separating it from the sulphur and making it pure. With each procedure, it changes from orange to bright yellow colour suggesting removal of impurities. During the heating of sulphur, until it melts some of the impurities might have been removed through oxidation process. *Ghee* (clarified butter) and *Dugdha* (cow milk) both are *Madhura Rasa* and *Jeevaniya Dravya,* purification in these drugs might have removed *Visha Dosha* present in sulphur and thus incorporating the unctuous property in it, thus dissolving the fat-soluble impurities present in Sulphur. Milk containing various salts and minerals like calcium sulphate, potassium, magnesium phosphates, sodium chloride and trace of phosphate of iron and mineral salts as compounds of calcium, potassium, sodium, phosphorus, iron and chlorine present in the milk might have reacted with the constituents present in sulphur thus separating out impurities or toxic matter from it.[9]

***Gairika* (Ochre):** In raw *Gairika,* the presence of water and oxygen molecules increases the chances of having free ferrous ions. The body must protect itself from free ion which is highly toxic and participates in chemical reactions that generate free radicals. So, when ochre is roasted with ghee ferrous ions are converted into ferric form. During *Shodhana*, free $Fe^{2+}$is converted into Fe^{3+} ions. Fe^{3+} are absorbed easily and carried in the plasma by protein transferring. So, *Shodhana* process may increases the absorption rate of *Gairika* in body. [10]

***Kasisa* (blue vitriol):** *Kasisa Shodhana* is done by trituration with lemon juice. Lemon juice is a rich supplier of vitamin C and vitamin B complex, which acts as an intrinsic-factor in the absorption of iron in the body providing a synergistic effect. The color of *Shodhita Kasisa* is pale green, fine powder and soft, smooth in touch.[11]

***Sphatika* (Alum):** The *Shodhana* of *Sphatika* is done by two methods; one is closed method by subjecting to *Gajaputa* and other is an open method by subjecting to heat in an iron pan. The colour of *Shodhita Sphatika* by *Puta* method is white and the colour of the *Shodhita Sphatika* by open method is dull white. This could be due to the oxidation that takes place and the colour imparted during the process. No specific odour and taste for both samples were observed. The colour change is because of the amount of heat given and the oxidation that occurs in closed and open methods of heating.[12]

***Hartala* (Orpiment)**

***Shodhana* of *Hartala* using *Tila Taila*, *Kanji* and *Triphala Kwatha*:** After *Shodhana* of *Hartala* in different media there was a shift of pH of media toward alkalinity or reduction in acidity such as in *Tila Taila* (2 to 4), *Kanji* (3 to 7.5) and *Triphala Kwatha* (2 to 2.4). Highly toxic fumes of sulphur and arsenic are emitted when in contact with acid or acid fumes. Produced sulphur gas may form H_2S which is soluble in aqueous media. A_2S_3 reacts with water, steam or even moist air to produce hydrogen sulphide gas. The utilization of H ions from the media might have been responsible for an increase in pH of all media after *Shodhana.*

Upon analysis of data of arsenic content in samples of *Ashudha* and *Shuddha Hartala*, it is observed that arsenic percentage after *Shodhana* has been significantly reduced i.e., *Kanji* (19.89 to 6.50), *Triphala Kwatha* (19.89 to 8.21), *Tila Taila* (19.89 to 14.39), which is probably due to leaching of arsenic in aqueous media as it is a well-known fact that arsenic partially leaches in water upon heating, may release arsine gas, even humidity also helps the phenomenon. It is known that the solubility of arsenic trisulfide increases in sulfide solutions and more in alkaline

sulfide solutions. Released arsine gas may form several organo-arsenic compounds with liquid media (*Kanji, Triphala Kwatha, Tila Taila* etc.), thus reducing arsenic content. Arsenic dissolution increases in sulfide solutions and due to the formation of H_2S gas while heating, sulfide solution of several trace elements, sulfurous acid in traces may get formed thus facilitating further leaching of arsenic into the liquid media for *Swedana*.[13]

