

PURIFICATION AND DETOXIFICATION PROCEDURES FOR METAL *TĀMRA* IN MEDIEVAL INDIAN MEDICINE

C Y JAGTAP*, B J PATGIRI** AND P K PRAJAPATI***

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Different *śodhana* (purification and/or detoxification) procedures are prescribed for *lauhas* (metals) including *tāmra śodhana* in different classics of *rasaśāstra*. Thirty- two classics of *rasaśāstra* belonging to 8-20th century AD were reviewed to compile the different processes, analyze them, and establish their scientific basis by correlating with some modern concepts. Out of thirteen methods of *sāmānya śodhana* for *lauhas*, nine methods of *nirvāpa* (heating and quenching in prescribed medium) were found. On *tāmra śodhana* procedures, twenty six *nirvāpa*, eight *pācana* and six special procedures were recommended. In *nirvāpa*, quenching was done in *taila*, *takra*, *gomūtra*, *kānjī*, and *kulattha kvātha* for several times in each in subsequential manner. Objective of *nirvāpa* was to eliminate impurities by reduction in particle size along with induction of anticipated therapeutic qualities. It involves size reduction as explained by Griffith theory, stress corrosion cracking and caustic embrittlement. The objectives of the procedure seems to eliminate physical and chemical impurities, eradicate or minimize toxicity of the material; transform the hard and non-homogeneous material to soft, brittle and homogeneous material; potentiate therapeutic efficacy of the drug material; and to convert the material in suitable form for further processing. An appraisal of *tāmra śodhana* procedures establishes the scientific nature of *rasaśāstra* and wisdom of ancient Indian seers.

Key words: *Lauha*, *Nirvāpa*, *Rasaśāstra*, *Śodhana*, *Tāmra*

INTRODUCTION

Rasaśāstra (science of pharmaceuticals and alchemy) is one of the branches of *āyurveda* (science of life) dealing with the alchemical and

* Ph.D Scholar, Institute of Post Graduate Teaching and Research in Ayurveda, Gujrat Ayurveda University, Jamnagar, 361008; email: drshikhar84@gmail.com

** Reader, Institute of Post Graduate Teaching and Research in Ayurveda

*** Professor and Head, Institute of Post Graduate Teaching and Research in Ayurveda

pharmaceutical process of herbs, metals, minerals of aquatic and soil origin.¹ It is a treasury of pharmaceutical processing like *śodhana* (purification and/or detoxification), *māraṇa* (calcinations), etc. These methods are developed to detoxify the raw material by chemical transformations and enhance the respective therapeutic potentials.^{2,3} Among various procedures, *śodhana* has its own importance. This process is primary step in preparation of *rasauśadhis*. A wide range of *śodhana* methods are prescribed for metals, minerals and other substances in different classics of *rasaśāstra* including many precious and dynamic concepts. To correctly appreciate and establish the scientific nature of *rasaśāstra*, it is necessary to reappraise the old facts, concepts and practices in order to reconfirm the old concepts or even correcting and modifying them.

Copper is the first metal ever discovered and used by man or at least one of the oldest.⁴ Many references of uses of *tāmra* (copper) are also found in Vedas. *Tāmra dhātu* (metal) has a unique role in *rasaśāstra* as it is used for various purposes like *lohasiddhi* (changing metal from lower to higher potency), *dehasiddhi* (disease free long life). The *pārada* (mercury) is passed through eight types of purifications (*aṣṭasaṃskāras*) and has been given much importance among the different metals especially regarding its toxic nature. Before using it in different formulations it should be processed thoroughly and properly. *Aśodhita* (unpurified), *apakva* (improperly prepared) *tāmra* likewise has been quoted as poison because of its hazardous effects on the body.⁵ *Aṣṭamahādoṣas* (eight major ill effects) of *tāmra* have been quoted and due emphasis have been given to its *śodhana* procedure.⁶

In the present study, different *tāmra śodhana* procedures are compiled and classified into different sections. The discussion has been done to justify the utility of different materials and procedures in *tāmra śodhana*. All this exercise will provide an insight into the fundamentals of *śodhana* of metals especially with reference to physical and chemical concepts.

MATERIALS AND METHODS

Sāmānya śodhana procedures of all the *lauhas* (metals) were compiled (Table 1). To screen out the *tāmra śodhana* procedures, thirty two classics of *rasaśāstra* belonging to 8th to 20th century AD were reviewed. List of textbooks is as below: *Rasārṇavam* (RNV)⁷, *Rasaḥṛadayatantra* (RHT)⁸,

Ānandakāṇḍa (AK)⁹, *Rasendramaṅgala* (RMg)¹⁰, *Rasopaniṣat*¹¹, *Rasaratnākara Riddhikhaṇḍa* and *Rasakhaṇḍa* [RR (Ri & Ra)]¹², *Rasendra cintāmaṇi* (RCi)¹³, *Rasaratnasamuccaya* (RRS)¹⁴, *Rasendrasārasaṅgraha* (RSS)¹⁵, *Āyurveda prakāśa* (AP)¹⁶, *Śāraṅghara saṁhitā* (SSMK)¹⁷, *Rasendra cūḍāmaṇi* (RCu)¹⁸, *Rasaparakāśasudhākara* (RPS)¹⁹, *Rasasaṁketakalikā* (RSK)²⁰, *Lohasarvasvam* (LS)²¹, *Yogataraṅgiṇī* (YT)²², *Rasakāmadhenu* (RKD)²³, *Rasapaddhati* (RP)²⁴, *Rasakaumudī* (RK)²⁵, *Rasamañjarī* (RM)²⁶, *Rasadarpaṇa* (RD)²⁷, *Rasataraṅgiṇī* (RT)²⁸, *Bṛhat rasarājasundara* (BRRS)²⁹, *Rasāmṛtam* (Rmr)³⁰, *Rasendra purāṇa* (RPu)³¹, *Rasendra saṁbhava* (RSam)³², *Rasajalanidhi* (RJN)³³, *Rasāyanasāra* (RaSa)³⁴, *Rasatantrasāra va Siddhaprayoga saṅgraha* (RTSSPS)³⁵, *Bhāratīya rasaśāstra* (BR)³⁶, *Āyurvedīya auśadhi guṇadharmasāstra* (AAG)³⁷.

