Journal of History, Art and Archaeology

Vol. 4, No. 1, 2024, pp. 61-74

URL: www.arfjournals.com
https://doi.org/10.47509/JHAA.2024.v04i01.07

A HISTORICAL REVIEW ON THE BOTANICAL FACETS OF *BṚHAT SAṂHITA*- VARĀHAMIHIRA'S *MAGNUM OPUS*

RAGHAVA S. BODDUPALLI
Institute of Sanskrit and Vedic Studies (ISVS), Sri Siddhi Vinayaka Temple, Sastry Memorial Hall, Sanjayanagar, Bangalore. E-mail: raghava7boddupalli@gmail.com

Abstract: *Varāhamihira's most famous work was Bṛhat Saṃhita. It is an encyclopedic work on architecture, temples, planetary motions and many other topics.The Bṛhat Saṃhita described various morphologic and physiologic features of vegetation as hydrologic indicators to locate sources of ground water at different depths.Hence, the Bṛhat Saṃhita establishes Varāhamihira as the first hydrologist who codified all the then existing knowledge on the subject in his magnum opus.Altogether, there are more than 545 herbs, shrubs, trees and crops that were mentioned in the two parts ofBṛhat Saṃhita. The vṛkṣāyurveda chapter deals with treatment of plant diseases and prescriptions of remedies, nutritional and other aspects of plant life.The plants that are revealed in the Bṛhat Saṃhita can be classified into huge trees, edible fruit trees, shrubs, herbs, creepers, water plants, grasses, pulses, cereals, wild cereals and others, as per the Bentham and Hooker taxonomic system of plant classification. Till date, there is no systematic study on the flora or botany of this historical work on Bṛhat Saṃhita. Therefore, a systematic floristic study and the uses of these plants/trees are comprehensively discussed in this review article.*

Keywords: *Varāhamihira, Bṛhat Saṃhita, plants, flora, plant indicators, floristic analysis*

Received : 2 May 2024
Revised : 26 May 2024
Accepted : 12 June 2024
Published : 30 June 2024

TO CITE THIS ARTICLE:

Boddupalli, R.S. (2024). A Historical Review on the Botanical Facets of *Brhat Samhita*-Varahamihira's *Magnum Opus*. *Journal of History, Art and Archaeology*, 4: 1, pp. 61-74. *https://doi.org/10.47509/JHAA.2024.v04i01.07*

Introduction

Trees and forests augment manifold the beauty of the earth. They are the very basis of human life and the biosphere. Plants are one of Earth's greatest resources. They are sources of food, medicines and materials with vast economic and cultural importance. In the four Vedas, there are many herbs, vines, shrubs and tree species are described (Boddupalli, 2019). Following the

Vedic texts, several ancient epics to till recent Sanskrit texts described various plants and trees that are useful for humanity.

One such Sanskrit text that was the most valuable contribution to the scientific world is the *Bṛhat Saṃhita* by Varāhamihira. Among 106 chapters described in the *Bṛhat Saṃhita*, Varāhamihira designated seven (07) chapters for plants and named them as flowers and plants (*kusumalata*), on Indra's banner and house building (*Indra dhvaja*), on undercurrents/plant indicators (*dakargala*), gardening (*vṛkṣayurveda*), forest trees (*vanasampraveśa* or *vanapraveśa*), perfumes (*gandhayukti*) and on tooth-brushes (*dantakaṣṭha-lakṣaṇa*). There are three glossaries of medical and botanical terms. It also deals with a wide range of subjects of human interest, such as astrology, planetary movements, eclipses, rainfall, clouds, architecture, growth of crops, manufacture of perfume, matrimony, domestic relations, gems, pearls, and rituals (Bhattotpala, 1895; Chakravarty, 1991; Iyer, 1884). Each of these subjects has been treated, keeping in view its significance as an augury or its astrological effects (Sastri and Bhat, 1946).

Varāhamihira and his Monumental Works

Acharya Varāhamihira, son of Ādityadāsa, also called Varāha or Mihira, born in the year 505 in Avanti, Ujjain, Madhya Pradesh, India and died in 587. According to one of his own works, he was educated at Kapitthaka (Shastri, 1969; Shastri, 1991; O'Connor and Robertson, 2000). He was an Indian philosopher, astronomer, mathematician and editor of the *Pancha-siddhantika* (Five Treatises, as we know it), a compendium of Greek, Egyptian, Roman, and Indian astronomy (Bhattotpala, 1895; Iyer, 1884).

Varāhamihira studied *Jyotiṣa* (astrology) from his father, Ādityadāsa. Both father and son were worshippers of Sun God. Āryabhata, the celebrated astronomer was older than Varāhamihira but the two met frequently at Kusumapura in Magadhadesa. Varahamihira's knowledge of Western astronomy was thorough. An intellectual with a broad outlook, Varāhamihira who respected learning wherever it was found, was intimately acquainted with the astrological literature of the Greeks to which he makes a reference in his works, but he was not a blind follower of old ideas. The outstanding works of Varāhamihira are *Panchasiddhantika*, *Vivahapatala*, *Bṛhajjātaka*, *Laghujātaka*, *Yātra* and *Bṛhat Saṃhita* possibly written in that order. The Panchasiddhantika is a summarization of five siddhāntic texts that were known to Varāhamihira. These are, the *Saura Siddhāntika*, *Pauliśa Siddhāntika*, *Romaka Siddhāntika*, Vaśiṣṭha *Siddhāntika* and *Paitāmaha Siddhāntika* (Bhaṭṭoṭpala 1895, Chakravarty 1991).

Varāhamihira belongs to the galaxy of Indian scientists that include Dhanvantari, Caraka, Susruta, Āryabhata and Bhāskarācharya whose fields of specialization ranged from medicine and surgery to mathematics. In the long history of Bharatiya Jyotiṣa (Indian Astrology), Varāhamihira stands supreme as a versatile personality. His greatest work, *Bṛhat Saṃhita,* deals with an astonishing variety of subjects of exceptional interest and value. Al Biruni, the Arabian astronomer who translated the *Laghujātaka* of Varāhamihira into Arabic, eulogizes the *Bṛhat Saṃhita* for its richness in details (Bhat 1996). Astronomy, architecture, sculpture, medicine, psychology, physiology, botany, zoology, groundwater and other subjects are treated in a masterly fashion and the language and style used prove Varāhamihira to be a poet of high order in Sanskrit. He had a great admiration for Kālidāsa. A later tradition includes them among the nine jewels of Vikramāditya's court, but their contemporaneity has been disproved (Sarma, 1981).