The major constituents of *Kushmanda* (*Benincasa hispida)* fruits were volatile oils, flavonoids, glycosides, sugar, mannitol, cucurbitin, histidine-like amino acids, carotenes, vitamins, minerals, ß-sitosterin anduronic acid. A research study shows that flavonoids can flush out arsenic from the body. Sugar and mannitol present in *Kushmanda Swarasa* may be helpful in the excretion of arsenic through urine. Histidine is an alpha amino acid with an imidazole functional group that humans and other mammals require. Imidazole has good antifungal activity. It may help to enhance the *Kushthghna* property of *Hartala.*

The pH of lime water is highly alkaline. It might help to remove alkaline-soluble impurities from the mineral. Lime water is used primarily as a softening agent. As the pH is raised, the hydrogen ion concentration decreases, shifting the equilibrium toward the reactants and releasing arsenate to the solution. Calcium is enhancing the surface adsorption of arsenic onto the solids in solution. The reduction in arsenic leachability at higher pH values is most likely due to the divalent cation effect of calcium and not due to the formation of a calcium arsenate solid.

Acidic media like *Nimbu Swarasa*, juice of *Jambira* fruit (*Citrus Jambiri* Linn) and *Kanji* are used for the *Prakshalana* (washing) alone or along with some solid alkaline drugs like *Tankan* (borax), limewater. The alkaline drugs may convert an acidic medium to mild acidic or neutral, or it could serve as a buffer.[14,15]

***Manahshila* (Realgar)**: In the *Shodhana* of *Manahshila* by *Adraka Swarasa*: a) Phytochelation: Phytochelatins are heavy metal-binding peptides that play an important role in the detoxification of heavy metals by chelation. Ginger contains two important sulphur-based amino acids called cysteine and methionine which can act as phytochelatins and can render arsenic non-toxic in *Manahshila*. b) Methylation: methylation is a process of detoxifying arsenic in the body through accelerated excretion. This process takes place in the liver by the addition of a methyl group to the arsenic and transforms it into a non-toxic form which is then excreted. Cysteine, which is a methyl donor peptide in ginger, helps in the process of methylation. c) Preservation of Glutathione: Glutathione, a natural antioxidant recycling enzyme is an important detoxifying compound present in the blood, which combines with arsenic and excretes it via bile. Arsenic poisoning reduces the level of glutathione in the blood. It has been shown that, following ingestion ginger reduces the fall in the amount of Glutathione in the blood. Hence, it supports detoxification as well as combatting its possible depletion due to arsenic. d) Neutralization of alkalinity: Ginger is acidic with a pH value of 3.6 and *Manahshila* has a pH of 8.15. Because of its acid-base reaction, the alkalinity of *Manahshila* is reduced and is safe to use.[16]

***Sadharana Rasa*:** *Sadharana Rasa* are eight in number i.e., *Kampillaka* (*Mallotus philippinensis muell*-arg), *Gauripashana* (white arsenic), *Navsadara* (Ammonium Chloride), *Kapardika* (Marine shell), *Agnijara* (Ambergris), *Girisindura* (red oxide of mercury), *Hingula* (Cinnabar), *Mridarshringa* (Litharge).

Table 3: *Sadharana Rasa* and media used for their *Shodhana* process

S.no.	*Sadharana Rasa*	Media used
1.	*Kampillaka* (*Mallotus philippinensis* muell-arg)	*Jala*
2.	*Gauripashana* (white arsenic)	*Tanduliya Swarasa,* goat milk, *Karvellaka, Godugdha*
3.	*Navsadara* (Ammonium Chloride)	*Jala*
4.	*Kapardika*(Marine shell)	*Amla Drava, Kanji, Nimbu Swarasa, Kultha Kwatha*
5.	*Agnijara* (Ambergris)	-
6.	*Girisindura* (red oxide of mercury)	-
7.	*Hingula* (Cinnabar)	*Nimbu Swarasa,* sheep milk*, Adraka Swarasa, Lakucha Swarasa*
8.	*Mridarshringa* (Litharge)	*Jala*

***Kampillaka* (*Mallotus philippinensis muell-arg*)**

The *Shodhana* of *Kampillaka* is done by dipping it into water. All the impurities will settle down while *Kampillaka* floats over water. The floating particles of *Kampillaka* are collected, dried and preserved.

