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# SCIENTIFIC LITERATURE

(SKT2C08)



STUDY MATERIAL

II SEMESTER  
CORE COURSE

MA SANSKRIT (GENERAL)

(2019 Admission onwards)

UNIVERSITY OF CALICUT

SCHOOL OF DISTANCE EDUCATION

CALICUT UNIVERSITY- P.O

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**SCHOOL OF DISTANCE EDUCATION  
UNIVERSITY OF CALICUT**

**STUDY MATERIAL  
SECOND SEMESTER**

**MA SANSKRIT GENERAL (2019 ADMISSION ONWARDS)**

**CORE COURSE:**

**SKT2C08- SCIENTIFIC LITERATURE**

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## SYLLUBUS

Unit I :-An introduction to scientific literature in Sanskrit -Essentiality of the awareness of this branch of literature -A general study of major works (Bṛhatsaṃhitā, Manuṣyālayacandrikā, Yuktikalpataru, Samarāṅkaṇasūtradhā-ra, Śārṅgadharaśaṃhitā, Śilparatna, Mayamata and Mātaṅgalāla) (No questions shall be asked from Unit 1 for external examination. This unit may be covered through components of Internal assessment.)

Unit II: Intensive study of the following articles: 1. Sanskrit Literature on Medical Science: Dr. K. Raghavan Tirumulpad, in Technical Literature in Sanskrit, Ed. S. Venkita Subramonia Iyer. 2. Scientific Methodology in Ancient India, Dr. K. N. N Elayath, in Indian Scientific Traditions. 3. Astronomy and Mathematics in Sanskrit Literature: K. V Sarma, in Technical Literature in Sanskrit, Ed. S. Venkita Subramonia Iyer. 4. The Critical and Rational Approach of Kelallur Nilakantha Somayaji: N.K. Sundareswaran, in Kerala School of Mathematics: Trajectories and Impact 5. Yukti bhāṣā : T.B Venugopala Panikker, in Kerala School of Mathematics: Trajectories and Impact.

Unit III: - Intensive study of the following articles: 6. Sanskrit Literature on Architecture and Iconography: Dr. N.V Mallayya, in Technical Literature in Sanskrit, Ed. S. Venkita Subramonia Iyer. 7. Vastuvidya and Ecology: Dr. C. Rajendran, in Indian Scientific Traditions. 8. Indigenous Knowledge Base of Traditional Architecture of Kerala: A. Achyuthan & Balagopal T.S Prabhu, in Indian Scientific Traditions. 9. Thoughts on Biodiversity and Conservation in Ancient and Medieval Sanskrit Literature: Dr. N.V.P Unithiri, in Indian Scientific Traditions. 10. Environmental Awareness in Sanskrit Literature: D r .C .Rajendran , in Indian Scientific Traditions .

## UNIT 1

### AN INTRODUCTION TO SCIENTIFIC LITERATURE IN SANSKRIT

In the ancient India Sanskrit was the medium of communication, education, law, administration, trade, commerce, art, entertainment, research and of all modes of intellectual debates. Phonetics of the Sanskrit has roots in various energy points of the body and reading, speaking or reciting Sanskrit stimulates these points and raises the energy levels, whereby resistance against illness, relaxation to mind and reduction of stress are achieved. Sanskrit is the best computer friendly language. It has been furnished with solid contributions to the system of knowledge. The rich tradition and the scientific linguistic structure have made the language unique. Sanskrit processes a vast source of original texts representing various kinds of scientific Epistemology, like- Astronomy, physics, Engineering, Mathematics, Ayurveda, Agriculture and many others.

#### **Brhat- Samhita**

The *Brihat- Samhita* is written as an encyclopedia covering topics ranging from astronomy to divination and various arts such as architecture, agriculture and jewelry. The work is also known as in Sanskrit as Varāhamihira Bṛhatsaṃhitā. It is one of the fundamental works of ancient Indian astronomy (known as Jyotisha). It was written in the 6th century A.D. (or 1st century B.C.) in about 4000 Sanskrit verses (slokas) by the polymath known as Varahamihira, who was considered as a great scientific scholar of mathematics, astronomy and astrology.

#### **Manushyalaya Chandrika**

The *Manushyalaya Chandrika* is a sixteenth century CE treatise in Sanskrit dealing with domestic architecture. The work is authored by Thirumangalath Neelakanthan Musath and is a summarization of the basic principles of domestic architecture then widely followed in that region of India now known as Kerala State. The popularity of the text as a basic reference of traditional Kerala architecture has continued even to modern times. From the references to the deities in temples at Triprangode, Trikkandiyur, Alathiyur, etc. in the opening invocation of the treatise it can be safely surmised that the author of the work should have been a native of some place close to these temples. Nothing much is known about the life of the author other than that he has also authored a work on elephantology titled *Mathangaleela*.

### **Yuktikalpatharu**

This work deals with several topics including statecraft, politics, city-building, jewel-testing, characteristics of books, ship-building etc. It was written by Bhoja (reigned c. 1010–1055 CE) was an Indian king from the Paramara dynasty. His kingdom was centered around the Malwa region in central India, where his capital Dhara- nagara (modern Dhar) was located. Bhoja is best known as a patron of arts, literature, and sciences. The establishment of the Bhoj Shala, a centre for Sanskrit studies, is attributed to him.

### **Samarangana Sutradhara**

It is an encyclopedic work on classical Indian architecture (Vastu Shastra) written by Paramara King Bhoja of Dhar (1000–1055 AD). In 83 chapters, the subjects treated are town planning, house architecture, temple architecture and sculptural arts together with Mudras (the different hand poses and the poses of the body as well as the postures of legs), the canons of painting, and a chapter on the art of mechanical contrivances, the yantras (chapter 31).

*Samarangana Sutradhara* also includes a chapter about the decoration of palaces, which describes the construction of mechanical contrivances (automata), including mechanical bees and birds, fountains shaped like humans and animals, and male and female dolls that refilled oil lamps, danced, played instruments, and re-enacted scenes from Hindu mythology.

### **Sharangadhara Samhita**

It is a popular treatise on Ayurvedic medicine written by Acharya Sarangadhara. It has been categorized under Laghu Trayee or the lesser triad of Ayurveda along with Madhava Nidana and Bhavaprakasha. The whole treatise consists of 3 divisions, 32 chapters and 2600 verses. The poorva Khanda is the first division of the Samhita and comprises of seven chapters. Madyama Khanda is the second division of the Samhita and comprises of 12 chapters. Uttara Khanda is the third division of the Samhita and comprises of 13 chapters. This section deals with details of Pancha Karma.

### **Shilparatna**

*Shilparatna* is a classical text on traditional South Indian representational-performing arts. It is particularly influential in painting and theatrical performance. It was authored by Srikumara in 16th century AD. In the title, the word *Shilpa* (sculptural) *Ratna* (Gems) is used as a broad term embodying artistic forms that either uses the body as a medium of expression (like Dance, Drama or Dance-Drama) or that which represents the body as an expression (like Sculptures and mural arts). It ranks only after the Natya Shastra and the Abhinaya Darpana as a text of fundamentals on the performing arts. It lays down the tenets of painting such as the proper set of colours and the right combinations which leads to stylized balance and rhythm. It is adhered to as principles in South Indian paintings known as Dravidian mural art or Dravidian

mural painting. The text describes yellow, white, red and terre Verte as the pure colours. These colours could be used as single colours or in combinations to make another chroma.

The shilparatna also lays down principles for stage performance, like the optimal space for a performance. The *Natya Griha* (classical Dance spaces and theatres), *Natya* (Postural dance) and *Griha* (house) in Kerala is made according to these principles and those laid down by the *Natya Shastra*. It describes the elaborate codified language of *mudras* (stylized gestures and symbolic signs by the hands and body posture used in Bharatanatyam and Kathakali) as *angikabhinaya* meaning body- expressions.

### **Mayamata**

This is one of the prominent Sanskrit works on *vāstu- śāstra*, believed to have been written in the 5th century and of South Indian origin. It contains various topics such as temple construction and the rituals associated with them. It is also known as *Mayamatam*. Mayamata is the name of a Sanskrit word partly dealing with the “science of architecture” (*vāstuvīdyā*).—The two principal south Indian texts, *Mayamata* (1000 CE) of Mayamuni and *Mānasāra* (1300 CE), share a common understanding of the architectural plan and design of the southern (*Drāviḍa*) vintage but while the former has a practical outlook, the latter develops the theory of the science.

## UNIT 2

### SANSKRIT LITERATURE ON MEDICAL SCIENCE

**Dr. K. RaghavanTirumulpad**

India is a country with an age-long independent culture and tradition. In spite of the apparent transformations that our culture has undergone during the course of history, the spirit has always remained the same, every onslaught resulting in some sort of reformation and rejuvenation. Ayurveda is an integral part of India's culture and the above statement is true of it also. No other branch of our culture is subject to such an acute competition as Ayurveda is with modern medicine with its world-wide appeal and encouragement, with an aura of the modern science behind, trying to make it obsolete. During the British period of our history every encouragement was given to Allopathy, with a vested interest, so to say, making it appear capable to deal with every problem of health and disease, in the most attractive and practical way, allowing Ayurveda with its conservative and passive attitude to die a natural death.

The Vedas are the foundation of our culture. Ayurveda is considered to be *upavededa* of Atharvaveda which deals with the mundane aspect of life. Some say it is *upaveda* of Rgveda. But rudiments of Ayurveda are seen scattered in all the Vedas. A kind of psychosomatic approach is seen in them, as prayers, propitiation of deities etc., are also prescribed as treatment in them in addition to drugs. Fundamental principles, physiology, pathology, drugs with their properties and applications, diseases with their treatments, surgical treatments etc., are seen mentioned in the Vedas, though not in a coordinated or systematic form. Cases of Rajayaksma, Udara, Andhya, Badhira, Sandya, Kustha, Kamila, Hrdroga, Jvara etc., joined. Mention is seen of physicians also with their collection of medicines.

The system of Ayurveda developed into two branches, kayacikitsa and Salyatantra. There is another division for specialization– the eight- fold division Kayacikitsa, Balacikitsa, Grahacikitsa, Urdavangacikitsa, Salyacikitsa, Damstracikitsa, Jaracikitsa and Vrsacikitsa the eight parts or astangas of Aurveda. In the samhita one of the parts is usually and mainly elaborated in the text, with the other parts dealt with in the uttarasthana as if in an appendix. Specialization is expected in the background of general proficiency. There were separate samhitas compiled in all the eight parts. Now only names of the authors with some quotations are found in the commentaries in the case of most books. Some books can be found in the collections of big manuscripts Libraries, mostly not published. Even those published are not readily available today. Caraka for Kayacikitsa, and Susruta for Salyatantra are the important source books available now.

### **Charaka and Susruta**

CharakaSamhita and SusrutaSamhita are two important works in the field of Indian traditional medicine, that have survived from ancient India. CarakaSamhita is written by Caraka. The pre- 2<sup>nd</sup> century CE text consists of eight books and one hundred and twenty chapters. It describes ancient theories on human body, etiology, symptomology and therapeutics for a wide range of diseases. The CarakaSamhita also includes sections on the importance of diet, hygiene, prevention, medical education , the team work of a physician, nurse and patient necessary for recovery to health.

Susrutacarya who wrote the original Samhita in his name, SusrutaSamhita. His time is guessed to be about B.C 1000.The SusrutaSamhita is of great historical importance because it includes historically unique chapters describing surgical training, instruments and procedures

which is still followed by modern science of surgery. The *Susruta Samhita* is divided into 186 chapters and contains descriptions of 1,120 illnesses, 700 medicinal plants, 64 preparations from mineral sources and 57 preparations based on animal sources.

### **Kayachikitsa and Salyatantra**

The system of Ayurveda developed into two branches, *Kayachikitsa* and *Salyatantra*. There is another division for specialization- the eight- fold division *Kayachikitsa*, *Balacikitsa*, *Grahacikitsa*, *Urdhvangacikitsa*, *Salyacikitsa*, *Damstracikitsa*, *Jaracikitsa* and *Vrsacikitsa* the eight parts or *astangas* of Ayurveda. Ayurveda is the holistic approach, which is mainly concerned with the treatment of the body. In the process, the person undergoes a change in the lifestyle, which includes change in food, clothing and sometimes even residence. *Asana* and *vyayam*, *yogasadhana* and *gati* are some of the vital components that are included in an Ayurvedic treatment. In *Kayachikitsa*, it is the first branch of *Astanga Ayurveda* or eight-branched Ayurveda that deals with general medicine. The total treatment procedure is called *Kayachikitsa* wherein *kaya* means 'body' and *chikitsa* means 'treatment'.