Varāhamihira's chief work, *Bṛhat Saṃhita,* deals with an astonishing variety of subjects of exceptional interest and value. Al Biruni, the Arabian astronomer who translated the *Laghujataka* of Varāhamihira into Arabic, eulogizes the *Bṛhat Saṃhita* for its richness in details. Astronomy, architecture, sculpture,

medicine, psychology, physiology, botany, zoology, groundwater and other subjects are treated in a masterly fashion and the language and style used prove Varāhamihira to be a poet of high order in Sanskrit. He had a great admiration for Kālidāsa. A later tradition includes them among the nine jewels of Vikramāditya's court, but their contemporaneity has been disproved (Sarma, 1981).

Among 106 chapters described in the *Bṛhat Saṃhita*, Varāhamihira designated seven (07) chapters for plants and named them as flowers and plants (*kusumalatā*), on Indra's banner and house building (*Indra dhvaja*), on undercurrents/plant indicators (*dakārgala*), gardening (*vṛkṣāyurveda*), forest trees (*vanasampraveśa* or *vanapraveśa*), perfumes (*gandhayukti*) and on tooth-brushes (*dantakāṣṭha-lakṣaṇa*). There are three glossaries of medical and botanical terms. The *Bṛhat Saṃhita* described various morphologic and physiologic features of vegetation as hydrologic indicators to locate sources of ground water at different depths. Hence, the *Bṛhat Saṃhita* establishes Varāhamihira as the first hydrologist who codified all the then existing knowledge on the subject in his *magnum opus*.

Previous works on Bṛhat Saṃhita

A perusal of literature survey indicates that majority of published information of *Bṛhat saṃhita* is on the *jyotiṣa* and astronomy. Iyer (1984) published the *Bṛhat Saṃhita* in two volumes with English translation. Bhaṭṭoṭpala (1895) made a commentary for all ślokas of *Bṛhat Saṃhita* in Sanskrit language. Seal (1915) published information on chapter 54 of *Bṛhat Saṃhita* with English translation of the Sanskrit ślokas of Varāhamihira. Majumdar (1927) published a book on *Vanaspati* wherein he brought out some rudimentary information on the chapter 54 of *Bṛhat Saṃhita*. Sastri and Bhat (1946) brought a book on *Bṛhat Saṃhita* with English translation and notes. Shastri (1969) published a book on *Bṛhat Saṃhita*. Prasad (1980) published a research article on plant indicators of *Bṛhat Saṃhita* of chapter 54. Sarma (1981) published a book on Varāhamihira. Murthy (1987) published an article on Varāhamihira, the earliest hydrologist with information on plants of chapter 54. Bhat (1996) brought a two voluminous book on English translated *Bṛhat Saṃhita*. Vanadeep *et al*., (2012) studied 27 meteorological predictions and were compared with the on-site real-time recorded values of meteorological parameters like rainfall, wind velocity, wind direction, cloud direction, etc. over four Indian regions. Joshi *et al*., (2013) published an ancient water exploration technique based on Varāhamihira's *Bṛhat Samhita*. Majority of the publications provided information on the plants of chapter 54 of *Bṛhat Saṃhita*. Goyal (2014) brought out a report on the ancient water exploration practices based on Varāhamihira's *Bṛhat Saṃhita* and the results have been discussed considering conditions prevailing in forests and deserts separately. It is evident from the above-mentioned literature survey that only on undercurrents/plant indicators (*dakārgala*, chapter 54) of *Bṛhat Saṃhita* is floristically explored partially. There is no information on plants/trees from the other chapters of *Bṛhat Saṃhita* dealing with botanical aspects. Hence, there is a need to publish on the floristic analysis and on the plants and trees that were described in the other five chapters of the *Bṛhat Saṃhita* by Varāhamihira.

Discussion

Bṛhat Saṃhita

The *Bṛhat* Saṃhita consists of 106 chapters with a total of nearly 4000 ślokas (verses). It deals with a large range of subjects, including the movements of planets and their influence on human life, geography, architecture, iconography, omens, manufacture of cosmetics, botany, precious stones and so on. Encyclopaedic in character, the *Bṛhat* Saṃhita must have been of immense use to people, particularly to the kings of ancient India, providing guidance in their daily life in respect of many things. It shows the range and wide sweep

of Varāhamihira's mind. One can obtain a very good idea of India of Varāhamihira times from the study of the *Bṛhat Saṃhita* (Shastri, 1969; Vanadeep *et al*., 2012).

Among 106 chapters in the *Bṛhat Saṃhita*, Varāhamihira designated six chapters for plants/trees and named them as (1) *kusumalatā* on flowers and plants, (2) Indra dhvaja or *dhvajastambha* on trees for house-building, (3) *dakārgala* on undercurrents/plant indicators, (4) *vṛkṣāyurveda* on gardening, (5) *vanasampraveśa* or *vanapraveśa* on forest trees, (6) *gandhayukti* on perfumes and (7) *dantakāṣṭha-lakṣaṇa* on tooth-brushes. There are glossaries of botanical terms for three chapters. Though he intermittently mentioned on plants in other chapters, but the predominant chapters are 29, 54, 55, 59, 77 and 85 on botany and plants.

Flowers and Plants *(kusumalatā)*

In the Chapter 29 of *Bṛhat Saṃhita* explains on majority of herbs, crops and weed plants with its characteristic feature of the particular plant or tree. There are 14 ślokas in this chapter. The floristic analysis is as follows - 45 tree species, 14 shrubs, nine (09) herbs, four (04) cereal crops, five (05) legume crops and two (02) water plants are included. In the śloka 1, it describes if the *Śāla* tree (*Shorea robusta* Roth.) should bear fruits and flowers, *kalama* (white rice) will grow in abundance; if the red *aśoka* (*Saraca indica* L.) should bear fruits and flowers red paddy will grow; if the *kṣīrika* should bear fruits and flowers white paddy will grow and if the black *Aśoka* should bear fruits and flowers black rice will grow. In the śloka 2, the growth of the *Nyagrodha* (the banyan tree, *Ficus benghalensis* L.) indicates the growth of yava (barley, *Hordeum vulgare*); the growth of *tinduka* [tendu, *Diospyros malabarica* (Desr.) Kostel.] indicates the growth of the *saṣṭika* rice; and the growth of the *aśvattha* (peepal, *Ficus religiosa* L.) indicates the growth of all crops. In the śloka 3, the growth of the *jambū* [the rose apple, *Angophora costaca* (Gaertn.) Britten] tree indicates the growth of the gingelly and black gram; the growth of *śirīṣa* indicates the growth of the *kaṅgū*; the growth of *madhūka* [mahua tree, *Madhuca longifolia* (Linn.) Macbride] indicates the growth of wheat and the growth of the *saptaparṇa* indicate the growth of the barley. In the śloka 4, the growth of *atimuktaka* [mountain ebony, *Bauhinia variegate* (L.) Benth.] and that of *kunda* (*Cassia* species) indicate the growth of *kapāsa* (silk cotton tree, *Bombax ceiba* L.), the growth of *asana* indicates the growth of *sarṣapa* [mustard, *Brassica juncea* (L.) Czern.]; the growth of *badarī* (jujube tree, *Ziziphus mauritiana* Lam.) indicates the growth of k*ulattha*, and the growth of *cirabilva* [*Holoptelea integrifolia* (Roxb.) Planch.] indicates the growth of the *mudga* [*Vigna mungo* (L.) Hepper]. In ślokas 5 to 13, several plants, trees and crops were mentioned on their luxuriant growth. It is also explained that there will be good amount rain in those places where trees, shrubs and creepers grow luxuriantly with glossy leaves uninjured by worms, but if the leaves are infested, it indicates that there will be short of rains.