***Gauripashana* (white arsenic):** *Karvellaka Swarasa* considered to be best for *Shodhana* of *Malla* because of

phytochemicals such as charantin, polypeptides, Ca, P, Fe, Mg etc. present in *Karvellaka Swarasa* might be reducing the toxicity of *Malla* or doing chemical detoxification.[17]

***Navsadara* (Ammonium Chloride)**: Impure *Navasadara* is first dissolved in water and the water is filtered and spread in a flat pan and kept in sunlight or under fire. After evaporation of water, white crystals are formed. It helps in the removal of physical impurities.

***Kapardika* (Marine shell):** *Kapardika Shodhana* is done by *Swedana* of *Kapardika* in *Nimbu Swarasa* using *Dola Yantra* as per the specification mentioned in Rasatarangini. The concept behind using *Nimbu Swarasa* (acidic nature) as media may probably be to reduce hardness and particle size of the drug.

***Hingula* (Cinnabar)**

***Shodhana* of *Hingula* using *Nimbu Swarasa*:** *Hingula Shodhana* is performed by *Bhavana* of *Nimbu Swarasa* for 7 times. The natural impurities present in *Hingula* are zinc, copper and antimony. Citric acid, mallicacis, retinol and amino acids present in *Nimbu Swarasa* are natural chelators. Citric acid helps in disintegration of HgS, organic acid is responsible to weaken the bond and hence facilitates dissociation of mercury. Thus, they can chelate these metals by binding to the metal ions the metal ions become ion inactive.[18]

***Shodhana* of *Hingula* using *Adraka Swarasa*:** *Hingula* when triturated with *Ardraka Swarasa*, the active constituents like Gingerdiols, gingerols, shogaols etc, may unite to form different co-ordinate complexes of ligands.[19]

***Dhatu*:** In Rasashastra, *Dhatu* has been classified as *Shudha Dhatu* (*Swarna, Rajata, Tamra, Loha*), *Puti Loha* (*Naga, Vanga, Yashada*) and *Mishra Loha* (*Pittala, Kansya, Varta Loha*).

Table 4: *Dhatu* and media used for their *Shodhana* process

S.no.	*Dhatu*	Media Used
1.	*Swarna* (Gold)	*Saindhav Lavana, Swarna Gairika, Panchmritika, Nimbu Swarasa, Kanji*
2.	*Rajata* (Silver)	*Agastya Patra Swarasa, Nimbu Swarasa, Changeli Swarasa, Jyotishmati Taila*
3.	*Tamra* (Copper)	*Nirgundi Swarasa, Kanji, Gomutra*
4.	*Loha* (Iron)	*Triphala Kwatha, Imli Patra Swarasa, Kadalimool Swarasa*
5.	*Naga* (Lead)	*Nirgundi Swarasa, Churnodaka, Goghrita, Gomutra,*
6.	*Vanga* (Tin)	*Arka Dugdha, Harida powder* mixed with *Nirgundi Swarasa*
7.	*Yashada* (Zinc)	*Churnodaka, Nirgundimool Swarasa, Arka Dugdha, Godugdha*
8.	*Pittala* (Brass)	*Harida powder* mixed with *Nirgundi Swarasa*
9.	*Kansya* (Bell metal)	*Gomutra*
10.	*Varta Loha* (Bronze)	*Ashava Mutra, Aja Mutra*

***Samanya Dhatu Shodhana*:** For *Samanya Shodhana*, *Dhatu* (metal) is heated to red-hot stage and quenching is done for 7 times in *Tila Taila*, *Takra*, *Gomutra*, *Kanji* and *Kulattha Kwatha* in order. These are acidic, acidic, basic, acidic and basic media in order. This specific order disrupts the internal structure of *Dhatu* (metal) during the process. The alternate heating and quenching in these media lead to corrosive changes in the metal and may also cause the removal of acid and alkali-soluble impurities from the metal. It should also be noted that these media were among the naturally and easily prepared sources of acid and base at ancient times.