*Kayachikitsa* mainly deals with the diagnosis and treatment of a variety of general diseases, such as skin disorders, diabetes, tuberculosis, rheumatoid arthritis and many other disorders. *Charakasamhita* is the most important scripture on *Kayachikitsa*. It discussed the basic principles of treatment, various types of therapies and purification or detoxification methods. *Kayachikitsa* is the general medicine. *Balacikitsa* is the treatment of the diseases of pregnancy and children up to the age of twelve. *Grahacikitsa* treats of diseases particularly affecting the mind, the Ayurvedic method of psychiatry. In *urdhvangacikitsa*, diseases of the head portion of the body are dealt with specializing in the diseases of the eyes (94 diseases) ears (25 diseases) nose (18

diseases) mouth (75 diseases) and head as such (19 diseases). Thus two hundred and thirty one diseases are dealt with in urdhvangacikitsa, of which many are surgical ones. Surgical removal of cataract is explained. Grafting of portions of the nose and the ear with tissues taken from the neighbouring areas is described. Salyacikitsa is surgery. One hundred and twenty seven surgical instruments are described with their appropriate application. Major operations are described by Susruta include amputations, grafting, setting of fractures, removal of foetus and operation on the bladder for the removal of stones. Abdominal sections were performed. Haemorrhoids and fistulas were removed. Agni and Ksara were used to burn away additional tissues. Conception of Marma, one hundred and seven in number, as centres of life, is peculiar to Ayurveda.

### **Pancabhutasiddhanta**

Ayurveda is scientifically established on the foundation of the theory of the five bhutas (pancabhutasiddhanta), the edifice being the theory of the three faults (tridosasiddhanta). Pratyaksa or direct perception by observation, Anumana or logical inferential reasoning and Aptavakya (sabda) or the competent testimony of the Acaryas of experience are the sources of valid knowledge (pramanas) adapted by the ancient teachers to enunciate the principles of Ayurveda. Without Pratyaksa or perception there can be no knowledge, for anumana or inference is based on it. But to connect the cause with the effect and at times the effect with the cause, we have to use anumana. Anumana leads to certain generalizations which become theories, which have to be applied in particular cases in given circumstances with the intention of modifying the prevalent conditions to that which is desired. In Ayurveda the condition that has to be changed is disease (roga), and the desired condition is health (arogya) – Arogyarthahkriyakramah. To understand the cause of disease (and of health), to use the knowledge thus gained to change the effect that is disease to the other effect which is ease, called perfect health, is the purpose of Ayurveda.

Pancabhutamayamjagat is the concept of Ayurveda, Man experiences the world around him through his senses. The senses are five, those of hearing, touch, vision, taste and smell. They are situated in the ears, the skin, the eyes, the tongue and the nose. The impression resulting from the contact of the matter with the sense is what is known as pratyaksa. The matter that can be experienced through each sense is calledbhuta. There are five senses, so there are five bhutas. Not available individually in nature, the five bhutascombine to make the various substances (dravyas) that we came across in nature. The difference in proportion with variation in the process of evolution is the reason why things are different from one another.

## SCIENTIFIC METHODOLOGY IN ANCIENT INDIA

**K. N. Neelakantan Elayath**

In addition to the sizable output in religion, philosophy and literature Sanskrit has vast store of writings on scientific subjects like mathematics, astronomy, chemistry, medical science and architecture. Though ancient Indians have made astounding progress in some of these basic and applied sciences, the methodology and arguments employed by them are not properly studied or investigated. Hence the reconstruction of ancient scientific methodology becomes a task for those who want to work on Indian science. Many of these works written in Sanskrit envisage knowledge of scientific postulates and other general notions. And Indian scientists might have employed several methods of investigation, as in other parts of the globe. But the ignorance of these methods has affected the proper understanding and assessment of Indian scientific thought, even to the extent of doubting the originality of their scientific achievements.

### **Historical Perspective**

Even from the period of Rgveda Indians were aware of the laws of Nature that governed phenomena and of the definite laws of causality. In spite of the tremendous advancements in mathematics, these laws were not stated in terms of mathematics. No mathematical theorizing to account for physical phenomena is available in the scientific literature of India. Mostly, physical phenomena was qualitatively defined and not quantitatively. And many Sanskrit literatures pertaining to science are silent about the methods and many notions remain to be discovered from available commentaries. Thus we have to put together the clues available in scientific and philosophical works and their commentaries and various other sources and reconstruct the methodologies employed by Indians in scientific investigations.

Indians from a very early period distinguished between religion, philosophy and science. If there had been any overlapping it was because of the holistic attitude developed by them. The concept of two types of knowledge systems as superior and inferior (para vidya and apara vidyaj in the Upanisads and the later notion of rational philosophy (anviksikf) and religious studies (trayl) are indicative of this attitude. Both in science and philosophy the basic methodologies are the same. All the postulates of science are accepted in philosophy also. The difference is that philosophy goes further into regions where science usually does not enter. And this is true even in the case of ancient Indian science.

### **Indian Context**

Scientific method is the collective name for the process of investigation. Though its main features are observation and experimentation, it consists of several steps. They are formation of a hypothesis, defining concepts, making deductions from the hypothesis, collection and analysis of data, verification by experiments and finally integration of the result to the existing body of knowledge. Systematic doubt, verification and universality are the main features of this method. The scientific postulates include, also fundamental laws of thought and logic, like the principle of identity and the principle of contradiction. And it proceeds from certain basic assumptions like principle of casuality, principle of objectivity, principle of empiricism and principle of parsimony. The ancient Indian scientists accepted all these postulates and they followed all the procedures. But the details are not properly known. Dr. K.V Sarma ascribes this to a particular trend in Indian tradition of “not keeping the record of the intermediary steps and arguments once the result is obtained”. New formulations of theories, and frequent corrections and amendments made by subsequent writers especially in astronomy and mathematics may be a pointer to their deviation in methodology. In spite of the absence of details in many scientific treatises, we find

considerable progress in the employment of scientific method in the early systems of Indian philosophy, especially in realistic and naturalistic philosophies like Nyaya, Vaishesika and Sankhya systems. These systems comprehended scientific method in the larger spectrum of pramanasastra, the science of valid means of cognition. All problems related to this were discussed under this head. They formulated several theories on the structure, origin and evolution of matter in their cosmological speculations. To attribute certain phenomena to “unseen power” (adrsta) may be due to the ignorance of proper methodology or absence of proper instruments. Pratibha (intuition) and imagination also might have played an important role in their scientific investigations. But its excessive application was often checked by pramanasastra. We find an elaborated discussion on pramanas in most of the philosophical treatises of ancient India. These pramanas are accepted in all the scientific disciplines and some branches like Ayurveda has contributed substantially to the theory of pramanas.

### **Divinity of Scientific Knowledge**

The traditional belief is that most of these sciences like religion are of divine origin. And even some of the scientific treatises in Sanskrit seem to endorse this view (brahman! upadistahA In fact, science in ancient India, as in any other parts of the world, is the result of observation and experiment. It is interesting to note that Nilakantha Somayaji, a prominent medieval astronomer of Kerala, in his Jyotirmimamsa, clarified the exact nature of the so called divine instruction. He points out that ‘divine-instruction’ does not mean direct instruction by Gods but only chastening of the intellect through divine grace as a result of which authors could express their thought logically. “granthakarane devataprasadah mativaimalyahetuh tasya kutah pariksanam? brahmanah sarvajnatvat .... avitathatvaniscayat iti cet, manda, maivam, devataprasado mativaipulyahetureva. na ca brahma adityo va svayamevagatya u pad i set, tasmad brahmanopadistamityetat

aryabhatiyavakye naiva viruddham” (p.2) [In the composition of the work, the blessing of God is the cause of clarity of the intellect (if somebody raises the objection). Because Brahma is omniscient and his words infallible, why should you examine them? Fool! it is not the case. The Divine grace is only the cause of sharpening of the intellect. Not that Brahma or the Sun God will come down and give instructions. So there is no contradiction in the statement of Aryabhatiya that this knowledge is the divine instruction of Brahma],

He also points out a passage from Taittiriya Aranyaka (1 .2.1 ) which says that the means of determining the planetary positions are smrti, pratyaksa, aitihiya and anumana (recollection, perception, tradition and inference respectively:

smrtipratyaksamaitihyam anumanam catustayam /

etairadityamandalam sarvaireva vidhasyate//

Interestingly a commentator glosses pratyaksa in the above verse as saksipratyaksa or yogipratyaksa. One may thus conclude that as in the case of European science, Indian science was also the result of observation and experiment and not a product of speculation, intuition or introspection. B. N. Zeal in his Positive Sciences of the Ancient Hindushas shown that in the investigation of any topic, Indian scientific methodology accepted the following procedures.

1. Proposition of the subject matter (uddesya)
2. Ascertainment of the essential character by pramanas resulting in definitions (iaksana)
3. Examination and verification (pariksa and nimayaj)

The truth established through these procedure was called siddhanta, conclusion. However all pramanas are subsidiary to siddhanta and all the scientific methods are auxiliary to pramanasastra.

### **The Test of Truth**

The ultimate criterion of truth is considered to be samvadipravrttijanaka that which culminates in fruitful activity. It is not coherence but correspondence with external objects. This is included in the discussin on pramanasastra, which deals with sources of human knowledge and its verification. The problems of pramanas are one of the major issues discussed in detail in most of the systems of Indian philosophy.

### **Observation**

Indians include observation as a scientific method in pratyaksa or perception. The nature of perception and its limits were carefully studied. The infra sensible (atindriya), the observed, abhibhuta like the star in the mid day light, the unmanifest or potential (anudbhuta) are clearly distinguished. In pratyaksa the Naiyayikas insisted on the completion of the circuit of the consciousness and the minimum visible- the trasarenu- was identified. The conditions of non-perception were clearly defined and their listing by Sankhya philosophers is quoted in Carakasamhita.

Atidurat samipyad indriyaghatan mano' navasthanat /

Sauksmyad va vyavadhanad abhibhavat samanabhiharacca //

(Non-perception may be) due to extreme distance, extreme proximity, defective organs, non-steadiness of the mind, subtlety, veiling, suppression and blending with what is similar) The word 'ca' (and) here refers to similar causes like the non-manifestation of effect in the cause.

Indians have also studied the fallacies or defects of observation resulting in illusion (bhrama) or superimposition (a ropa / adhyasa). Errors of observation was one of the important topics discussed in philosophical treatises under the head 'theory of illusion' (khyativada). According to Naiyayikas perceptive knowledge becomes erroneous due to the defect of the sense-organ (as in the case of eye in jaundice) defect of stimulus (sahakari) like the absence of proper light, undue distance etc. in vision; rousing of the memory of similar objects (samprayoga) and the influence of mental dispositions like habit, prejudice etc. The detailed discussions on perception and its fallacies in different darsanas bring out the importance attached by Indians to scientific observation. In specific sciences, the phenomena were clearly observed and analyzed. Since the ancient Indians did not possess sophisticated instruments most of the scientific theories must have been formulated by the power of observation. Observation was the basis of many physical, chemical and astronomical theories. This also led to the method of classification, one of the important scientific processes. The definition and classification of categories, substances and qualities in Nyaya-Vaisesika system are based on observation. In Ayurveda several theories are the result of precise and minute observation. In meteorology, weather fore-casts were made by the observation of the clouds and other atmospheric phenomena.

In scientific-planetary-astronomy, Indians have reached a remarkable degree of progress. For the determination of lunar constants determining the lunar periods and eclipses they went a step further. They scanned the heaven for long periods and revised astronomical parameters. It is recorded that Paramesvara, the Kerala astronomer, made observations of eclipses and

configuration of planets for 55 years before formulating drgganita. Theories of planetary motion, computation of eclipses, theory of the rotation of the earth etc., were the result of observation of physical phenomena. The classification of insects in Zoology and classification of plants in Botany though based on external characters, are the result of repeated observations.