Indra's banner and House building

The chapter 43 is described with name Indra's banner (Indra-*dhvaja* or *dhvajastambha*). There are 68 ślokas were described. Matters connected with the fall of the tree, the cutting of it, and with what might be inside the tree have been treated off are described in the chapter on *Indra Dhvaja* and on house-building. It is stated in the śloka 12 that shall not cut any tree growing in flower gardens, in temples, on cremation grounds, on public roads, on sacrificial fire-sites or trees of short growth, or dried trees or trees of stinted growth at the top, thorny trees or trees surrounded by creepers and parasitical plants. In the śloka 13, shall also reject trees with holes in which dwell numerous birds and trees injured by the wind or fire and he shall reject trees of feminine denomination, for all those trees are not fit for the staff of Indra's banner. In the śloka 14, five trees such as (1) *Arjuna* [*Terminalia arjuna* (Roxb.) Wight & Arn.], *Aśvakarṇa* (*Dipterocarpus turbinatus* C.F.Gaertn.), *Priyaka*, *Dhava* [*Anogeissus latifolia* (Roxb. ex DC.) Wall.

ex Guill. & Perr.] and *Uduṃbara* (cluster fig, *Ficus racemosa* L.) are suited for the purpose. Having chosen one of these trees or another well-known tree, or one growing on yellow or black soil, the astronomer shall, alone and at night, approach it and touch it with the hymns.

Manuring, Grafting, Gardening and Plantation

The ancients had a pretty sure knowledge of the fact that the plants derive their food materials from the soil, and they had an excellent knowledge of the science of manuring. The origin of manuring the soil can be traced as early as to a verse of the Atharvaveda below:

बभ्रोरर्जुनकाण्डस्य यवस्य ते पलाल्या तिलस्य तिलपिञ्ज्या।
वीरुत् क्षेत्रिय नाष्ठान्यप क्षेत्रियमुच्छतु

|*bahrorarjuṅakāṇḍasya yavasya te palāḻyā tilasya tilapiñjyā*|
vīrut kṣėtriyanāśanyapa kṣetriyamuchatu|| - Atharvaveda 2-8-3

The above verse explains, "With the straw of the brown, whitish, jointed barley for thee, with the sesame, stalk of sesame let the etc."

A more elaborate instruction on manuring is found in the *Bṛhat Saṃhita* in the whole chapter 54 is devoted to the purpose known as *Vṛkṣāyurveda*. Thus in *Bṛhat Saṃhita*, "To promote inflorescence and fructification, a mixture of one *adhaka* (64 *palas*) of sesame, two *adhakas* (128 *palas*) of excreta of goats or sheep, one *prastha* (16 *palas*) of barley powder, one tula (100 *palas*) of beef, thrown into one *droṇa* (256 *palas*) of water, and standing over for seven nights, should be poured round the roots of the plant. The measures given are for one plant. This measure is for all kinds of plants[14]".

The following are the essential preliminaries of plantation explained in the *Bṛhat Saṃhita*:

"One should plant the tree after oneself being pure and after worshipping the tree with a bath and anointment, and the result will be that the tree will be graced with luxuriant growth of leaves".

The following verses from *Bṛhat Samhita* distinctly name the plants and these methods:

"*kānthāl* (Jack fruit tree, *Artocarpus heterophyllus* Lam.), *aśoka* (*Saraca indica* L.), *kadali* (banana/ plantain, *Musa paradisiaca* L.), *Jambu* [jamoon/ Indian blackberry, *Syzygium cumini* (L.) Skeels.], *lakucha* (jack fruit tree, *Artocarpus heterophyllus* Lam.), *dadima* (pomegranate, *Punica granatum* L.), *drākṣya* (grapes, *Vitis vinifera* L.), *pālibata*, *vījapura* [lemon tree, *Citrus limon* (L.) Osbeck], *atimuktaka* [*Hiptage benghalensis* (L.) Kurz] these are the plants to be propagated by means of cuttings besmeared with cow dung [*ētē drumāḥ kāṇḍadōpyā gōmayēna pralēpitā*]".

"Better than this method is the method of propagation by grafting. This can be done in two ways the cuttings of one plant are either inserted on the root of another plant or on the stem of another plant [*mūlōcchēdēyavāskaṃdhērōpaṇōyāḥ param tataḥ*]".

"*gōmāṃsamudakaścaiva saptarātram nidhāpayet* - To increase thy production of flowers and fruits one should sprinkle ghee with cold milk, also a mixture of sesame, excreta of goats and sheep, barley powder and beef, thrown into water, and standing over for seven nights should be poured round the roots of the plant".

"Grafts should be smeared with cow dung. For transplanting, plants should be smeared from root to the top with ghee (clarified butter), sesame oil, and the honey of the khudra variety of the bee of the *uṣira* [*Cymbopogon citratus* (DC.) Stapf], the *viḍaṅga* (*Emblica ribes* Burm.f.) milk and cow dung [*śranvadeśē nōtvā rōpayēdityarthaḥ*]".

The Chapter 54 ślokas 8 & 9 indicates that it is best to plant trees at intervals of 20 cubits, an internal of 16 cubits is next, and worst is the interval of 12 cubits. Closely planted trees become fruitless (barren).

What should be the soil for such plantation? It says, "The most suitable ground to plant in is soft soil that has been sown with *Sesamum indicum* and dug up and trodden with sesame in flower".

Dakārgala - Underground Water and Springs Exploration using Plant Indicators

The term '*Dakārgala*' in Sanskrit connotes 'water exploration'. '*daka*' means water (derived

from the Sanskrit word '*udaka*' for water) and '*argalam*', a bolt or bar; i.e., 'a branch of science dealing with water locked up or imprisoned in the bowels of the earth'. The *dakārgala* mentions several indicators to presence of underground water. These are geological, geo-botanical, bio-geological, and non-biological indicators of the surface and sub-surface of the earth that even today could be useful in several regions of India. The other common surface indicators of groundwater, such as termite mounds have also been mentioned (Murthy, 1987; Vanadeep *et al*., 2012; Joshi *et al*., 2013).

