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A review on the principles of *Rasa Shastra* in Indian System of Medicine and its homology with Modern Chemical Processes

Parinita Kaundal[1], Ashish Arora[2]

[1]*Post Graduate Scholar, Department of Rasa Shastra Evam Bhaishajya Kalpana, R. G. G. P. G. Ayurvedic College & Hospital, Paprola, Kangra, Himachal Pradesh, India.*

[2]*Lecturer, Department of Rasa Shastra Evam Bhaishajya Kalpana, R. G. G. P. G. Ayurvedic College & Hospital, Paprola, Kangra, Himachal Pradesh, India.*

ABSTRACT

Ayurveda medicine is one of the oldest holistic healing sciences it was developed around 3000 years ago. Different branches of science were nurtured by it like biology, genetics, microbiology, clinical medicine, surgery, astronomic, pharmaceutics and metallurgy etc. In *Ayurveda* system of medicine various formulations have been described in the traditional literature, which adopted the processes which are quite similar to the processes used today in modern medicine for formulation of various dosage forms to get the desired effect for the optimum period. Science and technology in ancient and medieval India covered all the major branches of human knowledge and activities. In any, early civilization, metallurgy has remained an activity central to all civilizations from the Bronze Age and the Iron Age, to all other civilizations that followed. Various chemicals like common salt, alkali, borax, and compounds of elements Cu, Fe, Hg and Au were used as well as techniques for making of the alloys were also very common. The applicability of natural preservatives like oil, sugar, salt were also very much known in ancient time. However, the terms used as stated in traditional literature were not similar to the modern times. Also, the acidic and alcoholic fermented products were prepared very commonly.

Key words: *Ayurveda, Rasa Shastra,* pharmaceutics, metallurgy, clinical medicine.

INTRODUCTION

Chemistry, as we understand it today, is not a very old discipline. It was not studied for its own sake, rather it came up as a result of search for two interesting things: a) *Philosopher's stone (Paras)* which would convert all baser metals e.g., iron and copper into gold. b) *'Elexir of life'* which would grant immortality. People in ancient India, already had the knowledge of many scientific phenomenon much before the advent of modern science. They applied that knowledge in various walks of life. Chemistry developed mainly in the form of Alchemy and Iatrochemistry during 1300-1600 CE.[1]

In Ancient India, an important role in the development of chemistry was made by Ayurveda which used a variety of minerals. Chemistry in Ancient India was called *Rasayan Shastra*, *Rasatantra*, *Rasa Kriya* or *Rasa Vidya* roughly translating to 'Science of Liquids. Science and technology in ancient and medieval India covered all the major branches of human knowledge and activities, including mathematics, astronomy, physics, chemistry, medical science and surgery etc.[2]

Remains of glazed pottery have been found in Mohenjodaro. Gypsum cement has been used in the construction work. It contains lime, sand and traces of

Address for correspondence:
Dr. Parinita Kaundal
Post Graduate Scholar, Department of Rasa Shastra Evam Bhaishajya Kalpana, R. G. G. P. G. Ayurvedic College & Hospital, Paprola, Kangra, Himachal Pradesh, India.
E-mail: parinita.pk@gmail.com

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$CaCO_3$. Harappans made faience, a sort of glass which was used in ornaments. They melted and forged a variety of objects from metals, such as lead, silver, gold and copper. They improved the hardness of copper for making artefacts by using tin and arsenic. A number of glass objects were found in Maski in South India (1000–900 BCE), and Hastinapur and Taxila in North India (1000–200 BCE). Glass and glazes were coloured by addition of colouring agents like metal oxides.[3]

Nagarjuna was a great Indian scientist. He was a reputed chemist, an alchemist and a metallurgist. His work *Rasratnakar* deals with the formulation of mercury compounds. He has discussed methods for the extraction of metals, like gold, silver, tin and copper. A book, *Rasarnavam*, appeared around 800 CE. It discusses the uses of various furnaces, ovens and crucibles for different purposes. It describes methods by which metals could be identified by flame colour. This type of evidences related to ancient development in technological era indicates the well awareness of fundamentals of science and technology among ancient societies.[4]

Materials and Methods

Data and evidences were collected from secondary sources which include books, articles, Wikipedia etc.

The concept of Matter

The concept that matter is ultimately made of indivisible building blocks, appeared in philosophical speculations. *Acharya Kanda*, born in 600 BCE, originally known by the name *Kashyap*, was the first proponent of the 'atomic theory'. He formulated the theory of very small indivisible particles, which he named '*Paramanu*' which are eternal, indestructible, spherical, suprasensible and in motion in the original state. He explained that this individual entity cannot be sensed through any human organ. *Acharya Kashyap* added that there are varieties of atoms that are as different as the different classes of substances. He said these (*Paramanu*) could form pairs or triplets, among other combinations and unseen forces cause interaction between them. He conceptualized this theory around 2500 years before John Dalton (1766-1844).[5]