Table 1. Text wise description of drugs and procedures used for *sāmānya śodhana* of *lauhas*

Sr. No.	Textual reference	śodhana drugs/media	Procedure	No. of repetition/duration
1	RCi 6.3-4, RRS 5.13, RSS 1.245-246; AP 3.49-51, Rmr 3.4-5	Taila → takra → gomūtra → kṅjī → kulattha kvātha	Heating and dipping (Nirvāpa)	7
2	YT 1.72-73	Taila → takra → gomūtra → kṅjī → kulattha kvātha	Nirvāpa	Frequency not mentioned
3	RCi 6.5, AP 3.54, RKD, RT 15.7	Kadalīmūla svarasa	Nirvāpa	7
4	SSMK 11.2-3, RJN	Taila → takra → kṅjī → gomūtra → kulattha kvātha (for svarṇa, tāra, tāmra dhātus)	Nirvāpa	3
5	RR (Ri) 3.105-106	Taila → takra → gomūtra → kṅjī → arka dugdha → kulattha kvātha → jambira svarasa	Nirvāpa	7
6	RP 49; AP 3.48	Takra → kṅjī → gomūtra → tila taila → kulattha kvātha	Nirvāpa	21

Sr. No.	Textual reference	Śodhana drugs/media	Procedure	No. of repetition/duration
7	RNV 7.116-117	<i>Snuhī</i> and <i>arka kṣīra</i> , <i>halinī</i> , <i>kaṁcukīkanda</i> , <i>citraka</i> , <i>gunjā</i> , <i>karañja</i> , <i>dhattūra</i> , <i>aśvagandhā</i> , <i>indravāruṇī mūla</i> – all these kept in <i>māhiṣa takra</i> for 7 days	<i>Nirvāpa</i>	1
8	RMg 1.54	<i>Jambira rasa</i> + <i>karkaṭaśṅgi rasa</i> / <i>kvātha</i>	Trituration and boiling (<i>bhāvanā</i> & <i>svedana</i>)	1
9	RK 3.1-2	<i>Amla kṣāra</i> , <i>snuhī</i> and <i>arka kṣīra</i> , <i>dhattūra</i> , <i>citraka</i> , <i>triphalā kvātha</i>	<i>Nirvāpa</i>	7
10	RM 5.2½	<i>Taila</i> → <i>takra</i> → <i>gomūtra</i> → <i>kulattha kvātha</i> → <i>kānjī</i>	<i>Nirvāpa</i>	7
11	RD	<i>Taila</i> → <i>takra</i> → <i>gomūtra</i> → <i>kānjī</i> → <i>triphalā kvātha</i>	<i>Nirvāpa</i>	7
12	RT 15.4-6	<i>Kānjī</i> → <i>takra</i> → <i>kulattha kvātha</i> → <i>gomūtra</i> → <i>tila taila</i>	<i>Nirvāpa</i>	3
13	BR	<i>Taila</i> → <i>takra</i> → <i>gomūtra</i> → <i>kānjīkā</i> → <i>ravidugdha</i> → <i>kulattha kvātha jambira drava</i>	<i>Nirvāpa</i>	7

For easy understanding, procedures of *tāmra śodhana* were classified on the basis of main procedure involved in them. Procedures involving the principle of *nirvāpa* (heating and quenching) and *pācana* (boiling in the prescribed medium) were separated (Table 2 and Table 3). The procedures which cannot be included in these categories and are special were compiled separately (Table 4). *BRRS*³⁸, *RPu*³⁹ and *RSam*⁴⁰ explain specific drugs to nullify the specific *tāmra doṣa* (Table 5). Different drugs used in the *tāmra śodhana* procedures were classified as drugs of herbal origin (Table 6), drugs of animal origin (Table 7) and drugs of mineral origin (Table 8).