The plants/trees described in the Chapter 54 of *Bṛhat Saṃhita* can also be termed as biological indicator or bio-indicator or phyto-indicator or hydrologic indicators. In other words, plants which indicate some very specific conditions of environment are called plant indicators. The knowledge of relationship between plants and ecological factors can be used as an indicator of environment. Many plants are used as indicators of environment. In a plant community some plants are dominant and found in abundance. These plants are important indicators because they bear full impact of habitat. It has been seen, in general, that plant communities are better indicators than individual plants. Individual plants or plant communities are used to determine the types of soil and other conditions of the environment. Sometimes these also indicate past or future conditions of the environment.

The knowledge of plant indicators can be helpful to determine local soil, thus it can be decided which crops should be cultivated in a particular soil and which soil should be left for pasture or other purposes. Plant indicators are also used to determine optimum use of land resources for forest, pasture, and agricultural crops. Many plants also indicate the presence of particular mineral or metal. So the presence of precious metal can be detected by the growth of the specific plant in an area.

In the Chapter 54, there are 125 ślokas are described. There are 100 species of trees, 15 shrubs, eight (08) herbs, five (05) cereal crops, four (04) legume crops and three (03) water plants.

In the ślokas 63-71, Varāhamihira describes the possibilities of water where ant-hills are present near tender bamboo [*Bambusa arundinacea* (Retz.) Roxb.], *rohitaka* [*Aphanamixis polystachya* (Wall.) R. Parker] trees, Indra trees and golden trees and the quality of water varying from sweet to brackish. Various ecological and environmental interactions are mentioned as indicators of groundwater under the following headings: (a) *phreatophytes* (a plant with a deep root system that draws water supply from near the water table) (b) *phreatophytes* associated with termite mounds, (c) symbiotic inter-growth of trees, i.e. a tree united with another tree species, and morphological, physiological, and mutational features of plants and plant cover (Prasad, 1980). Ślokas 72, 74, 75, 76, 78, 83 and 96 particularly describe the type of trees that show symbiotic intergrowth and indicate water under the ground. The examples are: *Palāśa* (Flame of the forest, *Butea monosperma* (Lam.) Taubert) and *Badarī* (Jujube, *Ziziphus mauritiana* Lam.), *Bilva* [Wood apple, *Aegle marmelos* (L.) Correa] and *Uduṃbara* (Fig tree, *Ficus racemosa* L.), *Karīra* [Wild caper, *Capparis decidua* (Forssk.) Edgew.] and *Pīlu* (Toothbrush tree, *Salvadora persica* L.) and *Śami* [Indian desert tree, *Prosopis cineraria* (L.) Druce]. An isolated cold spot in a warm ground denotes cold water, while a solitary warm spot in cold ground indicates warm water (śloka 94). A copper-coloured soil mixed with gravel yields astringent water; pale yellow earth is indicative of salt, and a blue soil shows the presence of sweet water (śloka 104).

Springs of water in a woody tract (forest) are situated at a lower level than in open country, and in a desert even lower than in a woody region (ślokas 62, 86, 89 & 93). The appropriate places for digging wells in villages or towns are indicated in ślokas 97 and 98. Construction of embankments for ponds and the shading of the banks by trees are advised by him in śloka 119. Similarly, Varāhamihira gives a recipe for

a substance to be added to water. It is a mixture of *anjana*, *mustā*, *usra*, *rājakosātaka*, *emblic myrobalan* and *kataka* (ślokas 121 and 122). The plant indicators of different soil types that were described in the *Bṛhat saṃhita* are presented in the Table 1. The plant communities as ecological indicators for ground water in Indian deserts are elaborated in the Table 2. Varāhamihira suggests the asterisms which are propitious for sinking wells (śloka 123) and ends chapter 54 with comments on exploration for springs (Prasad, 1980; Murthy, 1987; Vanadeep *et al*., 2012; Joshi *et al*., 2013).

The hydrological indicators documented in ancient India had a scientific basis; applied study is bound to go a long way in satisfying the need for water for irrigation, industrial and domestic use. Varāhamihira documented more than 100 plant species occurring (i) individually, (ii) in association with termite mounds, (iii) in presence of two or three different species together, and (iv) in conspicuous morphologic or physiologic features. With the aid of specific plants, sources of groundwater were located at depths varying from 2.3 to 160 m in different environments of arid and semi-arid regions. Varāhamihira estimated not only the depth of the groundwater but also the distance and direction with respect to the indicator plants (Prasad, 1980; Murthy, 1987; Joshi *et al*., 2013; Goyal, 2014).

Table 1: Plant Indicators for Different Soil Types

S. No.	*Plant Indicators*	*Characteristic of Soil*
1	*Salvadora oleoides*	High calcium and boron, good soil suitable for crop plants
2	*Zizyphus mauritiana*	Good soil for agriculture
3	*Prosopis cineraria*	Good soil for agriculture crops provided irrigation is available
4	*Peganum harmala*	Soil is rich in nitrogen and salts and good for agriculture
5	*Butea monosperma*	Heavy alkaline soil
6	*Capparis decidua*	Alkaline soil
7	*Rumex acetasella*	Acid grassland soil
8	*Salsola, Suieda fruticosa*	Saline water condition
9	*Andropogon scoparium*	Sandy loan type soil
10	*Argemone mexicana*	Recently disturbed or flooded soil
11	*Phyla nodiflora and Rumex species*	Nitrate rich soils
12	*Pinus and Juniperus spp.*	Uranium rich soil

Table 2: Plant Communities as Ecological Indicators for Ground Water in Indian Deserts

S. No.	*Plant Communities*	*Indicated depth of ground-water*
1	Euphorbia caducifolia	12-18 m
2	*Acacia senegal - Terminalia pendula*	12-18 m
3	*Salvadora oleoides - Tamarix* species	6.0 m
4	*Salvadora oleoides - Prosopis cineraria*	10-20 m
5	*Prosopis cineraria-Zizyphus mauritiana-Capparis decidua*	6.0-18 m
6	*Salvadora oleoides-Capparis decidua*	6.0-12 m
7	*Salvadora oleoides-Zizyphus mauritiana*	18-28 m
8	*Panicum turgidum-Zizyphus complex*	6.0-18 m
9	*Panicum turgidum-Polygonoides calligonum*	6.0-18 m
10	*Crotolaria burhia-Leptadenia pyrotechnica*	6.0-20 m
11	*Suaeda fructicosa-Alurophus lagopides*	6.0 m
12	*Capparis decidua*	12-20 m
13	*Acacia indica-Prosopis cineraria-Salvadora oleoides*	12-20 m

Gardening and Diseases (vṛkṣāyurveda)

