

Dakargalam – An Ancient Water Exploration Technique Based on Varahamihira’s Brhat Samhita

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Varahamihira (505–587 AD), also called Varaha or Mihira, was an Indian astronomer, mathematician, and astrologer. He is considered to be one of the nine jewels (*Navaratnas*) of the court of legendary King Vikramaditya (believed to be the Gupta Emperor, Chandragupta II alias Vikramaditya). Varahamihira was the son of Adityadasa of Ujjain in Madhya Pradesh, India. He was a devout worshiper of Surya Narayana (the Sun) and was instructed in astrology by his father. He was a keen observer of geo-botanical and physiographic features around him.

Varahamihira compiled Pancha-Siddhantika, a treatise on the five astronomical canons, which gives information about older Indian texts that are now lost. The work is on mathematical astronomy and it summarizes five earlier astronomical treatises, namely, the *Surya Siddhanta*, *Romaka Siddhanta*, *Paulisa Siddhanta*, *Vasishtha Siddhanta*, and *Paitamaha Siddhantas*. It is a compendium of native Indian as well as Hellenistic astronomy (Greek, as also the Egyptian and Roman elements). The 11th century Muslim scholar Al-Biruni has also described the details of the five astronomical canons.

The other most important contribution of Varahamihira is the encyclopedic Brhat

Samhita. It consists of 105 chapters with 4000 *slokas* (verses) in *anustub* meter (*anustub* meter means each quarter of the *sloka* contains 8 Devnagari letters). Varahamihira was also an astrologer. He wrote on all 3 main branches of *Jyotisha* (astrology), which include (a) *Brhat Jataka* (considered as one of the 5 main treatises on Hindu astrology), (b) *Daivaigya Vallabha*, (c) *Laghu Jataka*, (d) *Yoga Yatra*, and (e) *Vivaha Patal*. The *Romaka Siddhanta* (Doctrine of the Romans) and the *Paulisa Siddhanta* (Paul’s Doctrine) were two works of western origin, which influenced Varahamihira’s thought. A comment in the Brhat Samhita by Varahamihira reads: “The Greeks, though impure, must be honored since they were trained in sciences and therein, excelled others ...”

Varahamihira’s most valuable contribution to the scientific world is the Brhat Samhita. It deals with a wide range of subjects of human interest, such as astrology, planetary movements, eclipses, rainfall, clouds, architecture, growth of crops, manufacture of perfume, matrimony, domestic relations, gems, pearls, and rituals. This volume also explains a topic on gemstone evaluation criteria, found in the Garuda Purana, and

comments on the ‘sacred nine pearls’ from the same text. This text is supposed to be ancillary to the Vedas. Chapter 54 deals exclusively with water.

The term ‘*Dakargalam*’ in Sanskrit connotes ‘water exploration’. *Daka* means water (derived from the Sanskrit word *udaka* for water) and *argalam*, a bolt or bar; i.e., “a branch of science dealing with water locked up or imprisoned in the bowels of the earth”. The chapter on *Dakargalam* mentions several indicators to presence of underground water. These are geological, geo-botanical, bio-geological, and non-biological indicators of the surface and subsurface of the earth that even today could be useful in several regions of India. The other common surface indicators of groundwater, such as termite mounds have also been mentioned.

The hydrological indicators documented in ancient India had a scientific basis; applied study is bound to go a long way in satisfying the need for water for irrigation, industrial and domestic use. Varahamihira documented more than 100 plant species occurring (i) individually, (ii) in association with termite mounds, (iii) in presence of two or three different species together, and (iv) in conspicuous morphologic or physiologic features. With the aid of specific plants, sources of groundwater were located

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at depths varying from 2.3 to 160 m in different environments of arid and semi-arid regions. Varahamihira estimated not only the depth of the groundwater but also the distance and direction with respect to the indicator plants (Fig. 1).

The area under study lies between the latitudes 17°30’ N and 19°30’ N and longitudes 75°30’ E and 76°E. The project area falls under semi-arid region. The temperature in June ranges between 35°C and 45°C, while the minimum is about 5°C. Scanty rainfall extends from mid-June to October. The Sina river basin is classified as a drought-prone region in the Sholapur district of Maharashtra, in the southern part of the state, fringing along the Karnataka–Maharashtra boundary. The geo-hydrological investigations in the present study were mainly carried out in the northeastern boundary of Sholapur district and adjoining southwestern region of Osmanabad district. The region falls under the watershed of Sina river basin, which is a tributary of the river Bhima. The main drainage direction of the streams in the study area is towards southeast. Being a drought-prone zone, the region is characterized by an average rainfall of about 770 mm.