Table 2. *Viśeṣa śodhana* of tāmra by nirvāpa method as per different classics

Sr. No.	Reference	Drugs used for lepana on tāmra	Media for nirvāpa	Repetition/ Duration
1	RNV 7.106	<i>Snuhī kṣīra, arka kṣīra, lavaṇa, kṣāra, amla</i>	<i>Nirgunḍī svarasa</i>	<i>bahuśā</i> (many times)
2	RHT 9.13	<i>Lavaṇa, kṣāra, amlavarga, snuhī kṣīra, arka kṣīra</i>	<i>Nirgunḍī svarasa</i>	-
3	RR (Ra) 8.47, RCi 6.10	<i>Snuhī kṣīra, arka kṣīra, lavaṇa, kānjī</i>	<i>Nirgunḍī svarasa</i>	12
4	RJN, RR(Ra) 8.48-49½; AK 2.4.17-18	<i>Khamikā, lavaṇa, takra, āaranāla</i>	<i>Nirgunḍī svarasa</i>	6
5	RRS 5.50, RJN, AK (KV) 4.10	<i>Saindhava lavaṇa and nimbu rasa</i>	<i>Sauvīraka</i>	8
6	RRS 5.51, RJN, AK (KV) 4.11	<i>Saindhava lavaṇa and nimbu rasa</i>	<i>Nirgunḍī svarasa</i>	8
7	RM 5.26, RMg 1.52	<i>Lavaṇa, vajradugdha</i>	<i>Nirgunḍī svarasa</i>	7
8	RM 5.27	—	<i>Snuhi kṣīra, Arka kṣīra</i>	7
9	AP 3.118	—	<i>Snuhi kṣīra, Arka kṣīra</i>	-
10	AP 3.118, RPu 13.12-13	<i>Snuhī kṣīra, arka kṣīra, lavaṇa</i>	<i>Nirgunḍī svarasa</i>	3
11	RSam 2.273	<i>Paṭu (Saindhava), ravidugdha</i>	<i>Nirgunḍī svarasa</i>	-
12	RaSa	—	<i>Taila, takra, gomūtra, kānjī, kulathāmbu, amlikā kvātha, nimbukāmbu, kumārī rasa, sūraṇa rasa, godugdha, nārikela jala, mākṣika (madhu)</i>	7
13	RPu 13.11	—	<i>Taila, takra</i>	-

Sr. No.	Reference	Drugs used for <i>lepana</i> on <i>tāmra</i>	Media for <i>nirvāpa</i>	Repetition/ Duration
14	<i>RPu</i> 13.14	—	<i>Vajra & arka dugdha</i>	-
15	<i>LS</i> 120	—	<i>Māhicḍī takra</i>	7
16	<i>RJNAK (KV)</i> 4.15-16	<i>Snuhī, arka kṣīra, lavaṇa, kānjīka</i>	<i>Nirgunḍī svarasa</i>	12
17	<i>AK (KV)</i> 4.18-19	<i>Amla takra</i>	<i>Tiktaka rasa</i> and <i>Lavaṇayukta kānjī</i>	3
18	<i>RSS</i> 1.270	<i>Saindhava lavaṇa</i> and <i>arka dugdha</i>	<i>Nirgunḍī svarasa</i>	-
19	<i>RCu</i> 14.46	<i>Saindhava lavaṇa</i>	<i>Sauviraka</i>	8
20	<i>RCu</i> 14.47	<i>Saindhava lavaṇa</i> and <i>Nimburasa</i>	<i>Nirgunḍī svarasa</i>	8
21	<i>RCu</i> 14.48-50	<i>Kṣīra</i> and <i>tintiḍphala kalka, lavaṇa, nimburasa</i>	<i>Nirgunḍī svarasa</i>	7
22	<i>RK</i> 3.2	—	<i>Amla – kṣāra, snuhī kṣīra, dhātura, chītraka, triphala kvātha, gomūtra</i>	7
23	<i>Rmr</i> 3.39	<i>Lavaṇa</i> and <i>arkadugdha</i>	<i>Nirgunḍī svarasa</i>	7
24	<i>RT</i> 17.12	<i>Cāmgerī patra svarasa</i>	—	21
25	<i>RT</i> 17.15	<i>Arka – Snuhī dugdha</i> and <i>saindhava lavaṇa</i>	<i>Nirgunḍī svarasa</i>	7
26	<i>RT</i> 17.18	<i>Trikṣāra</i> and <i>kānjī</i>	<i>Nirgunḍī svarasa</i>	7

Table 3. *Viśeṣa śodhana* of *tāmra* by *pācana* method as per different classics

Sr. No.	Reference	Procedure	Media	Repetition/ Duration
1	<i>RJN, RSam</i> 2.274; <i>AP</i> 3.119; <i>RCi</i> 6.11	<i>Pācana</i>	<i>Amla, kṣāra</i> added in <i>gomūtra</i>	1 <i>Yama</i> (3 hours)
2	<i>RSam</i> 2.275	<i>Pācana</i>	<i>Nilapuṣpa svarasa</i>	1 day

Sr. No.	Reference	Procedure	Media	Repetition/ Duration
3	<i>RPu</i> 13.15	<i>Pācana</i>	<i>Cincā</i> & <i>patu</i> added in <i>gomūtra</i>	1 <i>Yama</i> (3 hours)
4	<i>RSK</i> 2.18	<i>Pācana</i> by <i>dr̥dhāgni</i> (strong heat) for 1 <i>aha</i> (day) and then <i>kṣālana</i> (washing) by <i>vāri</i> (<i>Jala</i>)	<i>Gomūtra</i>	15
5	<i>RR(Ra)</i> 8.50; <i>RRS</i> 5.52; <i>AK (KV)</i> 4.19; <i>RM</i> 5.28; <i>RSS</i> 1.271; <i>Rmr</i> 3.39½	<i>Pācana</i> by <i>dr̥dhāgni</i>	<i>Gomūtra</i>	1 <i>Yama</i> (3 hours)
6	<i>RT</i> 17.13	<i>Pācana</i>	<i>Nirgunḍī svarasa</i>	1 day
7	<i>RT</i> 17.14	<i>Pācana</i>	<i>Saindhava lavaṇa</i> , <i>kānjī</i>	1 day
8	<i>RT</i> 17.17	<i>Pācana</i>	<i>Saindhava</i> (1/8 th part) in <i>gomūtra</i>	2 <i>Yama</i> (6 hours)