As in philosophy, in all branches of science, inference or anumana was employed as a foolproof method of investigation. However, the Naiyayikas and the Buddhists worked out its theoretical details. This is a process of ascertaining the truth through the medium of mark (lihga) that a thing possesses. It is, therefore based on the establishment of invariable concomitance (vyapti) between the mark and the object inferred. It is a rigorous formal statement in the form of five propositions- proposition to be established (pratijna), the reason (hetu) ascription of the mark, the general proposition stating the vyapti with an example (udaharana), ascertainment of the existence of the mark (upanaya), and finally the conclusion (nigamana). The Buddhists accept causality and identity (tadutpatti and tadatmya) as the ground of inference. Vyapti or invariable concomitance is established by agreement in presence (anvaya) and agreement in absence (vyatireka). According to later Naiyayikas it is invariable and unconditional concomitance between two phenomina. Even a suspected condition (sahkitopadhi) should be absent and this can be removed by repeated observation (bhuyodarsana). In addition to inference a hypothesis (kalpana) properly tested and verified was considered as a method to ascertain a certain phenomena. Jayantabhatta in his Nyayamanjari says that a proper hypothesis should fulfill the following conditions:

1. It should not be in conflict with other observed facts or established thesis (drstasiddhaye na drstavighataya adrstam kalpyate)
2. No unobserved agencies should be assumed when it is possible to explain the fact by observed agencies (drstakalpana)
3. When there are rival hypothesis the simpler should be preferred (laghava)
4. When there are different hypotheses the immediate and relevant should be adopted rather than the remote (prathamopasthita)
5. Hypothesis should be verified by showing that it is deduced from a general proposition already established. (See B.N. seal)

Like perception this method of logic also was comprehended under the wider conception of pramanasastra. In fact, inference is one of the major methodologies of all sciences. In mathematics, astronomy and medical science this inferential method was applied and we have general logic and logic of special sciences. A typical example is the application of logic in Indian system of medicine. Logic, as found in Caraka's system is applied to the problems in the study of diseases, their causes, symptoms and remedies (Vimanasthana Ch. IV).

Caraka at the very outset says that things are either existent or non-existent and they can be investigated by four pramanas - utterance of a reliable person (aptopadesa), perception (pratyaksa), inference (anumana), and continuous argument (yukti) (1.11.17). A detailed discussion on pramanas is taken up in the relevant context of the Carakasambita. He classifies anumana into three types: from effect to cause, from cause to effect, and from association other

than causal relations. Yukti is sometimes differentiated from anumana. When a conclusion is reached as a result of the examination of various causes and considerations, we have yukti. The example Caraka gives is the forecasting of good and bad harvest from the conditions of the ground, rains, climatic condition etc. It is also called uha, a kind of guess work, by some commentators. According to others it is only an inference of the effect from the cause.

Logic in Ayurveda had twofold function. It was used not only for diagnosing diseases but also for debating purposes. On the occasion of the treatments of illness of rich people, physicians had to show their skill in debates and establish their thesis. The art of carrying on a debate successfully was considered to be an essential qualification of a good physician. In *Carakasambita* we have an elaborate treatment of debating techniques and a whole chapter is set apart for its discussion (Rogabhisagjitiya vimana , 1 1 1 . 8). Caraka even goes to the extent of saying that hetu is the foundation of all knowledge - hetur nama upalabdihikaranam. And his four-fold classification of siddhanta brings out the importance of discussion and debate in arriving at the truth (sarvasiddhanta, pratitantrasiddhanta, adhikaranasiddhanta and abhyupagama siddhanta). In arithmetic and geometry Indian theories were very close to modern European science. Indians have worked out all achievements in these two disciplines by continuous hard work in the realm of abstract thought.

## **Experiments**

Experiments have been always the major methodology in scientific investigations. For experimentations the ancient Indian scientists must have used some instruments, though the details of them are not fully known. It is possible that the astronomers in India used certain instruments for observation and experiments. In some context these instruments are casually

mentioned but not described in detail. The golapada of Aryabhata mentions an automatically rotating golayantra (sphere) keeping pace with time for astronomical demonstrations.

In Ayurveda experiments were conducted on the dead bodies. The reference to several sharp instruments in surgery reveals that there were experiments. Again the description of about five hundred herbs and their therapeutic uses would not have been possible without experiments. The knowledge of toxicology dealing with the nature and effects of poisons point to experimentations. Several toxic plants were identified and studied by them, in the kitchens of great rulers, experts in poisonous substances were employed to examine the food prepared for the king. This would not have been possible without experiments.

In chemistry the preparation of medicines, preparation of colours and cosmetics presuppose the employment of experimental method. The knowledge of about eighteen mercury compounds and various chemical processes like extraction, purification, liquefying, melting, tempering etc. were the result of continuous trial and error method.

In the field of ancient architecture (vastuvidya) which reached a high degree of perfection in India, all the achievements were the results of centuries of experiments and theorization. Its concept of vastumandala from which design theories are derived to suit different types of buildings, its system of measurement yavamana and purusamana, the yoni concept (system of defining the orientation of vastu with respect to different directions) all point to experimentation.

In the selection of a site suitable for the construction of a building a systematic method through experiment and observation is prescribed. The ideal site should satisfy the following conditions: even topology, fertile soil for useful plants, compact soil conditions for supporting the building, and availability of water and moderate climate. When most of these conditions are

known through observation, compact soil condition is tested with experiments. To cite an example, a spot is first excavated and it is filled with excavated soil. If it is completely used for filling, then the ground is not compact and it is not suitable for building. If a good portion of the excavated soil remains even after filling, it shows the compact nature of the soil and so it is suitable for houses. The details of this process are furnished in *Manusyalayacandrika* and *Brhatsamhita*.

## ASTRONOMY AND MATHEMATICS IN SANSKRIT LITERATURE

**K. V. Sarma**

### **Introduction**

In Sanskrit parlance, the disciplines of mathematics, astronomy and astrology are comprehended in Jyotisa, which is one of the fourteen ancient Indian systems of knowledge and forms one of the six auxiliaries of the Vedas. In the pursuit of Vedic studies and in leading a Vedic life, Jyotisa is considered as important as eyes are to man, for the reason that it provided the means for the computation of auspicious moments for the performance of Vedic ceremonies and thereby attain emancipation. This aspect of Jyotisa had induced the ancients to put that discipline at the top of the other Vedangas.

### **Scope of Jyotisa**

Jyotisa is conceived in ancient India, took under its purview not only astronomy and mathematics, but also astrology, both horoscopic and natural. It was broadly divided into three skandhas or 'branches' called respectively Ganita, Jataka, (or Hora) and Samhita (or Sakha). Thus, that section of Jyotisa which concerned itself with the computation of time, spherics, the planetary motions and positions, and eclipses constituted Ganita (Astronomy and Mathematics). The section which foretold the future of individuals on the basis of the position of the planets at their time of birth and other allied indications is called Jataka, Hora, Kala or Muhurta (Horoscopy). The third section which occupied itself with prognostication based on natural phenomena is termed Samhita (natural astrology). Predictions based on omens, gems, physiognomy, palmistry etc., also come under the purview of Samhita. As examples of

Varahamihira and the Jatakapaddhati of Sripati and, of the Samhita-skandha, the Brhatsamhita of Varahamihira, the parasara- samhita ascribed to sage Parasara etc.

### **Divisions of Ganita**

Works on Ganita fall mainly under three classes, viz., Siddhanta, Tantra and Karana in view of the different zero points, fundamentals and parameters they adopt as the basis of computation. Thus the Siddhanta texts take the beginning of an extensive period of 1008 caturyugas as the starting point of calculations when all the planets and their nodes and apogees would have been at Mesadi the first point of Arises.

The Tantra texts, sometimes sub- divided into Mahatantra and Tantra, prescribe the parameters for the catur-yuga at the beginning of which all the planets and the Moon'S apogee and node would have been at the zero-point, Mesadi and compute the planets using current Kalidina, viz., the number of days which have passed by in the present Kali-yuga.

The Karana is a type of text which takes a recent, generally contemporary date, as the zero-point, calculate accurately the planetary positions at sunrise on that day and use them as zero-corrections. Calculations are simplified on account of smaller multipliers and divisors.

### **Vedanga- Jyotisa**

Vedanga- Jyotisa dated to about 1200 B.C. and attributed to sage Lagadha, that one finds Vedic astronomy set out as a regular discipline. The Rgveda and Yajurveda Jyotisas contain respectively, 36 and 43 verses, of which 30 verses are common. These works enunciate the methods to determine, for the purposes of rituals and sacrifices, the positions of the sun and the moon at the solstices, new and full moons in the stellar zodiac of twenty- seven nakshatras, the

tithis, the parvan-s, visuvat-s etc. The basis of calculation of the Vedanga- Jyotisa is a five- year cycle called yuga, arrived at on the basis of solar years and lunar months. A solar year was taken as 366 days. Five such years would make up 1830 days, which is exactly 62 lunar months. Two of these lunar months are considered as intercalary months (adhimasa), one at the end of the third year and the other at the end of the fifth year, and were ignored in the count. Thus the lunar month cycle was made to coincide with the solar cycle at the end of the intervals of five years.

### **The five Siddhantas**

The pancasiddhantika of Varahamihira (A.D.505) preserves the main features of five early astronomical treatises, the Paitamaha, Vasistha, Paulisa, Romaka and Saura siddhantas, promulgated during the early centuries of the Christian era.

Towards the beginning of this work in 18 chapters, he gives the order of accuracy of these Siddhantas as Saura, Paulisa, Romaka, and then the other two. And among the topics that he depicts from these Siddhantas are the rules for the computation of the eclipses of the Sun and the Moon, the directions, the conjunctions and obscurations of the stars and the planets, the longitudes, prime vertical, rising of the moon, construction of astronomical instruments, the shadow of the gnomon, sine latitude and colatitude, declination and other topics. The significance of these Siddhantas lies in their indicating the transition of Indian astronomy from the non-scientific to the scientific phase.

### **Scientific Indian Astronomy**

#### **Aryabhata (A.D.476)**

Scientific astronomy can be said to have been ushered in by Aryabhata I who flourished at Kusumapura (modern Patna) through his two works, the Aryabhata- Siddhanta and the Aryabhatiya, the latter composed in A.D.499. He was an observer par excellence and, as a result of his investigations, he revised the then current astronomical parameters, introduced new techniques in calculation and established astronomy on a scientific basis. An anonymous verse describes him as a great teacher who was born in Kusumapuri as the incarnation of the Sun in order to resurrect astronomy when the results arrived at from the Five Siddhantas began to be erratic.

### **Varahamihira**

Varahamihira, son of Adityadasa and a younger contemporary of Aryabhata, is one of the profile writers in Jyotisa but the bulk of his writings pertain to natural and horoscopic astrology. His only work on astronomy is the Panca-siddhantika, noticed earlier, being a resume of the teachings of the five siddhantas of Paitamaha, Vasista, Lomasa, Romaka, and Saura. But this work is of the greatest significance for it portrays the period when Indian Jyotisa was developing into scientific astronomy.

### **Brahmagupta (A.D. 598)**

In the Brahmasphutasiddhanta of Brahmagupta, composed in A.D.628. In 24 chapters, it encompasses arithmetic, algebra, geometry and astronomy, the last including sections on astronomical diagrams and instruments. One comes across, in this work, severe criticisms of some of the earlier writers, such as Aryabhata, Varahamihira, Srisena and Visnucandra. Certain pronouncements of Brahmagupta have been refuted by later astronomers like Vatesvara.

### **Bhaskara (A.D. 629)**

The Mahabhaskariya and the Laghubhaskariya both by Bhaskara I of Valabhi in Gujarat, the foremost among the followers of Aryabhata have already been mentioned. The two works, each in eight chapters, redact, continue and elaborate the precepts of their source-book. Both the works have been popular, especially in Kerala and have attracted several commentators including Govindaswami (A.D. 800) Sankaranarayana (A.D 869) Udayadivakara (A.D 1073), Suryadeva-Yajvan (A.D 1191).

### **Lalla (A.D. 8<sup>th</sup> century)**

In the Sisyadhi-vrddhida, a work of the Mahatantra type, in about a thousand verses, by Lalla, we have an orderly exposition of the teachings in the Aryabhata, set out here in fourteen chapters. The sections on the armillary sphere and on astronomical instruments are particularly instructive.

### **Mahavira(A.d.850)**

In Ganita- sarasangraha of Mahavira, the Jain mathematician who flourished in the court of the Rashtrakuta king Amoghavarsa Nrpatunga in the Karnataka region of South India, we have one of the most extensive works on arithmetic, algebra and geometry. Highly logical in presentation, Mahavira's work contains a very large number of problems and riders illustrating the rules. He is the only Indian mathematician who has referred to the ellipse(ayata- vrta) and given a formula for the area and perimeter of the ellipse.

### **Sridhara (A.D.900)**

The Patiganita of Sridhara, a Saivite Hindu, posterior to Mahavira but anterior to Aryabhata II is an extensive work on Arithmetic and mensuration, said contain 800 verses, which formed a model for the well- known lilavati of Bhaskara II. To the textual verses, the author adds ample

illustrations. Thus., the only manuscript of the work known, which is incomplete and is endowed with an anonymous commentary, contains 118 definitions and 133 examples.