At early stage of *Shodhana*, repeated heating and cooling of metal disrupts compression-tension equilibrium leading to cracks on the flake surface (stress corrosion theory). During red hot state, compounds are formed on the surface of metal. Expansibility differs from metal to compound on heating [generally expansibility of compound is less than metal (theory of thermal expansion)]. So, on repeated heating cracks are seen on the surface leading to breaking of metal into coarse and some fine powder. [20]

From Ayurvedic point of view

Tila Taila: It has *Sukshma* and *Ashukari* properties, by these properties it may easily and rapidly enter into the material through the cracks and intermolecular space and make film coating and causes a chemical reaction, compound formation and breaking of the material.

Takra: It has *Tikshna, Samghata-Bhedana* and *Shaithilikaran* properties which may cause softening and breaking of the material.

***Gomutra*:** It has *Dahana* and *Pachana* properties. So, it may wear out the material and this way it may cause eradication of undesired substances from the material.

***Aranala/ Kanji*:** It also has the same properties like *Takra* and may cause softening and breaking of the material.

Kulattha Kwatha: It has *Ashmari Bhedana* property. This property may cause breaking of the material. All these liquid media act as cooling media during process of *Nirvapa*, these may serve a favourable atmosphere to the material for the occurrence of particular chemical reactions and compound formation. According to *Rasarnava*, the *Kshara Dravya* are used for eliminating impurities. *Amla Rasa Dravya* are used to introduce *Prabhodhana* in the metal and *Sneha Dravya* are used to produce softness in the metal. They may also act as source of inorganic traces.

***Rajata* (Silver):** *Samanya Shodhita Rajata* is again heated till red hot and quenched in *Nimbu Swarasa* seven times repeatedly. On repeated *Nirvapa*, porosity develops in the *Rajata* foil, bonding between silver atoms becomes loose and some bonds are seen to break up. During the *Nirvapa*, inorganic and organic compounds present in liquids come in contact with hot foils of silver and dissociate due to high temperature (700 degree Celsius) and may react with silver atoms. Thus, few elements infuse with the silver atoms. When *Nirvapa* process is done further, many elements react with compounds of the medium used. As the process of *Nirvapa* is done several times in 6 different media, repeated chemical reactions take place.[21]

When *Nirvapana* of *Rajata* is done in *Nimbu Swarasa*, due to *Ushna*, *Tikshna*, *Chedana*, *Bhedana*, *Deepana*, *Pachana Karma* there may be *Shithilata* in *Dravya sanghatana* or *Dravya samyojana*. The *Nimbu Swarasa* contains citric acid, Citrine 76%, and Sulphuric acid. The acidic nature of *Nimbu Swarasa* may be responsible for corrosive effect on the metal. After *Vishesha Shodhana* the metal become more brittle.

***Tamra* (Copper):** *Vishesha Shodhana* of *Tamra* is done by *Swedana* of *Tamra* in *Gomutra* using *Dola Yantra*. Possible hypothesis for conduction of this process may be further micropurification and impregnation of qualities for Bhasma preparation. In this process, components of *Gomutra* may pierce through the micropores and cracks created during Samanya *Shodhana* and may produce the required change specific to *Tamra* for further process. There might be reaction between ammonia from *Gomutra* and copper to form the cuprammonium ion $[Cu(NH3)_4]$, a water-soluble chemical complex. This complex gets washed away during washing with hot water.[22]

***Loha* (Iron):** Regarding the excessive use of *Triphala* in the processing of *Lauha*, we can say that it mainly consists of tannins and ascorbic acid. The absorption of food iron can be greatly influenced by other constituents in the diet, such as ascorbic acid (vitamin C) and phenolics. Ascorbic acid increases the bioavailability of iron by converting Fe^{3+} to Fe^{2+}, while phenolics can reduce the bioavailability of iron by binding to its phenolics (e.g., tannins). Excess of ascorbic acid and/or a lack of dietary tannins have both been suggested as contributing to clinical/ pathological iron storage disease. Too much iron is toxic. It can damage the liver, heart and pancreas and irritate the stomach and gut, causing constipation or diarrhoea. In other words, this may also be taken as the various constituent of *Triphala* is antagonizing the function of one another. Thus, too much absorption is prevented.[23]

***Vanga* (Tin)**

***Samanya* and *Vishesha Shodhana* using *Churnodaka* and *Nirgundi* decoction mixed *Haridra* powder respectively:** *Samanya Shodhana* (general purification) is done by *Dhalana* using *Churnodaka* (lime water) for seven times. *Vishesha Shodhana* (specific *Shodhana*) is done using *Nirgundi* (*Vitex nigundo* Linn.) decoction mixed *Haridra* (*Curcuma longa* Linn., Turmeric) powder for three times.