Table 4. Special methods

Reference	Procedure
<i>RCu</i> 14.45; <i>RRS</i> 5.49; <i>RJN</i> ; <i>AK (KV)</i> 4.9	<i>Tāmra</i> with <i>kṣāra</i> and <i>amla</i> melted in <i>mūṣā</i> (crucible) and <i>gairika</i> is added; <i>Nirvāpa</i> is done in <i>māhiṣī takra</i> mixed with <i>gomaya</i> . Procedure repeated for 7 times.
<i>RR (Ri)</i>	Seven <i>Bhāvana</i> of <i>Jambīrī nimbu svarasa</i> are given to <i>triṣāra</i> and <i>pañcalavaṇa</i> . Paste is smeared on <i>tāmra patra</i> . <i>gajapuma</i> is given.
<i>RPS</i> 4.36	<i>Tāmra</i> should be mixed with six times of <i>Nāga</i> (lead) and <i>Dhamāpana</i> should be done until whole <i>nāga</i> from it gets removed completely.
<i>Rasopaniṣat</i>	Very complex procedures of <i>śodhana</i> of <i>tāmra</i> have been mentioned. But these procedures are for <i>dhātuvāda</i> . These procedures are to remove <i>kālikā</i> (blackness) and <i>kalmāṣa</i> (impurities) from <i>tāmra</i> and <i>pittala</i> (brass) and to improve their color. 12/26-31: Keep the following drugs soaked in <i>amla varga rasa</i> and <i>amla takra</i> for 3 nights – <i>guñjā</i> , <i>laṃgalī</i> , <i>nāgabālā</i> , <i>śleśmāṃtaka</i> , <i>baṃḍākī</i> ,

Reference	Procedure
	<i>āmrakara, gojivhā, vidārīkanda, pīluparṇi, rakta citraka, madana, palāśa.</i> Then by heating <i>tāmra patra</i> they should be dipped in these for 21 times in each. <i>Tāmra patra</i> should be pounded every time. After that these should be smeared with <i>viṣṭhāvarga</i> (as many as available) and <i>pācana</i> should be done by <i>puṭapāka</i> method for 21 times. After that this should be taken in <i>mūcā</i> and <i>dhamana</i> done to melt it. It is then poured into <i>surā, jyotiṣmati taila</i> and <i>karamṇja taila</i> for 21 times in each. After all this procedures <i>tāmra</i> becomes <i>kāñcanābhāsa</i> (golden color), <i>kālikarahita</i> (devoid of blackness), <i>doṣavarjitam</i> (free from flaws), <i>akṣaya</i> (non reducible), <i>sarva kriyāyogya</i> (capable of doing all processes). This <i>tāmra</i> is further used in the preparation of Gold.
<i>Vṛddha vaidyādhāra (AAG)</i>	Copper filings are taken. It is kept in <i>takra</i> for 4-5 days. Fresh <i>takra</i> is added daily after washing <i>tāmra</i> . After 5 days filings are washed with water; dried and kept in <i>taila</i> for 24 hours. After that it is heated on fire until oil burns completely and <i>tāmra</i> becomes red hot. Sprinkling of <i>takra</i> is done on this red hot <i>tāmra</i> and continuous stirring is done. Again it is heated to red hot and <i>takra</i> is sprinkled on it. The procedure is repeated again and again.
<i>RTS SPS</i>	Thin electric copper wires are taken, heated to red hot and quenched in <i>taila, takra, kāñjī, gomūtra, kulattha kvātha, dāḍīma</i> and <i>arka patra svarasa</i> for 7 times in each medium. After that it is powdered in mortar and this is taken in <i>haṇḍikā</i> (earthen pot) filled with <i>gomūtra</i> added with <i>cīncā</i> and salt; boiled for 12 hours. After cooling it is washed with water.

Table 5. List of specific drugs used for *śodhana* of specific *doṣa* of *tāmra*

Sr. No.	Doṣa	śodhana drug
1	<i>Vānti</i>	<i>Tīla taila, takra, gomūtra</i>
2	<i>Bhrānti</i>	<i>Kulattha kvātha, āranāla</i>
3	<i>Klama</i>	<i>Godugdha</i>
4	<i>Samtāpa</i>	<i>Nimbu rasa, Cīncā patra svarasa</i>
5	<i>Śūla</i>	<i>Nārikel jala, Kumari svarasa</i>
6	<i>Kaṇḍū</i>	<i>Godugdha, Ajādugdha</i>
7	<i>Virecana</i>	<i>Dadhi, Sūraṇa</i>
8	<i>Vīryaharatva</i>	<i>Yaṣṭīmadhu</i>