There are 31 ślokas described in the Chapter 55. In these ślokas, 66 trees species, 22 shrubs, 11 herbs, six (06) cereals, (03) legumes and four (04) water plants are described. The ślokas from 1-31 suggests gardening trees on the banks of rivers and lakes and other water bodies will be pleasant and agreeable if planted with shady trees. It is therefore necessary to form gardens on the banks of waters. It also describes on controlling the diseases using the same plant material. The ślokas 1 and 2 indicates that soft soil is congenial to the growth of all trees. Such a soil should be selected for the garden and the selected plants should first be grown in it. As soon as the plant begins to bear blossoms, it must be cut and removed from the spot. In the ślokas 3, 4, 5 and 6 describes that trees that grow without branches shall be grown in the *Śiśira* season, and in the *Hemanta* season shall be grown trees that grow with branches; in the winter season shall be grown trees possessing good trunk. The trees may be planted in any quarter of the gardens or in houses by their seeds and they will conduce to prosperity. Śloka 7 and 8 suggests the growing of trees by smearing over them from the root to the branches a mixture of ghee, of *uśīra* of sesamum seeds, of honey, of *viḍaṅga*, of milk and of cow-dung, is known as *saṅkrāmaṇa* growth. In the śloka 9 it says trees shall be watered both in the morning and evening in the dry season; in the cold season they shall be watered at mid-day, and in the rainy season whenever the ground is found dry. The Śloka 10 says that the *Jambū*, *Vetasā*, *Vānīra*, *Kadamba*, *Uḍuṃbara*, *Arjuna*, *Bījapūralca*, *Mṛdvikā*, *Lakuca*, *Dāḍimā*, *Vañjula*, *Naktamāla*, *Tilaka*, *Panasa*, *Timira* and the *Āmrātaka* shall be grown on wet soil. In the śloka 11 and 12, an interval of twenty cubits between trees is the best for the optimal growth and one of sixteen is passable; and one of twelve is injurious to growth. In the śloka 13, the trees that are planted very near to each other get their branches as well as their roots interwoven and such trees get choked and do not grow well. In śloka 14 and 15, describes that cold winds and hot sun produce diseases in trees, and the trees turn white and do not put forth new leaves; the branches become dry and the juice oozes out. In the next śloka (15) provides information on how to cure the tree of these diseases. First scrape off or otherwise remove the parts dead from the tree with a knife; rub over the parts a mixture of *viḍaṅga*, ghee and mire and pour water mixed with milk at the roots. In śloka 16, it suggests that if the fruits are seen to die out, then heat a mixture of horse gram, black gram and mudga (kidney bean), sesamum seeds and barley; after the mixture has fully cooled pour it at the roots. Then the trees will yield an increase of flowers and fruits (Shastri, 1969). In the ślokas 17 & 18, it is mentioned that two *ādhakas* of the excrement of the goat and the ram, an *āḍhaka* of sesamum seed, half an *āḍhaka* of saktu (the flour of barley or rice fried and ground), an *āḍhaka* of water and a *tula* (one hundred *palas*) of cow's flesh. Form a mixture of these, keep it untouched for seven days, and if at the end of the time spreading creepers, plants and trees be watered with the mixture, flowers and fruits will grow in abundance. The ślokas 19 & 20 describes to keep the seeds soaked in milk for ten days; then rubbing ghee over the hands the seed shall be taken up in the hands and passed from hand to hand till it is covered with ghee. It shall then be rubbed over several times with cow-dung and exposed to the smoke of the flesh of the hog and the deer. It shall then be mixed with the serum or marrow (of the flesh) of the fish and the pig, and when dry, it shall be sown in a well prepared soil and watered with a mixture of milk and water. When it grows, it will grow with flowers. Śloka 21 mention to mix together the flour of rice, black gram and sesamum seeds with the flour of barley (fried before ground) with the dead or decayed flesh, and with a small quantity of water; soak the seed of the tamarind in the mixture and expose it to the smoke of the root of the turmeric. The seed when sown will grow as a creeper. The śloka 22 describes put into the milk of the cow the roots of *Asphota*, *Dhātrī*, *Dhava*, *Vāsikā*, *Palāśinī*, *Vetasā*, *Sūryavallī*, *Śyāmā* and *Atimuktā* and heat the milk

on fire. After cooling, put into it the seed of the *Kapittha* and allow it to soak for 100 ghaṭikas (one *ghaṭika* is 24 minutes) and dry the seed in the sun for 30 days, if the seed be then sown in the soil it will grow as a creeper vigorously. In ślokas 24-26, it is mentioned to dig a pit in the ground a cubit square and two cubits deep, and fill it with water prepared with a mixture of the flesh of the fish. Allow the pit to dry up completely; dry it further by means of fire; rub the sides and bottom with a mixture of honey, ghee and ashes, fill the pit now with the flour of black gram, of sesamum seeds and of barley mixed with earth; pour over the pit water prepared with the flesh of the fish and pound the mixture well till it becomes hard. Sow any seed at a depth of four digits and water it with the water of the fish. The seed will grow as a fine creeper with tender leaves over terraces and the roof of houses in a most wonderful manner. In the ślokas 27 & 28 described to soak any seed one hundred times either in the *Kalka* (decoction) or in the oil of *Aṅkola*, or in the fruit of the *Śleṣmātaka*. The moment the seed is put into the ground it grows with branches laden with fruits. Ślokas 29 & 30 recommends to soak any seed in the fruit of the *Śleṣmātaka* after removing its seeds, and then soak it in the water of the ripe fruit of *Aṅkola* and dry it in shade; repeat the operation seven times; rub the seed over with the dung of the buffalo, and keep it buried in the same dung for some time; then sow it in the soil drenched with the waters of the coconut. In the śloka 31, it says when the Moon passes through any of the fixed asterisms or the soft asterisms, or through the asterisms of *Mūla*, *Viśākhā*, *Puṣya*, *Śravaṇa*, *Aśvini* and *Hasta*, trees shall be planted or seeds sown according to the views of sages possessed of the inner eye of knowledge.