### **Suryasiddhanta (bet.650 and 950)**

The extant Suryasiddhanta is the most popular astronomical authority of North India. Its popularity can be gauged from the fact that more than forty commentaries on it have been recorded and that a large number of calendrical works have been prepared on its basis.

In fourteen chapters, containing in all about 500 verses, it endeavours to give a brief but complete account of all aspects of Astronomy. However, no illustrative problems are given and the treatment of arithmetic and algebra is completely eschewed.

### **Munjala or Manjula (A.D.932)**

The Laghumanasa, the only available work of Manjula of Kashmir, is a Karana-grantha in sixty verses, containing several novel innovations and methodologies. It has been commented upon by Parameswara, Suryadeve- Yajvan and Yallaya, the last two being very extensive. An anonymous commentary on the work in Malayalam has also been identified. Munjala had an admirer in an equally gifted astronomer Sripati who wrote a calendrical work, Dhruvamanasa-karana based on the Laghumanasa.

### **Sripati**

The Siddhantasekhara of sripati, son of Nagadeva, is a highly respected text of the Siddhanta type. In twenty chapters, containing 890 verses, the work deals with all aspects of astronomy, of which two deserve special notice, viz, ch.17 Rahunirakaranadhyana, on the demolition of the theory of the legendary heavenly serpent Rahu causing the eclipses, and ch.19

Yantradhya, on astronomical instruments. The work does not deal with mathematics, which the author does in a separate work entitled Ganitatilaka, which has been commented in detail by Simhatilakasuri.

## **Bhaskara**

Bhaskara II, son of Mahesvara and resident of Bijjadabida, identified with Bijapur, in the Deccan, is the most renowned of mediaeval Indian astronomers. His Lilavati, in 13 chapters, deals with the different topics of arithmetic and geometry and his Bijaganita, in 11 chapters, with that of algebra. But more important in his Siddhantasiromani divided into two sections called Ganitadhyaya and Goladhyaya, in 12 and 14 chapters, respectively, treating the entire gamut of Indian astronomy.

## **Ganesa-Daivajna (A.D.1507)**

In the Grahalaghava called also Siddhantarahasya and its autocommentary by Ganesa-Daivajna, son of Kesava- Daivajna of Nandigram, we have one of the most popular calendrical texts in Indian astronomy, composed in a highly poetic language. This work is avidly studied and widely used and has a number of commentaries written on it. His other calendrical manuals include patasamsadhana or patasarini, containing several astronomical tables, and Brhattithicintamani and Laghu-tithicintamani, both for the preparation of the lunar calendar.

## **Kerala works on Astronomy**

Astronomical practice in Kerala has been built entirely on the solid pedestal of Aryabhatan astronomy. While it might not be possible to substantiate the claim that Kerala was the home of Aryabhata, it can be asserted that this part of the country had been the fertile field for

the development of the Aryabhatan system which gradually faded out of North India on account of the criticism levelled against it by Brahmagupta and others. At least from the 7<sup>th</sup> century A.D., the system was current in the land. And, it became entrenched there from A.D. 683-84 when Haridatta promulgated the Aryabhata- based parahita system of astronomical computation at Tirunavay in North Kerala on the occasion of a mamankam festival held there, and wrote the works Mahamarga- nibandhana and Grahacaranibandhana espousing the system. While the former work is known only through citations, the latter and a redaction thereof called Grahacaranibandhanasangraha are known and edited. The system postulates a correction called Bhatabda-Samskara or Sakabda- Samskara to the Aryabhatan system and presents all the data, directions and sinetables necessary for the computation of the planets and for all allied matters.

## THE CRITICAL AND RATIONAL APPROACH OF KELALLUR NILAKANTA SOMAYAJI

Kelallur Nilakanta Somayaji (KNS) is a Keralite astronomer of 15th century, who staunchly advocated that astronomy is a science which can be (and should be) subjected to periodical verification and modification. KNS belongs to the school of Kerala mathematicians/astronomers, which is said to have done most brilliant work ever to be done in Indian Mathematics. Till recent times the Historians of Indian Mathematics held a view that after Bhaskara II no original work has been done in the twin disciplines of Mathematics and Astronomy in India. But it is widely accepted that in Kerala, there flourished a school of Mathematics during the 14th to 17th centuries which has made a commendable contribution to the development of Mathematics. In fact it was an unknown tradition which extended for five-six generations or more. KNS is the grand disciple of Vatasseri Paramesvara, the author of Drgganita. The latter is a good researcher who had been observing eclipses, the best celestial phenomena to verify the correctness of astronomical computations, for a continuous period of 55 years. The more important fact is that he has recorded the collected data in his works, especially the Siddhantadipika. He is a direct disciple of Sangamagramamadhava, the well known mathematician of Kerala, who is often called the father of Kerala school of Mathemaics. Taking cue from him, KNS also has written many works and recorded the collected data after observing eclipses. The most important thing is that he staunchly advocates the idea that astronomy is a pure science and that everybody should keep on doing investigation. Personal details KNS himself has given his date of birth in one of his works (Siddhantadarpanavyakhya) by the Kali chronogram Tyajamyajnatam tarkaraih as Kali day 1660181, which falls on 1444 AD.

At the end of the Ganitapada of his Aryabhataiya Bhashya, KNS gives a detailed colophon containing some information regarding his personal life. From this, it is learnt that he was initiated into Astronomy by Damodara, Son of Vatasseri Paramesvara, who in turn, is the author of Drgganita. He belonged to Gargagotra and was a follower of Asvalayanasutra. He had performed Somayaga. His favourite deity was Paramesvara of Svetaranya. He was initiated into Vedanta by Ravi. His father's name was Jataveda. Also he had a maternal uncle by the same name. He had a younger brother Sankara and a close associate, Subrahmanya.

Tantrasamgraha, (literally, *A Compilation of the System*) is an important astronomical treatise written by K N S, an astronomer/ mathematician belonging to the Kerala school of astronomy and mathematics. The treatise was completed in 1501 CE. It consists of 432 verses in Sanskrit divided into eight chapters. Tantrasamgraha had spawned a few commentaries: *Tantrasamgraha-vyakhya* of anonymous authorship and *Yuktibhāṣā* authored by Jyeshthadeva in about 1550 CE. Tantrasamgraha, together with its commentaries, bring forth the depths of the mathematical accomplishments the Kerala school of astronomy and mathematics, in particular the achievements of the remarkable mathematician of the school Sangamagrama Madhava. In his *Tantrasamgraha*, Nilakantha revised Aryabhata's model for the planets Mercury and Venus. His equation of the centre for these planets remained the most accurate until the time of Johannes Kepler in the 17th century. *Sidhantadarpana* is a short work in 32 slokas enunciating the astronomical constants with reference to the Kalpa and specifying his views on astronomical concepts and topics. *Candrachayaganita* is another important work in 32 verses on the methods for the calculation of time from the measurement of the shadow of the gnomon cast by the moon and vice versa.

Jyotirmimamsa (analysis of astronomy) is a treatise on the methodology of astronomical studies. This book stresses the necessity and importance of astronomical observations to obtain correct parameters for computations and to develop more and more accurate theories. It even discounts the role of revealed wisdom and divine intuitions in studying astronomical phenomena. Jyotirmimamsa is sometimes cited as proof to establish that modern methodologies of scientific investigations are not unknown to ancient and medieval Indians. The nature of the astronomical and mathematical work, the divine intuition, the experimental details of the science, corrections to the planetary parameters, reasons for the corrections for the planetary revolutions, Vedic authority for inference in astronomy, relative accuracy of different systems, and correction through eclipses, true motion, position, etc., of planets are some of the topics discussed in Jyotirmimamsa.

## YUKTIBHASA

### T. B. Venugopalapaniker

The work is also known as *Gaṇitanyāyasaṅgraha* (*Compendium of Astronomical Rationale*), is a major treatise on mathematics and astronomy, written by the Indian astronomer Jyesthadeva of the Kerala school of mathematics around 1530. The treatise, written in Malayalam, is a consolidation of the discoveries by Madhava of Sangamagrama, Nilakantha Somayaji, Parameshvara, Jyeshthadeva, Achyuta Pisharati, and other astronomer-mathematicians of the Kerala school.

The work was unique for its time, since it contained proofs and derivations of the theorems that it presented; something unusual for Indian mathematicians of that era. Some of its important topics include the infinite series expansions of functions; power series, including of  $\pi$  and  $\pi/4$ ; trigonometric series of sine, cosine, tangent and arctangent; Taylor series, including second and third order approximations of sine and cosine; radii, diameters and circumferences; and tests of convergence.

*Yuktibhāṣā* is mainly based on Nilakantha's *Tantra Samgraha*. It is considered an early text on the ideas of calculus, predating Newton and Leibniz by centuries. The treatise was largely unnoticed outside India, as it was written in the local language of Malayalam. It is often generalized that early Indian scholars in astronomy and computation lacked in proofs, but *Yuktibhāṣā* demonstrates otherwise. In modern times, due to wider international cooperation in mathematics, the wider world has taken notice of the work. For example, both Oxford University and the Royal Society of Great Britain have given attribution to pioneering mathematical theorems of Indian origin that predate their Western counterparts

*Yuktibhāṣā* contains most of the developments of the earlier Kerala school, particularly Madhava and Nilakantha. The text is divided into two parts – the former deals with mathematical analysis and the latter with astronomy.

The first four chapters of the *Yuktibhāṣā* contain elementary mathematics, such as division, the Pythagorean theorem, square roots, etc. Novel ideas are not discussed until the sixth chapter on circumference of a circle. *Yuktibhāṣā* contains a derivation and proof for the power series of inverse tangent, discovered by Madhava.

The first term is the product of the given sine and radius of the desired arc divided by the cosine of the arc. The succeeding terms are obtained by a process of iteration when the first term is repeatedly multiplied by the square of the sine and divided by the square of the cosine. All the terms are then divided by the odd numbers 1, 3, 5, .... The arc is obtained by adding and subtracting respectively the terms of odd rank and those of even rank. It is laid down that the sine of the arc or that of its complement whichever is the smaller should be taken here as the given sine. Otherwise the terms obtained by this above iteration will not tend to the vanishing magnitude.

Chapters seven to seventeen deal with subjects of astronomy: planetary orbits, celestial spheres, ascension, declination, directions and shadows, spherical triangles, ellipses, and parallax correction. The planetary theory described in the book is similar to that later adopted by Danish astronomer Tycho Brahe.

## UNIT III

### SANSKRIT LITERATURE ON ARCHITECTURE AND ICONOGRAPHY

**Dr. N.V. Mallayya**

Technical literature in Sanskrit is a priceless possession of the Indian people. Sanskrit is the mother or foster mother of languages and literatures in India. It knits together the various provinces in a cultural bond. The different branches of knowledge are borne to us through this vehicle. Studies in Sanskrit texts on the various subjects- art, architecture, iconography, engineering, medicine, mathematics, physical and biological science etc., will unfold achievements of the ancients- a source of inspiration to the present and future generations to make their own contributions in the field of knowledge.

The philosophical and architectural literature of India reveals the ideal of sacred architecture which was born of the conception of 'divinity in a spiritualised body'. India has left its legacy of idealism to the civilization of mankind. The idealism in Indian architecture and iconography relates temple to image as body to soul.

The significance of the temple lies in the fact of its being treated as the home of the eternal spirit symbolized by the image. The body needs soul for its significance and the soul needs body for its expression. Integral relation of the subjects, architecture and iconography, is seen emphasised in Sanskrit literature on them. Out of unavoidable human necessity arose images and temples to house them. The tendency to worship is ingrained in human nature. Worship implies object of worship. Temples and images embody the principles of religion and philosophy as crystallized conceptions. A study of the texts on these subjects unfold the spiritual consciousness of the people, the most vitalizing feature of India's culture.

## **General Character of Hindu iconography Compared to that of Temple Architecture**

Architecture is the art of modeling in space. It has to do with space, invisible to the eye. Proportions take the dominant role. Space is enclosed with a set purpose. Sculpture concerns itself in the surface, with what the eyes can see. The sculpture shapes the material such as clay, stone, wood or metal. In iconography, the transformation of the material into an image conveys to the mind of the worshipper ideas embodied in forms. Sculpture is the handmade of architecture. Both architecture and sculpture are governed by idealism. Idealism governing architecture is revealed in the interpretation of the temple in terms of the human organism.

### **Architecture-definition of the term**

Architecture is the art of building in such a way that the edifice raised, while serving the ends of use and convenience, also meets the aesthetic requirements. It is occupied with the considerations of the principles of constructive art combined with consideration of the principles of beauty. The views of Vitruvius and Ruskin and Indian architectural authorities on architectural idealism in the definition of the term in their respective works are identical.