Table 6. Description of drugs of herbal origin used in śodhana of tāmra

Sr. No.	Name of the drug	English name	Latin name	Used for
1	<i>Tila taila</i>	Sesame oil	<i>Sesamum indicum</i> Linn.	Nirvāpa
2	<i>Kulattha kvātha</i>	Decoction of Horse gram	<i>Dolichos biflorus</i> Linn.	Nirvāpa
3	<i>Snuhī (vajra) kṣīra</i>	Latex of common milk hedge	<i>Euphorbia nerifolia</i> Linn.	Lepana, Nirvāpa
4	<i>Arka (ravi) kṣīra</i>	Latex from <i>madāra</i>	<i>Calotropis procera</i> R.Br.	Lepana, Nirvāpa
5	<i>Arka patra svarasa</i>	Juice of leaves of <i>madāra</i>	<i>Calotropis procera</i> R.Br.	Nirvāpa
6	<i>Sūraṣa svarasa</i>	Juice of corm	<i>Amorphophyllus campanulatus</i> Blume.	Nirvāpa
7	<i>Nirguṇḍī (nīlapuṣpa) svarasa</i>	Juice of five leaved chaste	<i>Vitex negundo</i> Linn.	Nirvāpa, Pācana
8	<i>Kumārī rasa</i>	Juice of Indian aloe	<i>Aloe vera</i> Tourn.	Nirvāpa
9	<i>Nimbu svarasa</i>	Juice of lime	<i>Citrus medica</i> Watt.	Lepana, Nirvāpa, Pācana
10	<i>Jambūrī nimbu svarasa</i>	Juice of lemon	<i>Citrus limon</i> Linn. Burm.f.	Lepana
11	<i>Tintiphala (Cincā) kalka</i>	Pulp of Tamarind	<i>Tamarandus indica</i> Linn.	Lepana, Nirvāpa
12	<i>Cincā patra svarasa</i>	Juice of leaves of Tamarind tree	<i>Tamarandus indica</i> Linn.	Nirvāpa
13	<i>Cāṅgerī patra svarasa</i>	Juice of leaves of Indian sorrel	<i>Oxalis corniculata</i> Linn.	Lepana, Nirvāpa
14	<i>Dāima svarasa</i>	Juice of pomegranate	<i>Punica granatum</i> Linn.	Nirvāpa
15	<i>Triphala kvātha</i>	Decoction of three myrobalans (Embelic, Chebulic and Belleric)	<i>Emblica officinalis</i> Gaertn., <i>Terminalia chebula</i> Retz., <i>Terminalia bellerica</i> Roxb.	Nirvāpa
16	<i>Nārikela jala</i>	Coconut water	<i>Cocos nucifera</i> Linn.	Nirvāpa
17	<i>Dhātura</i>	Thorn apple	<i>Dhātura metel</i> Linn.	Prakcepa
18	<i>Citraka</i>	Leadword	<i>Plumbago zyleneica</i> Linn.	Prakcepa
19	<i>Yaṣṭīmadhu</i>	Liquorice	<i>Glycyrrhiza glabra</i> Linn.	Nirvāpa
20	<i>Amlavarga</i>	Group of sour herbs	—	Lepana, Nirvāpa, Pācana

Table 7. Description of drugs of animal origin used in *śodhana* of *tāmra*

Sr. No.	Name of the drug	English name	Used for
1	<i>Takra</i>	Buttermilk	<i>Lepana, Nirvāpa</i>
2	<i>Māhiṣī takra</i>	Buttermilk from buffalo milk	<i>Nirvāpa</i>
3	<i>Dadhi</i>	Curd	<i>Nirvāpa</i>
4	<i>Dadhi mastu</i>	Whey of curd	<i>Nirvāpa</i>
5	<i>Ghṛita</i>	Ghee (cow)	<i>Nirvāpa</i>
6	<i>Kṣīra</i>	Milk (cow)	<i>Nirvāpa</i>
7	<i>Godugdha</i>	Cow milk	<i>Nirvāpa</i>
8	<i>Ajādugdha</i>	Goat milk	<i>Nirvāpa</i>
9	<i>Gomūtra</i>	Cow urine	<i>Nirvāpa, Pācana</i>
10	<i>Gomaya</i>	Cow dung	<i>Nirvāpa</i>
11	<i>Madhu</i>	Honey	<i>Nirvāpa</i>

Table 8. Description of drugs of mineral origin used in *śodhana* of *tāmra*

Sr. No.	Name of the drug	English name	Used for
1	<i>Gairika</i>	Red ochre	<i>Prakṣepa</i>
2	<i>Saindhava, paṭu</i>	Rock salt	<i>Lepana, Pācana</i>
3	<i>Khaṭikā</i>	Chalk	<i>Lepana</i>
4	<i>Kṣāra</i>	Salt	<i>Lepana, Pācana</i>
5	<i>Trikṣāra</i>	Three salts (<i>sajjikṣāra, yavakṣāra</i> and <i>ṭāṅkaṇa</i>)	<i>Lepana, Pācana</i>
6	<i>Pañcalavaṇa</i>	Five salts (<i>Saindhava, audbhida, sāmudra, biḍa</i> and <i>sauvarcala</i>)	<i>Lepana, Pācana</i>
7	<i>Amla</i>	Acidic media	<i>Lepana, Pācana</i>
8	<i>Aarnala / kānjī</i>	Sour gruel prepared from grains like rice etc.	<i>Lepana, Pācana, Nirvāpa</i>
9	<i>Sauvīraka</i>	Acidic fermented product	<i>Nirvāpa</i>

OBSERVATIONS AND DISCUSSION

Śodhana is a procedure of elimination of *doṣa* (impurity/toxicity/flaw) in a drug.⁴¹ The term *doṣa* indicates not only impurities but also all that which makes the drug unsuitable for further process or therapeutic use. According to *Rasaśāstra*, different procedures like *prakṣālaṇa* (washing), *svedana* (boiling), *nirvāpa* (heating and quenching) etc adopted to remove the *mala* (impurities) are called *śodhana*.⁴² Generally impurities of drugs are of three types – natural, physical and chemical. The main objective of *śodhana*

procedure is to remove/reduce these impurities from the drugs improving their therapeutic effects and minimizing their undesired toxic effects. In some cases *śodhana* may lead to such physico chemical transformation of a substance making it feasible for therapeutic use directly whereas in some cases it makes the material suitable for further procedure/s. The metals and minerals which hail from mines, the chances of natural, physical and chemical impurities are more in them. To make these metals and minerals free from impurities and suitable for the body pharmacotherapeutically, each and every *Rasaśāstra* text commonly explains the procedure of *śodhana*.