Stoichiometry and Mole concept

The word 'stoichiometry' has been derived from the Greek word 'Stoicheion' means 'elements'and 'metrein' means 'to measure'. The numericals used to balance a chemical equation are known as stoichiometric coefficients. These numbers are essential for solving problems based on chemical equations. The mole method is very useful in such calculations. In Rasa Shastra, in *Sada Guna Rasabali Jarana* of *Parad*, many authors like *Rasaratna Samuchaya*, *Rasa Tarangani*, and *Ayurveda Prakash* advocated the use of Sulphur by six times of mercury because in this ratio both of these should react completely. In accordance to modern concepts mole theory, 1 mole of Hg equals to 200.6 gm and 1mole of Sulphur equals to 32.07gm. Hence, in order to complete the reactions to stochiometrically, the required amount of Sulphur should be six time of mercury (6×32.07 = 192.42) and it is almost equal to requirements of the condition.[6]

Hg (Mercury) + S (Sulphur) = HgS (Mercuric Chloride)

1 Mole (200.7gm) +1 Mole (32.06gm) =1Mole (232.76gm)

Isomeric compound showing variation in colors due to particle size

Isomers are different compounds that have the same molecular formula but the atoms are attached in different ways.[7] Different types of *Rasa Bhasma* like *Rasa Parpatti, Rasa Sindura* & *Sarvangsundar Rasa* are black, red and yellow in color respectively.

Similar variation of colours has been observed in *Swarna Makshika Bhasma* initially greenish-black pellets were turned to brownish-black after 3rd *Puta*, from 3rd to 8th *Puta* colour of product was observed blackish-brown and testing parameters did not sustain.[8]

After 11th firing the colour of the product was observed Reddish brown and found competent with all the *Bhasma Parikshya* including *Amla Parikshya*. This is considered due to variation in *'Agni'* i.e., quantum of heat applied. This process of calcination have three types of colour production in '*Swarna Makshika Bhasma.'*[9]

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- *Samagni* → Greenish black
- *Kharagni* → blackish-brown
- *Hathagni* → Reddish brown

It has also been studied by modern instrumentation techniques that the color difference is due to particle size variations. 6 differences in particle size of various formulations of *Bhasma* obtained by different treatments of '*Agni*' are associated with adopted method for dosage form development and media used in preparation of *Bhasma*.[10]

Placement of elements in period table

The periodic table is arranged by atomic weight and valence electrons. These variables allowed Mendeleev to place each element in a certain row (called a period) and column (called a group). The table comprises seven rows and 18 columns. Each element in the same row has the same number of atomic orbitals (the spaces where electrons exist) as the others in that row or period. That means all of the elements in the third period - sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chlorine and argon - have three atomic orbitals where their electrons reside. Meanwhile, the column or group signifies the number of electrons in the atom's outermost shell; these are called the valence electrons, and they are the electrons that can chemically bond with valence electrons of other elements. The valence electrons can be either shared with another element, a type of covalent bonding, or exchanged in a type of ionic bonding.[11]

Placement of Copper/Currency Metals place in same *Varga*

Group 11, of the periodic table consists of three metals - copper, silver and gold. These are collectively called as copper metals (copper being the predominant member) or coinage metals or currency metals because these have been used in the past in making coins for currency. They have similarities on the basis of number of electrons in the outer shell. Except for iron, these three metals were placed in '*Shudhaloha*' by Rasavagbhatta.[12]

Group 12 (IIB) of the periodic table consists of three elements namely zinc cadmium and mercury. These are collectively called as 'zinc metals' as zinc is predominant member. The melting and boiling point are low. These are volatile in nature and easily convert in to vapour state. According ally unstable metals and one who is capable of making these thermally stablto '*Rasa Ratna Samuchya"* Mercury and Calamine (ore of Zinc) both are thermal shall become the master of this science.[13]

Tin and lead place in same Varga Group 14 or IV A of long form of periodic table consist of five elements-carbon, silicon, germanium, tin, and lead. The last two elements (tin and lead) of this series were categorized in *Puttiloha* by *Rasvagbhatta* under *Lohavarga.*[14]

Naming of elements

Mercury has been described as *"Galad Rupaya Nibham"* in rasa Shastra classical texts.[11] It means liquid silver. Similarly Hg is the modern chemical symbol of mercury. It comes from hydrargyrum, a Latin form of the Greek word 'hydrogyrus' which is a compound word meaning "water Silver"-since it is liquid like water and shiny like silver.[15]

Formation and the structure of crystals

There are two main categories of solids - crystalline solids and amorphous solids. Crystalline solids are those in which the atoms, ions, or molecules that make up the solid exist in a regular, well-defined arrangement. The smallest repeating pattern of crystalline solids is known as the unit cell, and unit cells are like bricks in a wall - they are all identical and repeating. The other main type of solids are called the amorphous solids. Amorphous solids do not have much order in their structures. Though their molecules are close together and have little freedom to move, they are not arranged in a regular order as are those in crystalline solids.[16] Common examples of this type of solid are glass and plastics. *Puspa Kasis* (Ferrous Sulphate) is found in two forms-(1) *Baluka Kasis* & (2) *Puspa Kasis.* The first forms is crystalline in nature while second is amorphous in nature. Further, different crystal systems have been mentioned i.e., *Vaikranta* is Hexagonal, Vazara - Tetrahedralbipyramidal, Vimal - Tetragonal, Abhraka - Foliated (Monoclinic).[17]