### **The concept of 'Prasada' in technical literature in Sanskrit**

The term 'Prasada' signifies both temple and palace. The structural correspondence reflect, the character of both. The qualities of splendor and grandeur of each (temple or palace) make it a thing of beauty. Minds are delighted in this by virtue of its delightful setting. The central structure invites the repose and contemplation of the finest work of art. In the midst of structures, the Prasada stands firm, as firm as the faith of the faithful, and through the hands of

artists bloom into beauty. The accessory structures, in their turn, enhance the importance of the Holy of Holies and testify to the expression of the added dignity which it commands by virtue of its holding the position of the home of the Godhead invoked.

### **Six- fold vertical division**

Vertically divided, the Prasada has six main parts from bottom upwards- (1) Adhithana (basement), (2) Stambha (pillar), (3) Prastara (entablature) (4) Gala(neck), (5) Sikhara (head-roof), (6) Stupika or Sikha (final, literally upright tuft, top- knot). To raise the height, the optional member Upapitha beneath the Adhithana is prescribed.

#### 1. Adhithana

The description of the term is given in Isanasivaguru- devapaddhati, stating the derivation and meaning. The strongest, firmest and most solidly laid member (adyanga-the first member from bottom upwards) Adhithana is meant to carry the weight of the parts of the structure built above.

#### 2. Stambha (Pillar)

Above the basement and below the utara are constructed the pillars, spaced the intervals apart so that the weight supported is equally distributed among them. Their structural function is carrying the beam and the load above with ease. The synonymous Pada, Anghri, Jangha etc., denoting leg and in architectural literature the pillar echoes the human organism and confirms the theory of conception of temple in terms of human organism. In architecture we observe

enormous operations and balancing of forces involved, and weight, pressure and resistance exhibited in the functions of structural parts.

### 3. Prastara(entablature).

This is the horizontal, structural division in the six- fold classification, the third from bottom upwards, above Stambha and below Gala. Uttara the beam sits on the columns, one of the most important of architectural divisions- the Khandottara, Patrottara, and Rupottara are the three classes.

### 4. Gala and 5.Sikhara.

These are the fourth and fifth members. Sikhara corresponds to the roof and its constructions is described. Kuta resembles dhurdhura followers. It is octagonal, sixteenfaced or circular or lotuslike. Rules are given for the making of Lupas, rafters, Nipraphalaka, the plank, Valayas, the bands, the elements lending strength and cohesion to the rafters and binding them together, the Pidhanaphalaka the final coping plank or slab. Coppersheets, bricks and such other materials are prescribed for convering the roof.

### 6. Stupika.

The Stupika or finial the sixth member, the top- most crowning part of the structure, has four parts- Padma, Kumbha, Nala and Kudmala. Gurudeva in his Paddhati observes – sikhasabdena stupikocyate. In the Veda and in architectural literature, the terms Stupa and Sikha refer to upright tuft or topknot. Gurudeva's observation that the terms Sikha and stupika are synonymous is significant.

## **Aim of the study of Iconography**

Various elements and concepts have gone into the shape of the three gods of the Hindu triad-Brahma, Visnu and Siva. Our aim in the study of iconography should be to interpret and expound faithfully the original Sanskrit texts with a view to showing the inner dispositions of the ancient minds which activated the texts and the images. The history of the Gods should be traced through the varied stages of literature and in the light of this history should be sought the explanation of their iconography representations. Journey through the tracts of literature from Vedic times up to the Pauranic stage with reference to all the complex gods and goodness of the pantheon will bring home to the mind of the traveller the varied treasures of through which enrich our understanding and intelligent appreciation of the symbols in iconography.

## VASTUVIDYA AND ECOLOGY

### C. Rajendran

Vastu, which is derived from the Sanskrit root vas, meaning , to dwell' stands for dwelling apartments in a strict sense but the term vastusastra generally signifies architecture in Indian tradition. Here the term is used in the sense of India's traditional architecture especially as it developed in Kerala, where it is still practiced. India has a continuous history of architecture from at least the time of Indus valley civilization, with different styles varying from time to time.

Almost all treatises on vastusastra prescribe elaborate guidelines for the selection of a proper site for the construction of the dwelling house. This is in stark contrast with the modern practice of building houses in any place irrespective of the nature of the terrain. True, the problems created by rapid urbanisation do not leave much choice for us in the selection of site in modern times, but the prescriptions in ancient treatises should serve as some sort of guidelines for the modern town planners. Ancient treatises like Padmasamhita classify the terrain into four, mainly on the basis of the nature and location of the site. Accordingly, the land situated near sea, river etc. which abounds in water is called bhadra. It is ideal for the construction of house, as it is conducive to the growth of plants and trees. Puma is the name given to land on hillside favourable for the construction of dwelling houses. Supadma is the land in plains, also favourable for residential purposes. On the other hand, the land called dhumra has extreme climatic variations and rocky surface. It does not have enough water and also abounds in wild animals as well as poisonous plants. Needless to say, such land is not ideal for residence.

According to texts like Manusya/ayacandrika and Suparatna ie, ideal site should be rich with cows, human beings, flowering, fruit-bearing and sappy trees, of even level, sloping to the

East, smooth, producing good sound (when walked upon), with water flowing on clockwise direction. It should cause speedy germination of seeds, be compact, having perennial water and even in heat and cold. The land deficient in these qualities is bad, and that with mixed character is mediocre for settlement purposes. The land which is irregularly shaped and which is full of ashes, cinder, husk, bones, hair, vermin and anthill is also not recommended. Also, the land should not be concave in surface, foul smelling, and unmatching to the four cardinal directions. Land which is muddy, scorching in the sun, infested by pests, having scarcity of water, inhabited by demons, low-lying and rocky should also to be avoided. These stipulations seem to have been made to ensure that the land is rich in its biodiversity and conducive to the growth of trees and plants as well as friendly to animals. The stipulation that the site should be sloping to the eastern direction seems to be to ensure the availability was to ensure certain firmness for the ground.

Manusyalayacandrika, the work makes it clear that only places with perennial supply of water are fit for human habitation. Again, water should ideally flow in a clockwise direction, though the full implication of this stipulation is not known. Environmental considerations are again implicit in the prohibition of certain types of sites and soils to be used for building houses. Thus, land having the presence of ash, cinder, husk, bones, hair, vermin and anthill are not regarded as ideal. The reason seems to be that they must have been used for sacrificial purposes or as burial ground or dumping ground. Vermin and anthills are not good signs since they indicate the presence of termites and pests, which will be detrimental to the wooden and similar parts of the house. Land with concave surface is to be avoided, as it will have no capacity for wastewater disposal. Land with foul smell is to be avoided as it indicates degraded environment.

Most of the treatises on vastuvidya maintain that all constructions should be oriented to the cardinal directions. In fact, an onlooker passing through highways in places like Kerala can

readily see that most of the conventional buildings, constructed on traditional style are oriented to directions and not to the location of roads and the like. The reason seems to be the importance attached to the position of sun. Maximum presence of sunlight was ensured in houses at any cost. For this, the position of the sun in the uttarayana and daksinayana transits was taken into account. The climatic change resulting from the elliptical movement of the sun was also taken into consideration.

Manusyalayacandrika and similar treatises give utmost importance to the plantation of various types of trees in different parts of the compound. Bakula (*Mimusops elengi*) and banyan tree (*Ficus bengalensis*) in the east and udumbara (*F. racemosa*) and tamarind (*Tamarindus indica*) in the south will bestow prosperity. In the west, asvattha (*F. religiosa*) and saptacchada (*A/stonia scholaris*) and in the north, naga (*Mesua nagassarium*) and plaksa (*F. microcapra*) are prescribed. Jack tree (*Atrocarpus heterophyllus*), arecanut palm (*Areca catechu*), coconut palm (*Cocos nucifera*) are especially propitious in the directions of east etc. (east, south, west, north) respectively.

Manusyalayacandrika prescribes that trees will not block the sunlight coming from the south in winter due to the daksinayana movement of the sun. Similarly, trees with thick foliage were to be planted in the North, as they would be helpful to resist cold wind coming from the North. It seems that ancient works on vastusastra were aware of the ecological problems caused by the pressure on land due to unbridled construction work. This is evident from the zonal restrictions for residences near paddy fields, mountains, temples, oceans, rivers, hermitages, and cattlesheds. We also find areas earmarked for residential purposes in works like Kautilya's *Arthashastra* very much similar to modern practices in town planning followed in the developed countries.

A unique feature of Indian residential architecture is the concept of vastupurusa, the mythical demon, whose body symbolically represents the site on which the building is built. Vastupurusa essentially typifies an organic model, wherein the human edifice is conceived as an extension of the life force of the universe. This is in accordance with the ancient Indian notion of man as a part of the grand cosmic scheme and sharply contrasts with the European concept of mechanical structures, which are thrust on nature. There are sensitive areas in the body of vastupurusa, which cannot be tampered with in the construction of the building in Indian vision. Though the immediate scientific principle of such prescriptions is not known, it reinforces the basic notion of an environment-friendly approach to nature and life. Treatises like *Manusyalayacandrika* prescribe adequate precautions in house construction to ensure ventilation and privacy and to avoid overcrowding. Thus, it is prescribed that the plot is to be sub-divided into four quadrants. The north-east quadrant called manusakhanda is recommended as the ideal location for the actual building, which will bring prosperity. The south-west quadrant called devatakhandha is also good. This zonal restriction ensures that there is some gap between one house and the other. Again the outer vithi of the plot, called pisaca vithi was supposed to be unfit for construction, for the obvious reason that the distance between one house and the other will be less.

Eco-aesthetic considerations are also implicit in the unique conception of an inner quadrangle (atrium) opening to the sky, in the middle of the house. In this construction, the courtyard ensured that there is proper ventilation and sunlight available to the inner parts of the house without unduly compromising security. Atrium was a ritualistic area also, as it served as the place where some important rites were performed. Provision was also made for jasmine creepers grow in the atrium, which ensured the splendour and fragrance of flowers within the

house, also providing the most necessary touch of nature to human life. This is a legacy of the past, which we have sadly missed in our apartment life of modern times.

# INDEGENIOUS KNOWLEDGE BASE OF TRADITIONAL ARCHITECTURE OF KERALA

## **A. Achyuthan and Balagopal T.S. Prabhu**

The archeological monuments, the vernacular and Sanskrit texts and the hereditary skill of traditional craftsmen formed the three sub- systems of the indigenous knowledge of the traditional architecture (vastuvidya) of Kerala. Their synthesis resulted in making this knowledge base a living heritage. Out of these, the most vibrant element in Kerala was the tradition of craftsmen, of which the timber craft attained a dominant role in building construction. The technological base of vastuvidya is contributed by the flexibility, perfection and variety of techniques of construction in timber. Canons and practices, developed for planting trees in appropriate locations, their selection and extraction for construction, shaping, polishing and assembling the timber scantlings into load bearing and load transferring structures as well as decorative and protective elements reached a level of perfection. Strategies to incorporate this knowledge base in construction will enrich the technology, economy and overall quality of building industry in Kerala.

### 1. Introduction

Taccusastra, the building craft, originated with the attempt of man to settle down and build artifacts to make the settled life convenient and safe. Its origin can be traced to all ancient cultures. But it is only in India, that it evolved continuously and spread through hereditary tradition over the length and breadth of this vast peninsula. The building ! craft was modified to suit the regional variation. Over a time, these regional styles got canonised and came to be preserved as textual material among the practitioners, in regions subjected to cultural changes brought through earlier invasions or destruction through natural disasters, the traditions tended to

disappear into obscurity. However, in areas which were relatively not affected by such devastating havocs, the craft knowledge retained its indigenous character, evolved to greater perfection and even transcended to the levels of a design theory and philosophy. Kerala is one such region where the indigenous knowledge base blossomed to the higher level of building science designated as vastuvidya. The vitality of this knowledge base continues to be at the realm of the operational level of the building craftsmen.

## 2. The Pancakammalar

The five basic schemes in the building crafts are those of (i) iron smithy, (ii) metal work, (iii) gold smithy, (iv) stone work and (v) timber work. The guilds of these five streams evolved as social groups of 'aihkudi kammalar' or 'panca kammalar'. They were associated in varying degrees of participation in all aspects of development works related to community sustenance viz. agriculture, construction work and transportation. For example, the blacksmiths provided the implements and tools for all work operations. In the context of building artefacts, their contribution covered making of implements such as cutting axes, saws, chisels, drills, planers and fasteners. The perfection of their work could be seen in the large range of chisels and other tools used by timber workers. The indigenous knowledge of black smiths covered the metallurgical science of ferrous metals and the technology of annealing, tempering, case hardening etc.