Śodhana procedures of metals have been broadly classified into two types - *sāmānya* (general) and *viśeṣa* (specific). First one is commonly applicable for a group of materials or number of materials whereas latter one is specific for a particular drug/material. Out of thirteen *sāmānya śodhana* methods for *lauhas* (metals), nine methods of *nirvāpa* (heating and quenching in prescribed medium/a) were found. Variation in the frequency and sequence of quenching media is observed among the different methods. Seven methods among thirteen advocate the frequency of repetition of *nirvāpa* procedure as seven. *YT* doesn't mention the frequency whereas *RP* has mentioned the same as twenty one. Three times of repetition of *nirvāpa* procedure is mentioned in *SSMK*, *RJN* and *RT*. Commonest sequence of media of quenching is as *taila* → *takra* → *gomūtra* → *kānjī* → *kulattha kvātha*. *RP*, *AP* and *RT* have more or less altered this sequence. Some other media like *kadalīmūla jala* (expressed juice of tuber of *Muṣa paradisiaca*), *jambīra drava* (juice of *Citrus limon* Linn.), *arkadugdha* (latex of *Calotropis procera* R.Br.) and *kvātha* (decoction) of herbs are also found mentioned.

Nirvāpa

In spite of such variations in *sāmānya śodhana* procedures of *lauhas*, *nirvāpa* is the commonest among them. It is performed in two stages. In first stage metals/minerals are heated up to red hot state, and in second stage, red hot metals or minerals are quenched in prescribed liquid media. This process is repeated for specified times (frequency) in particular media. In this process changes are expected to occur at three phases: phase of heating, phase of quenching and post quenching interaction between solid hot material and cold liquid media.

First Phase: When heated metals or minerals, expand, this leads to increase in intermolecular spaces and deformation of crystal lattice.⁴³ Metals are solid, closed packed crystal structure. The condition in which a number of atoms occupy equilibrium positions of this kind in an aggregate is known as the solid state of matter.⁴⁴ The distance between such positions is the inter-atomic distance. Displacement of the equilibrium in either direction can be accomplished only by the application of a force of some kind, and a solid structure resists either an inward force, a compression, or an outward force, a tension. To the extent that resistance to tension operates to prevent separation of the atoms of a solid, it is commonly known as the force of cohesion.⁴⁵ By the application of force in the form of heat, the tension in matter is increased, causing increase in inter-atomic distance (linear expansion).⁴⁶ This causes weakening of electro-static forces. During red hot state, some metals react with atmospheric oxygen and compounds are formed on the surface. Expansibility differs from metals to compounds on heating.⁴⁷ So on repeated heating cracks are seen on the surface (generally expansibility of compounds are less than metals) leads to separation of compound part.

Second phase: After heating, immediate cooling in liquid media leads to decrease in tension and increase in compression force. Repetition in heating and cooling causes disruption in compression tension equilibrium which leads to increased brittleness, reduction in hardness and finally, reduction in the particle size.^{48, 49}

Third phase: After quenching and during instant cooling recrystallization occurs along with the reformation of grain boundaries.⁵⁰ In this reconstructed structure, each grain/ion is surrounded by the molecules of liquid media, may be imposing its properties on that purified metal.

Role of medium(a): Quenching in different liquids with different pH, different levels of heat, chemical composition will have an impact on the composition of the final product. This invariably affects the characteristic features physically, chemically and pharmacologically as mentioned below.

Tila taila has *snigdha* (unctuous), *sūkṣma* (subtle) and *āsukāri* (quickly acting) properties.⁵¹ By these properties it may easily and rapidly enter into the material through the cracks and intermolecular space, and makes film coating and further heating causes chemical reaction, compound formation and breaking of the material. Organic principles present in *taila* may induce

organic properties to the metal. *Takra* is having *amla* (sour/acidic), *saṅghāta bhedana* (union breaking) and *śaithilikaraṇa* (loosening) properties.⁵² It is acidic in nature and it removes *snigdghata* (unctuousness) imparted by *tila taila*. By these properties, it may cause softening and breaking of the material. *Gomūtra* (cow urine) have *tīkṣṇa* (sharp), *kṣaraṇa* (corrosive) and *pācana* (digestive) properties.⁵³ So it may cause worn-out of the material, and this way it may cause eradication of undesired substances from the material. *Kānjī* is also having *tīkṣṇa*, *bhedana* properties and may cause softening and breaking of the material. *Kulattha kvātha* has *aśmarī bhedana* (urolithiatic) property. By this property it may cause breaking of the material. Intensity of *tīkṣṇatā* increases in rising order in case of these media from *taila* to *kulattha kvātha*. It also induces organic nature to the material. These liquid media act as cooling media during *nirvāpa*; these may serve a favorable atmosphere to the material for occurrence of particular chemical reactions and compound formation. They may also act as source of inorganic traces. S-adenosyl-1-methionine is one of the many important substrates which can be found in all the five media of *sāmānya śodhana*. It provides an edge on the chelation of the metals making then biofriendly.⁵⁴ Regarding the use of different media for *sāmānya śodhana* of metals/minerals, Shuchi Mitra et al (2009) have postulated that microorganisms present in specific media at specific pH act on biomass and remove toxic elements by the process of biobeneficiation; yet it is needed to prove it on scientific grounds.⁵⁵