In *Samanya Shodhana* of *Vanga* (Tin), it is melted at 232°C and poured into lime water and the same process is repeated for seven times. On heating, the Sn-Sn bonds get energized and when plunged into lime water get broken into smaller fragments by reacting with water in which lime is present, resulting in probably, free Sn radicals. These free radicals react further with water producing SnOH (Tin hydroxide). Similarly, this type of heating and quenching in lime water, a large amount of slag formed and floats on water or seen floating over molten tin, ultimately converting to $Sn(OH)_4$ floating on surface. This compound, $Sn(OH)_4$ (Tin Tetra hydroxide) may react with $Ca(OH)_2$ (calcium hydroxide) in lime water at high temperature. This compound formation depends on concentration of $Ca(OH)_2$in lime water.

Since elemental tin is present along with the hydroxides from the very beginning, there is every likely hood of reactions of lower tin hydroxides like Sn(OH), $Sn(OH)_2$, $Sn(OH)_3$, $Sn(OH)_4$ with lime (calcium oxide, CaO) forming lower stannite.

In *Vishesha Shodhana* of *Vanga*, it is heated to melt more than temperature 232°C on electric heater and poured in to *Nirgundi* decoction mixed with *Haridra* powder. The same process was repeated for three times using fresh liquid. Turmeric powder adhered to tin catches fire during heating, forms carbonaceous material and floats over molten tin. Molten *Vanga* when comes in contact of liquid produces loud blasting sound. Melting duration of *Vanga* is extended on every *Dhalana* procedure due to presence of carbonaceous material.

The active components of *Nirgundi* and *Haridra* containing groups such as COOH- (carboxylic acid group), -OH- (phenolic group) may behave as acids and deprotonate to react with tin at high temperature.

When molten tin is added to decoction of *Nirgundi* mixed with *Haridra* powder, free metal particles of tin were generated during heating may react with water to give $Sn(OH)_2$, $Sn(OH)_3$, $Sn(OH)_4$ compounds. Further these compounds may react with organic chemicals containing COOH- (carboxylic acid group), -OH- (phenolic group) present in *Nirgundi* decoction or *Haridra* powder.[24]

***Naga* (Lead)**

***Shodhana of Naga using Churnodaka* (Lime water)**

Vishesha Shodhana was done by seven times quenching of melted *Naga* in *Churnodaka.*

Heating of *Naga* up to complete melting creates expansion in the molecules and sudden cooling after quenching in liquid media creates abrupt compression in the molecules. Repeated heating and sudden cooling help to break the bonds between molecules and thus help in increasing the brittleness of the metal. Some fraction of *Shodhana* media also forms a thin coating on the surface of metal which also helps to impregnate organic molecules in the metal. Moreover, heating of Naga in an iron ladle also creates a chemical reaction between the surface of melted Naga and oxygen present in the air. This leads to the formation of lead oxide (PbO) which was found in yellowish powder form floating over the surface of melted Naga. [25]

DISCUSSION

In *Rasashastra*, most of the drugs contain lot of impurities and toxic elements in their crude form. These are extremely toxic and fatal, if administer in their crude form. Hence, *Shodhana* is a preliminary step towards therapeutic administration. This is a process in which *Kshalana* (washing), *Mardana* (pounding), *Bhavana* (levigation), *Swedana* (boiling), *Bharjana* (frying), *Nirvapa* (Heating and dipping in specified liquids) etc are carried out on mineral drugs with a view to eliminate impurities. The media used in the process of *Shodhana* has very important role in either breaking down or destroying the chemical constituent that is not required as well as modify the active principles & enhance therapeutic action of substance. Hence, the concept of *Shodhana* is not merely a process of purification but also a process resorted to enhance the potency and efficacy of the drug.