Forest Entry *(vanasampraveśa or vanapraveśa)*

In the Chapter 59, there are 14 ślokas described. In these ślokas, 61 tree species, 12 shrubs, 11 herbs, five (05) cereal crops, four (04) legume crops and five (05) water plant species are mentioned. The ślokas from 1-14 suggests on the entry of forests and behaviour in the forests inside during the visit. On an auspicious day selected by the astrologer and suited to the master, when the several indications referred to on *Yātra* are all good, the party shall leave for the forest. They shall not cut trees that grow on cremation ground, in roads, in temples, ant-hills, flower gardens, the abodes of religious devotees, places of worship, junctions of rivers as well as trees grown by human labour. They shall not cut trees that are bent, that are covered with creepers or struck down by lightning or broken by the wind, or that have fallen of them or that are broken by elephants or that have dried or have been burnt or that contain the bee-hive. The trees that are of glossy leaves, flowers and fruits, are fit for the purpose; the tree selected shall be adorned with flowers and duly honoured. If the master is a *Brāhmaṇa*, the trees *Devadāru* [*Cedrus deodara* (Roxb. ex D. Don) G. Don], *Sandal* (*Santalum album* L.), *Śamī* [*Prosopis cineraria* (L.) Druce] and *Madhūka* [*Madhuca longifolia* (L.) Macbride] are fit for the purpose. If the master is a *Kṣatriya*, the trees *Margosa* (*Azadirachta indica* A. Juss.), *Aśvattha* (*Ficus religiosa* L.), *Khadira* [*Acacia catechu* (Linn. f.) Willd.] and *Bilva* [*Aegle marmelos* (L.) Correa] are fit for the purpose. If the master is a *Vaiśya*, the trees *Jīvaka*, *Khadira* [*Acacia catechu* (Linn. f.) Willd.], *Sindhuka* and *Syandana* should be selected for the purpose; and if the master is a *Śūdra*, the trees *Tinduka*, *Kesara*, *Sarja* and *Arjuna* should be selected. In the formation of the *Liṅga* or an image, the sides of the tree as it grew shall be preserved; for this purpose the sides as well as the bottom and the top shall be marked before cutting. The tree to be cut shall first be worshipped with rice cooked in milk, sweet-meat balls rice, curdled milk and sweet-meats made of ground sesamum and sugar and the like, liquor, flowers, scented smoke and sandal paste. Then shall be worshipped at night the Devas, the Pitṛs, the *Piśācas*, the *Rākṣasas*, the *Nāgas*, the Asuras, the *Gaṇadevas*, *Vināyaka* and others. The tree shall be touched by the hand and chant few *mantras*. Early next morning, water

shall be poured over the root of the tree; the axe shall be rubbed over with honey and ghee, and the tree shall first be cut on the north-eastern side, and the other parts shall be cut round from left to right. If the tree falls on the eastern, north-eastern or the northern side, it indicates prosperity. But if it falls on the remaining five sides - the south-east, the south, south-west, etc., there will respectively be fear from fire, suffering from hunger, disease, and death of horses.

Preparation of Perfumes *(gandhayukti)*

In the chapter 77 under the category of perfumes, there are 37 ślokas described. There are 22 trees, eight (08) shrubs, 42 herbs, four (04) cereals, two (02) legume species and three (03) water plants mentioned. The beauty items of plant derived products are - flower wreaths, sandal paste, perfumed smoke, clothes and also to blacken and embellish the hair. Ślokas 1 to 6 describes on the beautification of hair and rich perfume baths using plant ingredients. Put into an iron vessel vinegar or the like sour liquor; put in it a quantity of the *kodrava* grain (kodo millet, *Paspalum scrobiculatum*) after removing the husk and iron dust; heat the mixture; grind it well on a stone; rub it over the hair of the head freed from oil; tie over the hair the moist leaves of the green juicy leaves; remain so for six hours. Then remove the mixture from the hair, and rub over them the paste of the fruit of the *āmalaka* (Indian gooseberry, *Emblica officinalis*); cover them with moist leaves as before and remain so for another six hours. Then the hair will become black. Mix together equal quantities of woody *cassia*, *costus*, *Reṇu*, *Nalikā*, *Spṛkkā*, *Tagara*, *Vālaka*, *Keśara* and *Patra* and grind them on a stone forming them into a paste; rub it over the head and then bathe; such a bath is suited to kings. Mix together in oil the powder of *Mañjiṣṭhā*, *Vyāghranakha*, *Śukti*, *cinnamon*, *Kuṣṭha* and *Myrrh*; heat the mixture in the Sun. It is known as *Campakagandhi* oil. In the śloka 7, it is said to grind together equal quantities of *Patra*, *Turuṣka*, *Vāla* and *Tagara* and the person will get a perfume provoking sexual passion. Add to this perfume *Priyaṅguka* and expose the mixture to the smoke of *Kaṭukā* and *Hiṅgulika*. This will provide perfume which is known as *Vakulagandha*. To this add *Kuṣṭha* and can obtain a perfume known as *Utpalagandha*. Add to this sandal, will become the perfume known as *Campaka-gandha*. Add to this *nutmeg*, *cinnamon* and *Kustumbarī*; and that perfume is known as *Atimuktagandha*. Mix all the above said parts with one-fourth parts of *Śatapuṣpa* and *Kunduruka*, half-parts of *Nakha* and *Turuṣka*, and one part of *sandal* and *Priyaṅgu*; grind them well and expose the mixture to the smoke of *Guḍa* and *Nakha*. This will become an excellent perfume. The ślokas 9 and 10 describes in preparation of other perfumes using various other herbs. Grind together equal quantities of *Jaṭāmāṃsī*, *Vālaka*, *Turuṣka*, *Nakha* and sandal and form a paste; expose it to the smoke of *Bdellium*, *Bālaka*, *lac*, *Musta*, *Nakha* and *Śarkarā*. One part of Harītakī, two parts of Śaṅkha, three parts of Ghana, four parts of Drava, five pans of Ambu, six parts of Guḍa, seven parts of Utpala, eight parts of Śailaka and nine parts of Musta give a perfume. Numerous kinds of perfumes can be similarly prepared by mixing together different parts of each substance in certain combinations using various herbs. These are provided in the ślokas from 11 to 37.

Tooth-brushes *(dantakāṣṭha-lakṣaṇa)*

In this Chapter 85, nine (09) ślokas are described. There are 12 tree species, three (03) shrubs, four (04) herbs and two (02) cereal crop species mentioned in the ślokas. The ślokas from 1-9 suggests on the plant twigs that are used as tooth-brushes. It is still being used in the villages of India. The twigs of creepers, bushes, trees, and trees that grow widely can be used to make tooth brushes (*dantakāṣṭha*). A description of all their effects will be long and elaborate. Therefore, it is confined to twigs which are to be chewed to secure certain special ends are mentioned here. It is surprise to know that the there is no mention of the neem tree as a tooth-brush, which is used very commonly in India. Twigs of unknown trees