The ultimate objective of the *nirvāpa* in the *śodhana* of metals seems to be the reduction in particle size along with induction of anticipated therapeutic qualities. The size reduction during *śodhana* by *nirvāpa* process may be explained by three theories:

Griffith theory – According to this theory, all solids contain flows and microscopic cracks.⁵⁶ A flow is any structural weakness that may develop into a crack under strain like heat. The weakest flow in a particle determines its fracture strength. Usually the surface of particles is irregular. The applied force by the form of heat is initially taken on the high portion of the surface. As a result, high stress may be set up locally in the particles. The bonds at this place become weak, which may be responsible for creating flaws. The particle with the weakest flow fractures most easily and produces largest possible pieces. In the next step, another weakest flow fractures. By this way particle size is reduced.

Theory of Stress corrosion cracking (SCC) – It is the inter-granular or trans-granular cracking of a material due to the combined action of tensile stress and a specific environment.⁵⁷ It can lead to unexpected sudden failure of normally ductile metals subjected to a tensile stress, especially at elevated temperature in the case of metals. SCC is highly chemically specific means where specific metals are cracked by attack of specific solutions. For example certain austenitic stainless steels and aluminum alloys crack in the presence of chlorides, mild steel cracks in the presence of alkali (boiler cracking) and nitrates, copper alloys crack in ammoniacal solutions (season cracking). In *nirvāpa* procedure this specificity of chemicals is provided by the acidic and alkaline media.

Phenomenon of hydrogen embrittlement – In this phenomenon, atomic hydrogen which ingresses into the metal or alloy during various processes reduces the ductility and load bearing capacity causing cracking and brittle failure.⁵⁸ In relation to *nirvāpa* procedure, hydrogen produced by corrosion reactions may enter the metal in atomic form leading to increased brittleness of metals. Like SCC hydrogen embrittlement occurs in a number of forms but the common features are an applied tensile stress and hydrogen dissolved in the metal.

Thus, finally, regarding the procedures employed for *sāmānya śodhana* of metals it can be inferred that these procedures not only remove the impurities but also make the metals brittle which could be powdered easily for subjecting them to further pharmaceutical processes like *māraṇa*.

Among the different *lauhas*, much emphasis has been given to the *tāmra śodhana*. Forty two *doṣas* of *tāmra* have been found in different classics.⁵⁹ What makes the *tāmra* as poison? Copper is non toxic in metallic state.⁶⁰ When alloyed with other metals and converted to fine powder it acts as poison. The toxic nature of copper may be mainly attributed to its salts like copper sulphate (blue vitriol) and copper sub-acetate (verdigris). Both of these are irritant poisons. The sign and symptoms in acute poisoning of these salts are metallic taste in mouth, increased salivation, burning pain in mouth, nausea, eructation, repeated vomiting, thirst, diarrhea with much straining etc.¹⁶ These can be correlated to the *aṣṭamahādoṣas* of *tāmra* like *bhrama* (giddiness), *mūrcchā* (unconsciousness), *vidāha* (burning), *svedana* (sweating), *kledana* (moistening), *vānti* (vomiting), *aruci* (nausea),

cittasantāpa (mental irritation). Food contaminated with copper, derived from vessels in which it has been prepared or kept, commonly contains copper either as sub-acetate or carbonate; leads to the toxicity.¹⁶ Due to such high toxic nature, seers have rightly emphasized the *śodhana* of *tāmra*.

For *śodhana*, it is advised to take *tāmra patra* (sheets of copper). It is found quoted in twenty two procedures to take thin sheets of copper. To define the thinness of sheets, *ācāryās* have given characters like *sūcivedhi* (which can be pierced by needle), *kariṅṅakavedhi* (which can be pierced by thorn of *Acacia arabica* Linn.). Use of thin sheets facilitates the procedure. For the *nirvāpa* procedure, these sheets have to be heated to red hot state. Before this, *lepāna* (smearing) of some materials is done on *tāmra patra*. This process of smearing was found in eighteen procedures out of twenty six procedures of *nirvāpa* for the *viśeṣa śodhana* of *tāmra*. *Snuhī kṣīra* (latex of *Euphorbia nerifolia* Linn.), *arka kṣīra* (latex of *Calotropis procera* Linn.), *saindhava lavaṇa* (rock salt), and *kānjī* (sour gruel) are the commonest drugs mentioned for *lepāna*. Other drugs include *ciṁcā kalka* (pulp of *Tamarandus indica* Linn.), *nimbu rasa* (juice of *Citrus medica* Watt.), *khaṭikā* (chalk), *takra* (buttermilk), *amlavarga* and *kṣāravarga*. These *lepāna* materials are acidic and alkaline in nature. Addition of latex of *snuhī* and *arka* facilitates the formation of paste which can be easily smeared on sheets. After heating to red hot state, these *tāmra patra* are immediately dipped into the prescribed media. Out of twenty six procedures of *nirvāpa*, *nirgundī svarasa* (juice of *Vitex negundo* Linn.) is the medium in fifteen procedures, *sauvīraka* in two, *Snuhī kṣīra* and *arka kṣīra* in two procedures. Other media like *cāṁgerīpatra svarasa* (juice of *Oxalis corniculata* Linn.), *māhiṣī takra* (buttermilk from buffalo milk), *taila and takra*, *lavaṇayukta kānjī* (sour gruel mixed with sea salt) were found in one procedure only. *Rasāyanasāra* has given some additional media like *amlīkā kvātha* (decoction of *Tamarandus indica* Linn.), *nimbukāmbu* (juice of *Citrus medica* Watt.), *kumārī rasa* (juice of *Aloe vera* Tourn.), *sūraṇa rasa* (juice of *Amorphophyllus campanulatus* Blume.), *godugdha* (cow milk), *nārikela jala* (water of *Cocos nucifera* Linn.), *mākṣika* (honey) etc along with the *taila*, *takra* etc.