The metal workers developed indigenous technology for using metals like copper and zinc and alloys like brass and bronze. Their work covered forming or casting of utensils, lamps and icons. In the building construction, the craft reached the level of perfection in forming and covering of copper sheet roof frames and casting of brass and bronze fastenings. The casting of

complex forms with or without wax, grinding and surface finishing including that of metallic mirror is a unique craft side of metal worker, the indigenous base of which needs study and preservation today. The important role of goldsmiths is in the development of techniques in using precious metals like copper, silver, gold and their alloys. The properties of ductility and malleability of metals were effectively used for creating not only ornaments, but also filigree works, inlaying works, thin sheets, metal plating etc., all of which were employed in construction and decorative works. The precision and perfection required for such fine works gave gold workers a higher status in the hierarchy of artisans.

### **The Laterite Stone Masonry**

The load-bearing and supporting system of the buildings comprised mainly of stones and timber and hence the role of stone worker and timber worker became significant and critical in the evolution of building technology. The selection of stone-quarries, choosing the appropriate type of stones, the dressing and jointing the stones, finishing the surface of stone masonry by plastering etc, formed the basic crafts of the stone workers. There are three components of stone working. The first relates to the technological properties of natural stones and their apt use. The vast laterite formation of Kerala was effectively used to obtain building blocks having unique characteristics of easy quarrying and dressing on the one hand and hardening on exposure to atmospheric air on the other. The blocks could easily be quarried and dressed while they were fresh. The second related to their use in construction. They could be assembled in a simple trabeated system or could be effectively, incorporated in corbelled arch construction. The latter was perfected in 'kadalikarana' method of forming stable roof for the shrines. It could be incorporated in masonry work with laterite quarry dust or in lime mortar. This becomes the third component. Experiments lead to the development of surkhi mortars with sand, laterite dust and

lime, in the first stage. Development of tempered mortars using admixture of herbal juices and tree secretions was a notable achievement in obtaining strong, smooth and crack-resistant mortar. In a method of forming huge icons, specially prepared composite mortars (katusarkarayoga) were applied on a frame work of shrub wood. Further a mortar of 8 components was also developed to fix stone to stone as an adhesive (astabandha). The indigenous knowledge of stone masons is getting lost by in the modern construction and needs strategies for preservation.

### **Architecture in Timber**

The perfection of the building craft reached its pinnacle in the timber work. The timber worker preserved the knowledge base of the properties of large species of trees and their appropriate use under tension, compression, flexure, shear and bearing. Techniques for felling, seasoning, shaping, joining and preservative treatment were developed using indigenous materials and techniques. The importance of these was emphasised through rituals at different stages of operations. Timber was used as the base of well steining, walling of sacred structures and cladding for buildings. Doors, windows and other openings were developed indigenously combining safety, function and aesthetics. The structural use of timber found expression in column, beam, ceiling, attic and roof framing. Essential traditional Kerala architecture is architecture in timber. This aspect is best illustrated in the timber wall construction and roof framing. The space enclosure by timber walling called “ara and nira ”, is a traditional method resembling the modern stud wall construction with the difference that it has a structural frame along the edges and diaphragm wall of decorated timber planks. The lower frame could be fixed to the basement while the upper frame was integrated to the roof construction. This unique

technique was used for the storage rooms, the core house or even for the whole construction. In rare cases, it was adopted even for temples.

The timber roof frame evolved in Kerala is space-frame with six basic elements - wall plate, ridge, rafter, collar, pin and eave reaper (saddaruka). For large span structures additional purlins (arudhottara) supported on inclined struts (viskambha) were adopted to retain the strength and form of the roof. For theater, diagonal bracing similar to the modern “lameila” construction was incorporated with roof frame. The speciality of the timber frames was that it could be assembled on the wall plate. It could be dismantled and reassembled if needed at the same site or elsewhere in case of relocation. The system is well adapted to prefabrication.

Decorative treatment of timber was integral to the structural system. The points of load transfer, the joining of members etc. became natural locations for decorative treatments. The decorative treatment of columns included pedestals, shafts, capitals and brackets. The ceiling incorporated waffle treatments, sculptural ornaments and painting. The gable ends were projecting over the hipped roof as well as on the side, providing a characteristic feature of the timber architecture of Kerala.

The refinement of roof construction indirectly decided the shape and size of the building. The wood workers thus had the two additional functions viz. (i) providing the basic measurements for the building and layout of areas and (ii) ensuring the compliance of this layout right from the foundation laying. The master craftsman (acarya – asar Uthus became the de facto planner and designer as well. His services were sought for site selection, site layout, the foundation stone laying and every such stage of decision making in a building operation. This necessitated the widening and deepening of his knowledge to the niceties of design theory.

Owing to this ali important role of the wood craftsman (taksaka) the indigenous knowledge of building craft come to be designated as “taksakasastra” or “Taccusastra” in this region.

Design Grammar for Plans and Designs Design in its broadest sense involves obtaining the best solution by decision making under a variety of constraints. The tropical weather with its heavy rain fall, high humidity and intense solar insolation necessitated protection of buildings from the effects of the elements. Heavy rainfall warranted sloping roof and high basements. Humidity necessitated ample air flow and hence an open system of planning, staggered layout and design with thorough ventilation. The protection from solar radiation warranted low walls and large projecting eaves.

The consideration that house is a basic necessity was accepted by the society. Hence the plan was to be made simple as a rectangle. Economic considerations fixed the shape efficiency of rectangular shapes when more rooms were added to the core. The dimensional system was thus made modular and standardised. The proportion of width to length of the rectangular houses was limited to 1 : 3 to get a space efficiency of 0.66 in the floor area covered by unit perimeter.

The dimensional system was evolved from the anthropometric measure of span (vyama) into a scale of ‘hasta’ and ‘angula’. The module for measurement was pada, the octal division of vyama. The standardisation of rooms was effected by determining acceptable widths and perimeters. The dimensions of building in different orientations were normalised by the concept of yoni. There are rules for fixing the position of houses in a plot and also for entry to the plot. In short, the process of site planning and building design followed an algorithm and logic flow.

### **Harmonising the Building with Environment**

The house was always treated as part of the living environment and as such, every effort was made to harmonise the artefact with its surroundings. Right in the selection of site for building, the three determinants are favourable terrain (sthala), hydrological (jala) and biotic (vrksa) qualities (gunas). Rules for determining them were evolved. In the house layout, these three elements were given due importance by earmarking specific locations for groves, water bodies and trees. Canons were laid for the location of specific variety of trees and their distance from the building. These prescriptions appear to ; have been based on the flow/obstruction to the wind, solar radiation, beneficial effects of fruit bearing, flowering and medicinal use, foliage, j root-spread, strength etc. of each variety of tree. For example the 1 tamarind tree having good strength, foliage and useful fruits is prescribed \ for the SE location because it gives shades in summer and allows sunlight j in autumn and winter by shedding leaves.

### **Strategies for Preserving the Knowledge Base**

Ingenious knowledge in vastuvidya is linked to many areas such as geography, hydrology, biology, astronomy, material science, engineering, crafts and arts. This link tends to become obscure and needs to be enquired and disseminated. The strategy proposed for this is given below:

1. The need for research and study for vastuvidya is to be recognised and facilities shall be created for them at the University level.
2. There are several institutions engaged in research in vastuvidya. These should be recognised as approved research centres by the Universities for the purpose of registration for M.Phil and Ph. D degrees.

3. The role of craftsmen in preserving the indigenous knowledge in vastuvidya with its dynamism and purity is to be recognised and facilities to bring them into the mainstream of technological education shall be created. The knowledge base at this level is not well documented because it is transmitted orally from the master to the trainees. Since the oral tradition is vanishing, this knowledge base which is the vibrant and most significant part of Vastuvidya is becoming obscure. An elaborate project to study this base and document it should be set into motion urgently. Such projects should get sufficient funding from Government and other agencies.

4. Efforts shall be made to educate the public regarding the relevance of indigenous knowledge of house building through non-formal education by Government and voluntary agencies. For this awareness courses should be conducted.

5. Documentation on the crafts should be encouraged by giving financial help for publications.

## THOUGHTS ON BIODIVERSITY AND CONSERVATION IN ANCIENT AND MEDIEVAL SANSKRIT LITERATURE

**N.V.P.Unithiri**

Vrksayurveda is a branch of knowledge which was given very much importance in Sanskrit literature of ancient and medieval India. The term 'vrksayurveda' literally means 'the knowledge of tree life'. This discipline deals with plant pathology or treatment of trees in general. It includes concepts of biodiversity and conservation. Here an attempt has been made to present a few pieces of information regarding this subject with special reference to the vrksayurveda chapters of Brhatsamhita of Varahamihira ( BS , 6 m century A.D) and Samhita of Sarngadhara (1 4 th century A.D).

The discipline of vrksayurveda has a long history in India. Reference to disease of plants and their treatment can be seen in Atharvaveda (1200 B.C). Atharvaveda 29.7 mentions the destruction of corn by pestiferous insects. The commentator Sayana provides a long list of insects who destroy crops.

1. separate section by name gulmavfksayurveda occurs in Kautilya's Arthashastra (3rd century B.C). Carakasamhita (kalpasthana, chapter1) and Susrutasamhita (sutrasthana, chapter 37), (both of 2nd century A.D) and some other Ayurveda texts prescribe vegetable drugs depending on the nature of Soil-Treatment of plant disease is seen in ! Agnipurana (2nd century). Amarakosa (5th century) contains a section entitled 'ausadhivarga' on flora and fauna which is directly connected with vrksayurveda .There are some other works also like Vrksayurvedas of Surapala or Suresvara and Parasara (1 2th century ). Krsipafasara by Parasara and Krsisukti by Kasyapa are some of other tracts dealing with certain aspects of plant pathology. The various stages of growth

of plant life, resistance to diseases and recovery from wounds by the application of drugs are dealt with by Gunaratna (15th century) in his commentary on Saddarianasamuccaya. Tantra works like Paddhati by Isanasivagurudeva (12th century) and Tantrasamuccaya by Cennas Narayanan Namboodiripad (15th century) and architectural treatises like Manusyalayacandrika by Tirumangalam Nilakanthan Moosad (16th century) and SUparatna by Srikumara (16th century) treat some aspects of vfk sayurveda.

Worshipping trees and plants was an essential part of ancient Indian culture. Big groves known as 'nagas' (short form of nagavana or sarpakkavu / katu) were the places of such worship in ancient and medieval Kerala. According to tradition each and every person, who wishes to live long, should protect the tree assigned to his birth star. The following is the list of 27 stars along with the trees assigned to them:

Acacia catechu

Diospyros ebenum

Bambusa vulgaris

Ficus religiosa

Mesua ferrea

Ficus bengalensis

Butea monosperma

Ficus microcarpa

Spondias pinnata

Aegle marmelos

Terminalia arjuna

Flacourtia jangomas

Mimusops elengi

Aporosa lindleyana

Pterocarpus marsupium

Saraca asoca

Artocarpus integrifolia

Calotropis gigantea

Salix tetrasperma

Anthocephalus chinensis

Manjifera indica

Borassus flabellifer

Madhuca longifolia

It can be concluded that as a result of this belief, different types of trees were protected, thereby ensuring biodiversity. *Manusyalayacandrika* (123-26) gives the desirable and undesirable positions of trees in the compound of a residential building. Trees with thick foliage are recommended to be planted in the north of the house to resist the cold winds from that side.

Trees which shed leaves like tamarind (*Tamarindus indica*) and those without thick foliage like areca (*Areca catechu*) are to be planted in the south to allow sunlight during winter season, when the sun is moving in the southern hemisphere. Fruit bearing trees which are generally of hard wood-core type can be planted very near to the house. Trees whose contact causes allergy like cerumaram (*Semecarpus anacardium*) and certain trees which are not auspicious like kanniram should not be planted anywhere in the plot. Based on structure, trees are divided into four in accordance with the position of hard wood, namely, antassara (hardwood at core), bahissara (hard wood outer side), sarvasara (hardwood throughout) and nissara (soft wood). Antassara type of trees like jack (*Artocarpus integrifolia*) should be planted nearest to the house, sarvasara trees like tamarind outside them and the others far outside.

Chapter 29 of *Brhatsamhita* is called *kusumalatadhyaya* (chapter on flowers and creepers). The topic of this chapter is the phenological observation of flowers and trees of certain plants as indicators to predict the productivity of crops and the related aspects of agricultural climatology. It is stated that from the luxuriant growth of flowers or fruits of certain kind of trees, a large quantity of crops of a particular cereal or pulse, metals, things and persons can be predicted. The following list showing prognostication can be prepared from the observation made in verses 2-14 of this chapter. The presence of some plants serves as indicator for the growth of some other plants etc.