shall be rejected, and twigs with leaves, those of an even number of joints, those which are split or dry at the ends and those with no bark ought not to be chewed. The twigs of *Vikaṅkata* [Madagascar plum, *Flacourtia indica* (N. Burman) Merrill], *Śrīphala* (Indigo, *Indigofera tinctoria* L.) and *Kāśmarī* (*Gmelina arborea* Roxb.) if chewed, will give a person Brāhminical splendour. The *Arka* [*Calotropis gigantea* (L.) R. Br.] twig will increase the splendour of his appearance. The twigs of *Nyagrōdha* (Banyan, *Ficus benghalensis* L.), *Śirīṣa* (*Albizia lebbeck* (L.) Benth.) and *Karañja* [Pongame oil tree, *Pongamia pinnata* (L.) Pierre] if used as tooth-brush will make a person wealthy and prosperous. Those of *Aśvattha* (Peepal, *Ficus religiosa* L.) will make him respected by the people and renowned among his own caste-men. The twig of the *Badarī* (*Ziziphus mauritiana* Lam.) if chewed as a tooth-brush (*dantakāṣṭha*) will make a person healthy; that of the *Bṛhati* (*Solanum indicum* L.) will give him a long life; that of the *Khadira* [*Acacia catechu* (Linn. f.) Willd.] and Bilva [*Aegle marmelos* (L.) Correa] will increase his wealth; that of the *Atimukta* [*Hiptage benghalensis* (L.) Kurz] and *Kadamba* [*Neolamarckia cadamba* (Roxb.) Bosser] will bring him the object of his desire. The twig of the *Nīpa* if chewed as a tooth-brush will bring wealth to a person; that of the *Karavīra* (Indian oleander, *Nerium indicum*) will bring him good meals; that of the *Bhāṇḍīra* (Bhandira, *Clerodendrum infortunatum* L.) will bring him much food; that of the *Śamī* (*Prosopis cineraria*), *Arjuna* [*Terminalia arjuna* (Roxb.) Wight & Arn.] and *Śyāmā* (*Echinochloa frumentacea* Link) will destroy his enemies. The twig of *Aśvakarṇa* (*Dipterocarpus turbinatus* C.F. Gaertn.), *Bhadrataru* (*Trapa bispinosa* Roxb.) and *Cāṭarūṣaka* (*Grewia asiatica* L.) is chewed as a tooth-brush will bring a man self-worth; if chewed the stalks of *Priyaṅgu* [*Setaria italica* (L.) P. Beauvois], *Apāmārga* (*Achyranthes aspera* L.), *Jambu* [*Syzygium cumini* (L.) Skeels.] and *Dāḍimā* (*Punica granatam* L.) will make a person beloved of all people.

Sanskrit Plant Names and their Botanical Equivalents

Ascertaining the botanical identities of many of the plants described in Vedic texts and later Sanskrit literature is a difficult task as a single plant is designated by many names. Any investigation in the plant science of ancient India necessitates the survey of Sanskrit works, as they are replete with reference to plants, leaves, flowers, fruits, seeds and grains. For this purpose, the researcher would initially depend on the Ayurvedic works such as Āyurveda *Saṃhitās*, the *Caraka Saṃhita*, *Suśruta Saṃhita* and the *Aṣtānga Hṛdaya Saṃhita* for description of the plants referred to in them. Further, in the Sanskrit language some plant parts and products or certain plants have some special names too. This plurality of name enhances the difficulty of establishing the correct botanical identity of plants. Botanists occasionally differ in assigning scientific equivalents to Sanskrit plant names, and at times two Sanskrit synonyms are identified as two different plants. Several authors described and provided glossaries of plant names mentioned in Indian Epics, the Ramayaṇa, the Mahabharata, the Bhagavata, Purāṇas and others (Brandis, 1911; Majumdar, 1927a; Majumdar, 1927b; Basu, 1966; Chitrabhanu, 1978; Randhawa, 1979; Banerji, 1980; Dutt, 1980; Kirtikar and Basu, 1981; Balapure et al., 1987; Rai and Shukla, 1989; Sensarma, 1989). Sensarma (1992) compiled more than 500 Sanskrit names of plants and their botanical equivalents.

Flora of Bṛhat Saṃhita

In the *Bṛhat Saṃhita* different types of plants and trees are mentioned. The flora of *Bṛhat Saṃhita* consists of 545 plant species that are used in medicine, perfumes, gardening and other purposes are described. Also, it is observed that some species of plant names are duplicated in the *Bṛhat Saṃhita* chapters mentioned. Among the 545 plants, 437 species belong to the class Dicotyledonous, 108 species belong to the class Monocotyledonous and one (03) species belongs to the Gymnosperm

category, as per the Bentham and Hooker (1862) taxonomic system of plant classification. The scientific names of plants are documented as per International Code of Nomenclature (ICBN) from the latest Indian floristic studies and the Royal Botanical Gardens, Kew, London. A total number of 522 plant species, belonging to 55 families, includes 311 tree species, 74 species of shrubs and 85 species of herbs. Amongst the 85 herbaceous species, there are 26 species of grasses, 18 legume grain species, 15 other herbs of different families, 17 aquatic plants, two (02) creepers and two (02) oil seed crop species. The 1st highest number of species is from the family Fabaceae (legumes), the 2nd highest number of species is from the family Poaceae (grass family), the 3rd highest number of species belongs to family Moraceae (Fig family). Representative species from families such as Rhamnaceae, Clusiaceae, Lecythidaceae, Apocynaceae, Combretaceae, Capparaceae, Arecaceae, Asclepiadaceae and Nymphaeceae, Ebenaceae, Dipterocarpaceae, Verbenaceae, Linaceae, Salvadoraceae, Oleaceae, Bignoniaceae are also recorded in the *Bṛhat Saṃhita*. The chapter-wise floristic analysis of *Bṛhat saṃhita* is listed in the Table 3.

Table 3: Floristic Analysis of *Bṛhat Saṃhita*

Bṛhat Saṃhita Chapter No:	*Trees*	*Shrubs*	*Herbs*	*Cereal Crops*	*Legume Crops*	*Water Plants*
Chapter 29	45	14	9	4	5	2
Chapter 43	5	-	-	-	-	-
Chapter 54	100	15	8	5	4	3
Chapter 55	66	22	11	6	3	4
Chapter 59	61	12	11	5	4	5
Chapter 77	22	8	42	4	2	3
Chapter 85	12	3	4	2	-	-

Conclusions

Thus we have found that different Indian works and traditions contain various observations of plant-life that are scientifically valuable. We cannot but appreciate the keenness of spirit shown in these works. However, this spirit was not rigorously separated from fanciful superstitions and myths. This resulted in no further scientific advances in the study of plants and plant-life. It degenerated from science into an art, and from art into an artifice.

An important contribution of Varāhamihira is the encyclopedic *Bṛhat-Saṃhita*. Although the book is mostly about divination, it also includes a wide range of subjects other than prediction. It covers extensive subjects of human interest, including astronomy, planetary movements, eclipses, rainfall, clouds, architecture, growth of crops, manufacture of perfumes, matrimony, domestic relations, gems, pearls, and rituals. He deals with a dizzying number of subjects in this encyclopaedic treatise and gracefully condenses knowledge from all important walks of life for future generations.