Triphala Kwatha has been used for the *Shodhana* of various *Dravyas* such as *Abhraka*, *Makshika*, *Loha*, *Mandura*, *Shilajatu* etc. Ascorbic acid present in *Triphala Kwatha* has been known to antagonize the intestinal absorption of copper. More recent studies have characterized a post-absorption role for ascorbate in the transfer of copper ions into cells. The mechanism is unclear but nonetheless suggest both positive and negative regulatory functions for ascorbate in copper metabolism. Ascorbic acid increases the bioavailability of Fe by converting Fe^{+3} to Fe^{+2}, while phenolics can reduce the bioavailability of Fe by binding, for example, tannins. Excess of ascorbic acid and a lack of dietary tannins have both been suggested as contributing to clinical/pathological Fe storage disease. *Triphala* is a mild laxative and thereby counteracts the constipating property of iron and copper.

Godugdha (cow milk) also helps in *Shodhana* of various *Dravyas* such as *Abhraka, Shilajatu, Gandhak etc*. It contains various salts and minerals like calcium sulphate, potassium, magnesium phosphates, sodium chloride and trace of phosphate of iron and mineral salts as compounds of calcium, potassium, sodium, phosphorus, iron and chlorine present in the milk may react with the constituents present in the *Dravyas*, thus separating out impurities or toxic matter from it.

Nimbu Swarasa (lemon juice) has been mentioned for the *Shodhana* of *Tuttha*, *Hartala*, *Hingula*, Lemon juice is a rich supplier of vitamin C and vitamin B complex, which acts as an intrinsic-factor in the absorption of iron in the body providing a synergistic effect. Citric acid helps in disintegration of HgS, organic acid is responsible to weaken the bond and hence facilitates dissociation of mercury. Thus, they can chelate these metals by binding to the metal ions the metal ions become ion inactive.

The major constituents of *Kushmanda* (*Benincasa hispida*) fruits were volatile oils, flavonoids, glycosides, sugar, mannitol, cucurbitin, histidine-like amino acids, carotenes, vitamins, minerals, ß-sitosterin anduronic acid. A research study shows that flavonoids can flush out arsenic from the body. Sugar and mannitol present in *Kushmaanda Swarasa* may be helpful in the excretion of arsenic through urine. Histidine is an alpha amino acid with an imidazole functional group that humans and other mammals require. Imidazole has good antifungal activity. It may help to enhance the Kushthghna property of Hartala.

Adraka Swarasa is used in the *Shodhana* of *Manahshila* as it contains two important sulphur-based amino acids called cysteine and methionine which can act as phytochelatins and can render arsenic non-toxic in *Manahshila*. Cysteine is also a methyl donor peptide in ginger, helps in the process of methylation by detoxifying arsenic in the body through accelerated excretion. Glutathione, a natural antioxidant recycling enzyme in the body and arsenic poisoning reduces the level of glutathione in the blood. It has been shown that ingestion of ginger reduces the fall in the amount of Glutathione in the blood. Ginger is acidic (3.6) and *Manahshila* is basic (8.15) in nature. Because of its

acid-base reaction, the alkalinity of *Manahshila* is reduced and is safe to use.

Lime water is used primarily as a softening agent and is highly alkaline in nature. It might help to remove alkaline-soluble impurities from the mineral. Calcium present in lime water is enhancing the surface adsorption of arsenic onto the solids in solution.

Gomutra helps in *Shodhana* of *Tamra* as ammonia from *Gomutra* reacts with copper to form the cuprammonium ion [Cu(NH3)4], a water-soluble chemical complex. This complex gets washed away during washing with hot water.

CONCLUSION

Acharyas have mentioned various medias for the *Shodhana* of different *Maharasa, Uprasa, Sadharna Rasa* and *Dhatus.* Different studies have shown that these media help to remove impurities as well as impart therapeutic value to the substance. There are various medias for *Shodhana* of a single substance. So, media is selected by individual as per their therapeutic need. This study includes the medias which are chosen by different scholar according to the need of their study.

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