It is the responsibility of modern scientists to investigate whether there is any scientific base for these predictions or not. Now We may look into the *vrksayurvedadhyayas* of *Brhatsamhita* and *Sarngadharasamhita*. These are exhaustive chapters covering all the essential aspects of the life of trees and plants. These chapters which can be said as botanical treatises discuss the following subjects:

(1) Importance of planting trees

(2) Plant gardening

(3) Protection of trees

(4) Propagation of plants

(5) Fertilizers

(6) Preservation of seeds

and

(7) Pests and disease management

### **Importance of Planting Trees**

At the outset of vrksayurveda chapter of Brhatsamhita, Varahamihira makes us aware of the importance of laying out gardens on the banks of tanks and lakes because they will not be beautiful without shade on their sides. It is clear from this prescription that both reservoirs and gardens are mutually beneficial. From the view point of tourism too, this is significant and thus even today this observation has very much relevance. In this connection, it is to be noticed that Sarngadhara praises the glory of trees. In fact, in his vrksayurveda chapter of *Sarngadharasamhita* he devotes a whole section for this topic (Tarumahima, SST, verses 4-23). Better to have a tree planted by the way side where many rest under its shade, than to have many sons born who are devoid of wealth and virtue.

Excavation of a pond is equivalent in virtues to sinking of ten wells, a lake is equivalent to ten ponds, and a son is equivalent to ten such lakes; and a tree is as good as ten sons. Then Sarngadhara proceeds to highlight the virtues of planting some particular kinds of trees. We have already seen that *Manusyalayacandrika* also takes into consideration the importance of planting trees in the compound of a residential building.

### **Plant Gardening**

BS holds that before planting trees and plants soil of the ground should be prepared. Instead of using pesticides which creates many pollution problems, there was a traditional method according to which sesamum seeds were sown in the field and when their plants were in bloom they should be crushed and mixed with the soil. SST also prescribes the same method. The author says that one should sow pulses and sesamum on a level ground after it has been thoroughly ploughed with a plough and should cut the crops when they are ripe and then should sow seeds on that ground again <sup>9</sup>. According to modern scientific investigations, the root of sesamum creepers bear minute germs and such germs release nitrogen alkalies and later on helps the growth of plants to be cultivated in the field. This eco-friendly method is relevant even today. Then BS gives a list of auspicious trees and creepers to be planted first in gardens or compounds of houses. The list contains neem (*Azadirachta indica*), asoka (*Saraca asoca*), punnaga (*Calophyllum inophyllum*), sirisa trees and priyangu (*Aga/aia roxburghiana*) creeper. Kasyapa adds to this list some other titles also, namely, campaka, udumbara (*Ficus racemosa*) and parijata (*Erythrina indica*). Further, these are recommended by him to be planted in temple premises too.

According to SST the presence of Banyan tree in the east of a house fulfil all desires; udumbara in the south, pippala (*Ficus religiosa*) in the west and plaksa (*Ficus microcarpa*) in the north will provide good, and everything else should be strictly forbidden. He further maintains that one should avoid asvattha (*Ficus religiosa*) in the east of a house, plaksa in the south, Banyan in the west and udumbara in the north 12 . What is the rationale for this prescription is not explained. Whether there is any scientific reason for this is also to be investigated. It is noteworthy that SST objects planting any tree in front of a house. The idea of the relevant verse runs as follows; One should avoid the shades of all trees in one's house; one should not plant in front of one's house a tree even it is made of gold' 3 . Likewise SST prohibits making of a garden in the south-west or south-east corner of a house. He says that distress and sorrow will be its outcome.

When we plant trees, sufficient distance must be kept between two trees in a compound or garden. According to BS in the case of big trees the most desirable distance is 14 1/2 metres. 11 1/2 metres is moderate and it is inferior if it is 8 1/2 metres. 15 Reason for this is that trees growing closely and touching each other with their roots interlocked do not yield much. On this topic, SST gives some more details. It says that one should lay out the trees in a garden so as to look an altar, a circle, a svastika, a square, a sarvatobhadra, an avenue, a grove-bower and in clusters. The distance between trees recommended by SST is more or less the same as by BS. The only difference is in the case of inferior. While BS recommends 8>/2 metres, SST recommends 7 metres (65 ab). SST, however, adds to this that if the surface of the garden be plane one should plant grass-like plants at an interval of 1 1/2 metres and 3 metres and bushes at 2 metres 18 . He further points out that trees, if thickly sown, are hindered in their growth and if sown very sparcely, they are in danger of falling down even in consequence of mild winds 19 .

SST closes this section enjoining that one should plant trees with an eye to the fact that there is room for the spread of their roots and one must see that the leaves of each other do not touch.

### **Protection of Trees**

This topic is not dealt with in BS. But SST devotes two sections for its treatment. It prescribes rules for watering plants and protecting trees. One should water the newly planted trees both in the morning and evening. They should be systematically protected from cold, stress, and wind. Water the trees and plants every alternate day in autumn and in winter; everyday in spring, and twice a day during the summer. During the rainy and autumnal season when it does not rain one should fill the circular ditch under the tree with water. Pour water till the earth attached to the roots of the tree becomes wet; don't mind about the quantity of water applied for this purpose. Since trees suffer from indigestion if the water in the ditches is not dried up, one should not pour fresh water in it till such is the case. SST also prescribes that, in the interest of trees, one should extirpate the weeds, creepers and shrubs which grow beside them. Trees should carefully be protected from destructive influence of dew, strong wind, smoke, fire and spiders. Trees should be well protected with walls having ditches around them. Now we may look into a very interesting prescription by SST that one should take up the ashes of trees struck by lightning, throw the same around other trees and this will ensure the latter against cold. It says that these ashes have the power to allay even the burning Fire. Another prescription runs as follows: Throw boiled white sali rice mixed with curd and rock-salt round the trees. It will ensure their protection from poisonous or harmful rain.

### **Propagation of Plants**

Four methods for propagation of plants are described by both these authors: (a) Transplantation, (b) Sowing, (c) Cutting, and (d) Grafting.

**(a) Transplantation**

This is called samkramana-viropana. It means planting trees after bringing out them from another place. This method has a long history in India. During the reign of Asoka very rare medicinal herbs, roots and fruits were imported and transplanted wherever they were not existent. Before replanting, necessary care should be taken to avoid the menace of pests. For this, a kind of ointment is recommended which is made of mixing equal quantity of ghee, usira (*Vetiveria zizanioides*), sesamum, honey, vidanga (*Embelia ribes*), cow's milk and calf-dung. This ointment should be applied top to bottom of the tree to be transplanted. 31 The time of replanting is also stipulated by ancient Indian agriculturists. BS maintains that trees having undeveloped branches are to be planted in cold season (January- February), those having developed branches in winter season (November- December) and those having well-developed stems in rainy season (July-August).

**(b) Sowing**

On the subject of sowing BS s prescription is as follows: Soak the seeds in milk for ten days. Take them daily with your hand besmeared with ghee. Then role them many times in cow-dung. Fumigate them with flesh of hog and deer. With flesh and hog's marrow sow them in the soil that is already prepared with the sesamum treatment. Sprinkle over them by milk and water. No doubt, they will grow and bloom soon. Even the seeds of tamarind having hard shells will sprout, if they are watered by the mixture of flour of rice, black gram, seasmum, barley gruel along with rotten flesh and fumigated constantly by turmeric powder. In the case of wood apple

(kapittha/ seed, the following process is prescribed: roots of wild jasmine, amalaka. (*Embllica officinalis*), dhava (*Anogeissus latifolia*) and vasika (*Adhatoda vasica*), creepers and leaves of Vetasa tree, suryavalli (*Indigofera enneaphyllaf*), syama and atimuktaka, all of these on the whole is known as astamuli (eight roots). Boil this astamul i in milk and cool it. Then soak the wood- apple seeds in this liquid for a period of time equal to that of 1 00 beats of the hand. Take them out, dry them in the sun. Daily repeat this for a month. Then sow the seeds according to the following method: Dig a pit with the diameter of 72 cm. and the depth of 144 Cm. and fill it with milk and water. Dry it up. Burn it. Fumigate it (pit) with the mixture of honey, ghee and ashes. Then fill it upto 120 mm with mud. Put over it the mixture of the powders of black gram, sesamum and barley. Again put mud and the mixture once more. Then pour on it an infusion of fish and water. Then pound all this until the things of the pit becomes a thick mass. (More or less the same process is followed even now when we make compost manure). Then sow the seed of the tree 120 mm deep in the pit. Sprinkle it with fish water and flesh water. The creepers will be flourished with sprouts soon. For the sowing of the seeds of trees, certain stars are believed to be auspicious. They are dhruva stars, namely uttram, uttratam and uttrattati and rohini, and mrdu stars narnely, anizham, citra, makiryam and revati, and six other stars, namely, mulam, visakham, puyam, tiruvonam, asvati and attam.

### **(c) Cutting**

Jack tree, asoka, plantain, jambu, lakuca (annili- *Artocarpus lakucha*), dadima (*Punica granatum*), draksa (grape), palivata, citron tree and jasmine creeper, these are to be planted after cutting their stems smeared with cow dung. According to SST tambuii, sindhuvara, tagara (*Valeriana wallichii*) and such others grow out of kanda, portion of stems, ie. cuttings. patala,

dadima, plaksa, karavira (*Nerium indicum*), vata and such others, mallika, udumbara, kunda (*Jasminum multiflorum*) and others grow out of seeds and cuttings.

#### (d) **Grafting**

For the propagation of trees grafting is another means mentioned in BS. The work recommends two methods for grafting technique: (i) Inserting the cutting of a tree into the root of another, cut off from its trunk, and (ii) inserting the cutting of a tree into the stem of another. It is Utpala, the commentator, who explains these two methods clearly. Utpala adds to this that the junction of the two in both these cases is to be covered with a coating of mud (*atra mrttikaslesam dapayet*). Later we see that SST develops another method which can be called ‘parnayoni’ (transplantation through leaves). It is through leaves, instead of roots or stems (Relevant verse has already been quoted with translation in the section of ‘transplantation’). This is observed to be corresponding to the modern method of tissue culture (Manoharan, 1996, *Bhatsamhita - A Critical Study*, unpublished Ph.D. Thesis, Dept, of Sanskrit, University of Calicut, p.209).

#### **5. Fertilizers**

BS prescribes a special recipe for increasing the yield of flowers and fruits of trees and plants. The manure consists of a mixture of five litres each of the powder of dung of goats and sheep, five litres of sesamum powder, 1.25 litres of wheat particles, 9 litres of beef and 20 litres of water kept for seven nights. Trees, plants and creepers should be watered by this liquid mixture in all seasons. Kasyapa also recommends the same manure for the speedy growth and increasing the yield of trees and plants. Some other relevant points connected with preparation of fertilizers have already been referred to in a previous section (‘sowing’).

It is on the prescription and preparation of fertilizers that S7" makes substantial contribution. It prescribes a kind of nourishing solution called kunapajala which is very much healthy for plants in general. Preparation of this liquid mixture is described as follows: Eoil the flesh, fat and marrow of deer, pig, fish, sheep, goat and rhinoceros in water; when it is properly boiled, put the mixture in an earthen pot; add into it milk, powders of sesamum oil-cakes, black gram boiled in honey, the decoction of pulses, clarified butter and hot water (It is to be noted that there is no fixity as to the quantity of any of these ingredients); put the pot in a warm place for a fortnight. Then you j W 'H have kunapa water.

## **6. Preservation of Seeds**

According to BS seeds of trees and plants in general should be preserved in the following way: Water several times the seed of any tree or plant with the liquid portion of the fruit of ahkola tree or with the oil of slesmataka (*Cordia mixa*) tree. Only after this the seed should be sown. Regarding the slesmataka seed, he says: Remove the shell of the seeds and then soak them in ahkola fruit juice and dry them in shade. Do the same seven times. Then the seeds should be smeared with buffalo's dung and kept in buffalo's dung itself.

More or less in this same way, S5T also says about preservation of seeds. Well-matured seeds of fruits of the season should be sprinkled with milk and clarified butter, kept for five days in this condition and fumigated with frankincense. Another method: Besmear the seeds sprinkled with milk, with powders of brhati (*Solanum xanthocarpum*) and sesamum mixed with ghee; dry them and besmear them again with cowdung; then fumigate them with fat of some animal. Vet another way: Besmear the seeds with cowdung after having sprinkled with milk; dry them and besmear them again many times with vidanga powders mixed with honey.