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Instruments in Rasa Shastra

Rasa Shastra dealt with the metallic, mineral and poisonous drugs. These drugs were pharmaceutically processed and rendered fit for the internal administration. Various processes performed during Rasa Kriya require special type of instruments and arrangements of these instruments.[18]

- Baluka Yantra[19] - Sand Bath
- Dola Yantra[20] - Indirect heating arrangement
- Tryak Patana Yantra[21] - Downward displacement apparatus
- Putta[22] - basic type of furnace
- Musha[23] - crucible

Flame test

A flame test is an analytical procedure used in chemistry to detect the presence of certain elements, primarily metal ions, based on each element's characteristic emission spectrum. The color of flames in general also depends on temperature and oxygen fed.[24] In 12th century, Acharya *Bhairvanand Yogi* described flame test as *Jwala Parikasha* in his book '*Rasarnava*'.[25]

Particle size estimation/*Bhasma Pariksha*

Various traditional methods are prescribed in the *Ayurvedic* texts for characterization of the *Bhasma*. These methods are still in practice and have a great importance in evaluation of *Bhasma*.[25]

Varitara

In this the prepared *Bhasma* is sprinkled over the surface of stagnant water. If some *Bhasma* floats then it is said to be properly prepared and if it sinks then it is incomplete. Usually, a metal or mineral is heavier than water and sinks in water but when the same is converted into *Bhasma* the gravitational force created by the weight of the particles is less that it is unable to break the surface tension of water and hence floats.[26]

In this method, two principle of physical chemistry are accompanying first is colloidal dispersion and second is surface tension of liquid or water.

The most obvious method of dispersion consists of breaking down the coarser solid by mechanical grinding. This is done by *Bhawana* (wet trituration) with the help of mortar & pestle. In this way, the size of particle is reduced to such extent that their surface area increases many times.

Surface of a liquid behaves as it is in a state of tension. The force that tends to contract the surface of a liquid is known as surface tension. Surface tension may be defined as the force in dynes acting at right angles to the surface of a liquid along one centimeter length of the surface. It would take a force of 72.8 dynes to break a surface film of water at 250°C.

The density of *Bhasma* particles become so much lower than the original substance due to increase in surface area that the law of buoyancy is satisfied. The ultimate result is that *Bhasma* particles float on water surface. Hence, the particle size of Bhasma ranges between 0.2µ to 10Å.[27]

Apurnarbhava

Jaggery, *Gunja, Tankana, Madhu* and *Ghrita* are taken in equal quantity and mixed thoroughly and it is then mixed with equal quantity of *Bhasma* and heated in a *Musha*. After cooling it is observed for the presence of shining metal particles in it. If free metal particles are present, it shows that the *Bhasma* is incomplete. The *Mitrapanchaka* when heated turns to carbon and this carbon acts as a reducing agent thus bringing out the loosely bonded metal from the *Bhasma*. The *Tankana* helps in reducing the melting point of metal and hence if the *Bhasma* is not properly prepared or unstable, the shining particles are seen.[28]

Rusting of Iron

The iron reacts with water and oxygen to form hydrated iron (III) oxide, which we see as rust. Iron and steel rust when they come into contact with water and oxygen – both are needed for rusting to occur. Rusting is an electrochemical process that reduces iron-containing metals into their natural, unrefined states. Metals are extracted from their ores and nature again tries to convert metals in to their ore form. When iron is exposed to moist air, it is covered with a reddish-

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brown coating which can easily be detached. In 'Rasa Tarangani' this rust is termed as "*Mandura*", also stated that it must be used after 60 year for making medicines. A 100 year old *Mandura* is best in quality.[29]

Clarification of muddy water

In developing countries, ground water, which is contaminated with domestic and industrial waste, is commonly used for drinking. Color, turbidity and microbial content affect quality of potable water. The seed of *Nirmali* tree *Strychnos potatorum* Linn., showed coagulation properties in clarifying turbid water. This property was attributed to the presence of anionic polyelectrolytes having -COOH and free-OH surface groups that are present in the seed protein. This was told by *Acharya Sushruta* million of years ago that *Katak* (Nirmali) is one of the substances used in the clarification of water told by Acharya Sushruta, *Katak* (*Strychnos potatorum*) seeds are very hard and non-poisonous.[30]

CONCLUSION

Now, as we can see that the concepts of modern chemistry that are being discovered now, were not new to the ancient Indian Acharya. Every concept was well explained in the ancient classical texts. Due to the lack of interest and lethargic attitude of medieval and modern Indians, these researches got the new terminology and modern form e.g. Pythagoreans theorem (*Baudhayana*), law of gravity (*Bhaskaracharya*) and invention of decimal system, and still so many ancient researches are not fully comprehensible as these are in *Sutra* (codified) forms and most of the researchers have lack of interest in '*Sanskrit*' texts. Moreover, it can be concluded that in *Ayurveda* so many principles and fundamentals of sciences in general and of chemistry in particular are described that these have broad scope of their applicability for the welfare of human being.

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