Here most of the *nirvāpa* media are acidic in nature especially *nirgundī svarasa*. Various organic acids like 6'-p-hydroxybenzoyl mussaenosidic acid, betulinic acid, ursolic acid, p-hydroxybenzoic acid, protocatechuic acid,

oleanolic acid etc along with the other phytochemical constituents give acidic nature to its *svarasa*.⁶¹ Probable reason behind the use of these acidic media can be interpreted as - after dipping into these media the alkaline *lepana* substances (*saindhava lavaṇa*, *trikṣāra* etc) react with the acidic media to form some acids in which the carbonates, sulphates of copper etc dissolve and washed away. Same is the case in *viśeṣa śodhana* of *tāmra* by *pācana* process. Eight procedures of *pācana* in different media were found. *Gomūtra* added with *saindhava* or *kṣāras*, *cincā* or *amlavarga* was the commonest media of *pācana*. Other media mentioned are *nirguṇḍī svarasa* and *lavaṇayukta kānjī*.

Use of *gomūtra* along with *kṣāras* in *nirvāpa* and *pācana* procedures can be explained by the theory of 'season cracking' which is especially related to the copper and its alloys.⁶² Copper alloys crack in ammoniac solutions. Reaction between ammonia (from *gomūtra*) and copper takes place to form the cuprammonium ion $[Cu(NH_3)_4]$, a chemical complex which is water soluble, and hence washed from the growing cracks.⁶³ Acidic and alkaline substances used during the *nirvāpa* and *pācana* procedures produce the corrosive chemical environment which favors for the stress corrosion cracking of copper.

The phenomenon of 'Caustic embrittlement' may substantiate the use of *kṣāras* in the *tāmra śodhana* procedures especially during the *pācana* in *gomūtra* by adding *saindhava*. During boiling, sodium hydroxide (NaOH) is formed (Na^+ from *saindhava* and OH^- from *gomūtra*). The presence of NaOH makes the solution alkaline. This alkaline solution enters minute cracks present in the copper by capillary action. Inside the cracks, the water evaporates and amount of hydroxide keeps on increasing progressively.⁶⁴ As seen in season cracking the formation of cuprammonium ion goes on till the boiling is done. It is then washed away with water.

CONCLUSION

Nirvāpa is the commonest procedure for the *sāmānya śodhana* of different *lauhas*. The objectives of this procedure seems to eliminate physical and chemical impurities, eradicate or minimize toxicity of the material; transform the hard and non-homogeneous material to soft, brittle and homogeneous material; induce wanted qualities; potentiate therapeutic efficacy

of the drug material; and to convert the material in suitable form for further processing. Copper sulphate and copper sub acetate are the most toxic compounds of copper which lead to serious toxic effects when consumed and thus *śodhana* of *tāmra* have been given such high importance by ancient *rasācāryās*. An appraisal of *tāmra śodhana* procedures establishes the scientific nature of *rasaśāstra*.

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ABBREVIATIONS

<i>Ānandakāṇḍa</i> — AK	<i>Rasasaṃketakalikā</i> — RSK
<i>Āyurvedīya auśadhi-</i>	<i>Rasatarāṅgiṇi</i> — RT
<i>guṇadharmasāstra</i> — AAG	<i>Rasatantrasāra va Siddhaprayoga</i>
<i>Āyurveda prakāśa</i> — AP	<i>sagraha</i> — RTSSPS
<i>Bhāratīya rasaśāstra</i> - BR	<i>Rasāyanasāra</i> — RaSa
<i>Bṛhat rasarājasundara</i> - BRRS	<i>Rasendra cintāmaṇi</i> — RCi
<i>Lohasarvasvam</i> - LS	<i>Rasendra cūḍāmaṇi</i> — RCu
<i>Rasadarpaṇa</i> — RD	<i>Rasendramaṅgala</i> — RMg
<i>Rasahrdayatantra</i> — RHT	<i>Rasendra purāṇa</i> — RPu
<i>Rasajalanidhi</i> — RJN	<i>Rasendra saṃbhava</i> — RSam
<i>Rasakaumudī</i> - RK	<i>Rasendrasārasaṅgraha</i> —RSS
<i>Rasakāmadhenu</i> — RKD	<i>Rasaratnasamuccaya</i> — RRS
<i>Rasamañjarī</i> — RM	<i>Rasaratnākara Riddhikhaṇḍa</i>
<i>Rasāmṛtam</i> — Rmr	and <i>Rasakhaṇḍa</i> — RR(Ri &Ra)
<i>Rasaprakāśasudhākara</i> — RPS	<i>Śāraṅghara saṃhitā madhyama</i>
<i>Rasapaddhati</i> — RP	<i>khaṇḍa</i> — SSMK
<i>Rasārṇavam</i> - RNV	<i>Yogatarāṅgiṇi</i> — YT

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