The *Bṛhat Saṃhita* could indicate the occurrence of ground water at various depths with the help of different types of plants, trees and grass varieties used as plant indicators. Thus, Varāhamihira is established as the first hydrologist to compile all the knowledge on the subject in his *magnum opus* in the *Bṛhat Saṃhita*. Varāhamihira suggested various biological, pedological, geological, and geophysical characteristics as hydrologic indicators. A critical study of these indicators reveals that they are all primarily the results of the interactions between biotic and abiotic environment due to high relative humidity consequential to the occurrence of ground water in arid and semi-arid regions. He described various plant responses, in a ground water ecosystem as hydrologic indicators. This is the most significant aspect of this ancient work is that only those plant

responses which are very obvious were employed as hydrologic indicators. These plant indicators are still being used in India by the geologists in identifying water resources.

From the present study, it is evident that the ancient science of gardening, treatment of trees and other aspects of plants/trees which was very much technical in nature. The ancient methodology for treatment of trees shall be helpful for the deep study in further research program in the area of ancient botanical science. The Indian concept of *Vṛkṣāyurveda* may be the real contribution of our ancestors to the intellectual world of science. So, this kind of study is a primary attempt in the light of gardening. The text of *Bṛhat Saṃhita* is creating the new path of research in the area of modern science of treatment of trees and vegetation. Moreover, the implementation of ancient Indian science and technology in the science education is a greater attempt to purify the current curriculum of education. It can be rightly said that *naven anavaṁ śodhayet* or relook the ancient sources of knowledge in modern perspective.

Acknowledgements

The author profusely thanks Late Professor Piratla Narasimha Rao, Department of Botany, Acharya Nagarjuna University (ANU), Guntur, Andhra Pradesh, who has been a teacher, mentor and guide in Plant Taxonomy. Furthermore, he thanks Anantasri Boddupalli for helping him in various ways during manuscript preparation.

References

Balapure, K.M., Maheshwari, J.K. and Tandon, R.K. (1987). Plants of Ramayana. *Anc. Sc. off Life*, 7(2): 76 – 84.

Banerji, S.C. (1980). *Flora and fauna in Sanskrit Literature*. Naya Prakesh, Calcutta.

Basu, S.K. (1966). *A Glossary of plant-names mentioned by Valmeeki and Kalidasa*. West Bengal Forest (Centenary Commemoration Volume), Government of West Bengal, Calcutta.

Bentham, G. and Hooker, J.D. (1862). *Genera Plantarum*, Volumes I – III, London.

Bhat, M.R. (1966). *Bṛhat Saṃhita of Varāhamihira*, Part 1 & 2. Motilal Banarsidass, New Delhi, pp. 549–561, 737–738, 874–876.

Bhattotpala. (1895). *The Bṛhat Saṃhita*. With the commentary of Bhattotpala. Edited by Mahamahopadyaya Sudhakara Dvivedi. Under the superintendence of Arthur Venis. The Vizianagram Sanskrit Series No.12, Printed and Published by Lazarus & Co., Benares.

Boddupalli, R.S. (2019). Plant Biology of Yajurveda - Project Report. *Indian Journal of History of Science*, 54(2): 226-237.

Brandis, D. (1911). *Indian Trees*. Constable & Coy, London.

Chakravarty, A.K. (1991). Some studies on Varāhamihira. *Indian Journal of History of Science*, 26(1): 71-77.

Chitrabhanu, S. (1978). *Dictionary of the Vedic Rituals - Based on the Srauta and Grihya Sutras*. Concept Publishing Company, New Delhi.

Dutt, U.C. (1980). *Material Medica of the Hindus*. Revised by B.L. Sen, A. Sen and P.K. Sen, Chowkhamba Saraswatibhawan, Varanasi.

Goyal, M. (2014). Ancient water exploration practices - A seminar report. Department of Petroleum and Petrochemical Enginerring, Maharashtra Institute of Technology, Pune, p.1-18.

Iyer, N.C. (1884). *Brihat Samhita of Varāha Mihira*. Translated into English. Vols. 1&2. South Indian Press, Madura.

Joshi, R.R, Kulkarni, U.D., Vartak, A.V. and Khan, I.A. (2013). Dakargalam - An ancient water exploration technique based on Varāhamihira's Bṛhat Samhita. *Asian Agri-History*, 17(2): 175-181.

Kirtikar, K.R. and Basu, R.D. (1981). *Indian Medicinal Plants*. M/s Bishen Singh Mahendra Pal Singh, Volumes I to IV, Allahabad.

Majumdar, G.P. (1927a). *Vanaspati - Plants and Plant-life as in Indian Treatises and Traditions*. Published by the University of Calcutta, p.35-60.

Majumdar, G.P. (1927b). *Vanaspati*. Calcutta University. Calcutta.

Murthy, K.S. (1987). Varāhamihira, the earliest hydrologist. Water for the Future: Hydrology in Perspective. In: the Proceedings of the Rome Symposium, IAHS Publication No: 164.

O'Connor, J.J. and Robertson, E.F. (2000). *Varāhamihira*. MacTutor History of Mathematics archive, University of St. Andrews, Scotland.

Prasad, E.A.V. (1980). External features of vegetation as hydrologic indicators in Varāhamihira's Brihat Samhita. *Journal of Indian Institute of Science*, 62(B): 123-144.

Rai, M.K, Shukla, H.D. (1989). A Critical Study on plants of 'Ramcharitmanas' – a religious book of Hindus. *SEBS News Letter*, 8: 3-4.

Randhawa, M.S. (1979). *Flowering Trees*. National Book Trust, New Delhi.

Sarma, K.M.K. (1981). *Varāhamihira*. In: Scientists, Publications Division, p.73-82.

Sastri, V.S. and Bhat, M.R. (1946). *Bṛhat Saṃhita with an English Translation and Notes*. V.B. Soobbiah & Sons, Bangalore.

Seal, B. (1915). *Positive Science of the Ancient Hindus*. London: Longmans, Green and Co., reprinted by Motilal Brothers, New Delhi.

Sensarma, P. (1992). Plant Names - Sanskrit and Latin. *Ancient Science of Life*, 12(1-2): 201-220.

Sensarma, P. (1989). *Plants in the Indian Puranas – an ethnobotanical investigation*. Naya Prakash, Calcutta.

Shastri, A.M. (1969.) *India as seen in The Bṛhat Saṃhita of Varāhamihira*. Motilal Banarsidass, New Delhi.

Shastri, A.M. (1991).*Varāhamihira and His Times*. Kusumanjali Prakashan, Jodhpur, India.

Vanadeep, K., Murty, S.S.R. and Krishnaiah, M. (2012). Meticulous and meritorious meteorology enshrined in the *Brihat Samhita* - A comparative case study over four Indian regions situated in diverse climatic zones. *Indian Journal of Innovations and Developments*, 1(4): 229-290.