## 7. Pests and Disease Management

BS deals mainly with exogenous disease of trees. Pale-whiteness instead of greenness of leaves, scanty/sickly sprouting of leaves, fading of branches and leaking of saps from stems are the symptoms of diseases of trees and plants caused by extreme cold, wind and heat. Treatment to this disease can be done as follows: First the faded branch of the tree should be cut away at the point where the illness is not spread. On that part, apply the ointment mixing vidanga, ghee and silt. Then sprinkle milk and water. Utpala quotes four verses from Kasyapa in the commentary on this verse which hold the same view with some details. Diseases caused by branches, leaves and shade and those of absence of leaves and fruits and waning lustre of leaves are mentioned. They are due to cold, heat, rain and wind and by roots intertwined. Sometimes elephants are also responsible for tree disease. They rub their temples against trees.

Dropping out of fruits prematurely is another plant disease mentioned in BS. Treatment for this is to sprinkle a liquid mixture consisting of water, milk, horse gram, black gram, green gram, sesamum and barley which is to be boiled first and then cooled. SST deals with the treatment of plants according to the way of Ayurveda. He points out that trees, like men, get diseases through the affections of vata (wind), pitta (bile) and kapha (phlegm) - three pathological humours. So, in his view, one should diagnose the diseases through their symptoms and cure them radically. SST recommends cutting away of the affected parts in the cases when a tree is consumed by insects, burnout by fire, broken by storm, and struck by thunderbolt. But in the case of diseases, he prescribes different treatment. 58 He presents the characteristics of trees of windy humour as follows: They are tall, thin, short, sleeping or partly conscious; and they do not bear flowers and fruits. Then he describes trees of bilious temper: They cannot bear the rays of sun, are of yellow colour, and shed their branches over and over again, and bear premature

fruits. Then come trees of phlegmatic temper: They have their branches and leaves very glossy, flowers and fruits well shaped and of good appearance, trunks symmetrical, and all parts covered with creepers.

SST continues: Substance of pungent, bitter or caustic tastes are destructive of the windy humour of trees; those having bitter, hot, salty and acid juice are destructive of the bile, and those with graceful, sweet, acid or salty juice are destructive of the phlegm. Following this SST describes how can be cured these tempers; The affections of windy humour are alleviated through the application of graceful things like clarified butter mixed with flesh juice, the affection through the bile is alleviated through the application of things that are cold and graceful mixed with water; and the affection through phelgm is modified through the application of acid things mixed with hot water, or through pungent and bitter things. Then SST enumerates diseases of plants due to windy humour and prescribes the medicine thereof: Rudeness of appearance, tubercles (nodules over the body) both of large and small size are due to windy humour. The same may be overcome by the application of lodhra (*Symplocos paniculata*) flower, cowdung, fats and kunapa water. It continues; It should be understood that worms at the roots of plants affected with tubercles, of plants having paleness of buds and flowers, should be rooted out with care. Then application should be made to the trunk of the mixture of fresh urine of cows, clarified butter, vidanga, mustard and sesamum; fumigate them and then pour milk and water. SST recommends for the destruction of all kinds of worms, the application to the roots of trees the barks of Honge, Cassia fistula. Bead tree, saptaparna (*Alstopia scholaris*) pasted in the urine of cows together with vidanga and nutgrass . The author points out that the bodies of trees burnt with fire will bear leaves when besmeared with lotus bulb pasted with kunapa water and milk. SST maintains that one should besmear the branch of a tree broken by wind with the barks of

Peepal, arka (*Calotropis gigantea*) and *Ficus glomerata* pasted in ghee, honey and bees wax mixed with milk; should set it as before, and tie it to a post nearby, and apply finely powdered earth to the fractured part. Sprinkle it with milk over and over again; water at its root; then the tree will come back to its former position.

SST prescribes the treatment of trees struck by lightning thus: *Musta* (*Cyperus rotundus*), *usira*, *madhuka*, greengram, blackgram, barley and sesamum pastes with milk and water - this is to be applied to the roots of such a tree. It recommends *kunapa* water and milk again and again for removing dotage of trees through repeated production of fruits and flowers. When the branches of a tree become dry owing to excess or want of application of water, a boiled mixture of *vidanga*, clarified butter and milk is prescribed to be sprinkled for a week. When a tree suffers from incapacity to digest water, it is always pale, devoid of barks and leaves, full of ants and the smell of fish. Treatment for this is recommended as follows: Strike at the root of such a tree to draw the poisonous sap out of the trunk, apply to the affected place a paste of honey, *Vidanga* powder and sesamum and cover it with water and milk. The atrophy of a tree is radically cured, if it is besmeared with the above paste, after it is sprinkled with sugar and sesamum mixed with milk and water and then fumigated. Lastly, SST prescribed the treatment for exudation of trees. To stop this, it is recommended that the barks of *priyangu*, *vara*, *karkari*, *vetasa* and *nirmarutu* pasted with and boiled in milk should be applied to the tree.

In comparison to BS, in many aspects of science of plant pathology and allied subjects, SST stands far better, especially in prescription and preparation of fertilizers and treatment of plants. The reason for this is not merely that SST is posterior to BS. While the author of BS is primarily an astronomer cum astrologer and it is as a part of giving an encyclopaedic knowledge of each and every subject to an astronomy-astrology practitioner that he deals with plant

pathology too in his work, Sarngadhara is in the main an authority of medicine and it is as a part of the vast subject that he treats the present topic too. Anyhow, contributions of these two authors to the thoughts of vrksayurveda are remarkabale.

The above observations make it reveal that literary materials connected with treatment of plant life especially with biodiversity and conservation in ancient and medieval Sanskrit works are immense and most of them are relevant even today.

## ENVIRONMENTAL AWARENESS IN SANSKRIT LITERATURE

### C. Rajendran

Environmental problems have been the focus of attention of the industrialised world ever since the publication of Rachel Curson's *The Silent Spring* (1962), an epoch-making work, which documented the harmful impact of the use of DDT on soil and the living organisms. The earlier belief that the nature could be exploited without any sort of inhibition became thoroughly shattered by this and similar findings, as man gradually came to realise the price he had to pay for the unbridled manipulation of nature. The enlightenment vision of man as posited against nature had to be given up in favour of holistic concept of the cosmos in which man also was a member. Nature no longer remained an inexhaustible resource to be exploited ruthlessly; her forests depleted and water polluted, the very existence of life on earth became problematic. Man became belatedly aware of the inbuilt safety- mechanisms in nature like the green- house effect and problems posed by phenomena like global warming, industrial pollution, depletion of forest wealth, the drying up of rivers and the like. In short, man became more environment conscious. Against this background, ancient cultures like that of India have a pivotal role to play in removing the slop-sided concept of development of the modern man and in offering alternate visions of development and well-being. It has, indeed, been widely acknowledged that it is the relentless vigil of traditional sects like the Vaishnoi group and Chipko movement, drawing on traditional wisdom, -which have prevented total deforestation in places like Rajasthan and Himachal Pradesh against the exploits of man's greed. If we delve deep into our traditional lore, the depth of the vision of our ancestors about our environment and the care they took to preserve it in tact shall astound us. Here an attempt is made to explore the environmental awareness reflected in Sanskrit literature.

Even in the Vedic era, which represents the dawn of human civilisation, we find a holistic concept of the universe of which man is only a part. The Rgvedic poetry shows the early Indian's intimate connection with nature. Most of the Vedic gods are personified forms of natural forces like sun, dawn, thunder, rain, wind and the like. But the most interesting concept in Vedic thought is related to rta, which signifies, apart from the moral order of the universe, its physical order as well, consisting of cyclic recurrence of day and night and other natural phenomena. The former somehow is regarded as the basis of latter. The ecological significance of this is its conceptual similarity with the delicately poised order in nature recognised in modern science. Ancient Indians regarded the cosmos as an orderly whole, and considered trees and plants as infested with life. Mahabharata explicitly states that trees have life since they grasp both pleasure and pain and grow if cut.'

An interesting hymn in Rgveda is about aranyani, the forest goddess (X 97). The Rgvedic poet here describes the weird sights and sounds of the forest at night vividly. Plants are often evoked as divinities, along with waters, rivers, mountains, heaven and earth. One entire hymn in Rgveda (X.97) is devoted to medical plants. The Vedic poets' also refer to birds and animals, rivers and mountains seasonal variations and other facets of nature. We see environmental awareness much more sophisticated in Atharvaveda which gives a prominent place to herbal medicine and as such shows amazing awareness of the medicinal value of plants. Actually, Atharvaveda advocates a psycho-herbal mode of treatment in that it prefaces the administration of herbal medicine with the chanting of the appropriate mantra. The diseases mentioned include fever, leprosy, jaundice, dropsy, scrofula, cough, ophthalmia, baldness, lack of vital power, fractures and wounds; the bite of snakes or injurious insects, and poison in general; mania and other ailments. Macdonell describes

Atharvaveda as the oldest literary monument of Indian medicine. The Ayurvedic system of herbal medicine, which developed in India's soil, shows the intimate relation between man and nature in ancient India. Ayurveda believes that prevention is better than cure and the best way of prevention of ailments is living close to nature. Accordingly, great importance is given for *rutayana*, the 'seasonal regulations' by means of which we come to terms with the concerned season by way of appropriate food, exercise and lifestyle. *Susruta* maintains, in this connection, that *kala* or time, of which has the year as the body and the seasons the limbs is a major point of consideration in treatment. Of all, six seasons are accepted by Indian authors, viz., *sisira* (late winter), *vasanta* (spring), *grisma* (summer), *varsa* (rain), *sarat* (autumn) and *hemanta* (early winter). The first three seasons are regarded as seasons belonging to *uttarayana* or the northern movement of the sun and human body is supposed to be weak due to this. On the other hand, during the next three seasons, when the sun undergoes the *daksinayana* phase, man is invigorated due to this seasonal movement. Picturesque descriptions are given in works like *Vagbhata's Astangahrdaya* about the various seasons and the change they bring about in the environment. Thus in *hemanta*, the sky becomes smoky, atmosphere foggy, and the sun less hot. With cold winds blowing, there will be a tingling sensation in teeth and horripilation in body. Beautiful flowers like *lodhra*, *priyangu*, *punnaga* and *laveli* surround the earth. Since digestion becomes strong, more sweet/saline/sour food is required. Since a person becomes hungrier in the morning, he should eat heavy breakfast. Massaging and wrestling are suggested to keep the body fit. The same life-style is suggested for *sisira*, the late winter also.

In the spring season, which is portrayed very poetically, there is a sudden spurt of flowers and birds as well as bees become vociferous. The phlegmatic humour (*kapha*) gets aggravated in the body and produces nausea and indigestion. Strong inhalation therapy is prescribed to check

this. Exercises and light food, consisting of old barley, wheat, honey as well as the meat of animals dwelling in arid tips suggested to fight the heat. Environmental problems are addressed to in works like Arthashastra also, when dealing with settlement problems and the construct new cities. Kautilya shows astounding ecological awareness when he maintains that sanctuaries (called abhayavanas) are to be set apart for wild animals. Private parties who come forward to set up a garden or orchard are to be encouraged by the state. The land not used for agricultural purposes is set apart as grazing ground for domestic animals. Kautilya refers to three types of forests, viz. those used for hunting (mrgaya), those for timber and other forest products and those for elephants. There were provisions in the law to punish people hurting animals and capital punishment was accorded to a person killing an elephant. Fine is prescribed for cutting down trees and branches of trees.

Ecological aspects are taken into account in town planning also. Sanitation and water supply are given top priority by Kautilya. He maintains that some gap should be maintained between two houses. There should be provision to remove waste water from the buildings. If the drainage system is obstructed by somebody, it invites severe punishment'. Kautilya has also given astoundingly clear instructions for keeping the stables for horses and elephants clean with proper sanitary arrangements and separate fodder compartments so that food is not contaminated. Further, throwing up dirt and debris on the public road, contaminating public places with urination and disposal of corpses and carcasses of animals etc. are expressly prohibited". Kautilya also refers to natural calamities like fire and flood, epidemics, famine and pests and environmental degradation brought about by them and suggests remedial measures also, whenever possible.

Ancient Indians gave utmost importance to environmental engineering when planning settlements or building new houses. According to Devipurana, the first thing to be done is the plantation of trees: the building of the house should follow'. According to house construction manuals like *Manusyalayacandrika*, environmental considerations like the nature of the soil, its slopes, flora and the like are to be taken into account before one selects a site for residential construction'. The work also prescribes as to which plants are to be planted on different directions of the compound. Plantation of a tree is regarded as an auspicious deed and cutting down a tree as a sin.

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