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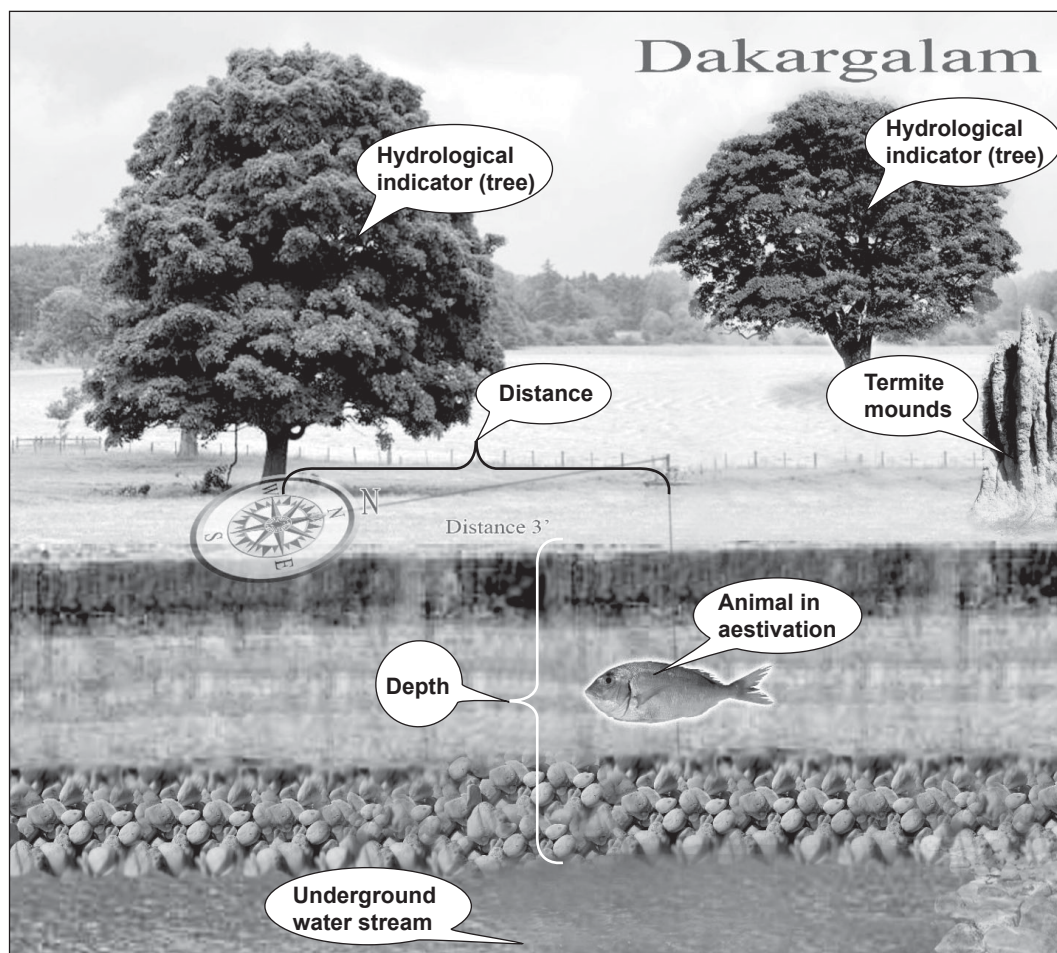


Figure 1. Graphical view of *Dakargalam*.

To evaluate the techniques of Varahamihira, five geological sites have been selected with varying geo-botanical and bio-geological indicators, having an ecological difference (Fig. 2). Geo-physical explorations were carried out to establish a correlation between Varahamihira's observations and present physiography. These sites include:

Site no. 1: Karamba-1 on Barshi-Sholapur road (Dist. Sholapur)

Site no. 2: Karamba-2 (Mr Bahirje's field) on Barshi-Sholapur road (Dist. Sholapur)

Site no. 3: Kasarwadi (Dist. Sholapur)

Site no. 4: Yedshi (Dist. Osmanabad)

Site no. 5: Mankeshwar (Dist. Osmanabad)

In the 21st century, there is a growing concern over the estimates of fresh water availability all over the world. The warnings given by the climates of southeastern



Figure 2. Map of Maharashtra indicating relevant districts.

countries reveal that we are moving into an era of water scarcity. With a fast increasing population, there is more demand for food and water. It is, therefore, inevitable that the pressure is and will be on detection of subsurface water storage. There is a dire need of simple, cheap but reliable methods of groundwater detection in the regions of scanty rainfall.

The Indian monsoon is known for its vagaries. Almost 85% of the rainfall is provided by the Southwest monsoon (i.e., from June to September) and some parts of Southern India receive rains from the Northeast monsoon (i.e., November and December). Rainfall distribution is also uneven with respect to time and space. A large part of the country is therefore, arid or semi-arid. In addition, the low-rainfall areas of the country have a fairly high coefficient

of variation, with droughts and floods at their extremity.

Most of the geo-botanical explorations today are based on biotic and abiotic earth resources. Under ecological conditions, geological phenomena also play a significant role in relation to the water below and above earth's surface. It is, therefore, essential that with the help of geo-botanical research, the explorations for groundwater, economically important mineral deposits, and fuel resources may be undertaken. This technique involves observations of the plant species, their habitat, morphology, ecological relationship, toxicity effects, and morphologic changes. Another field of biogeography has also evolved, which utilizes the study of the vegetation as an indicator of different physical and geographical conditions. In all these areas of geo-botany, the indicator plant is employed, which consists of two types: universal indicator and local indicator. Universal indicators are the plant species that are adapted to living exclusively on rocks and soils with particular mineral content. Local indicators are the species having widest distribution, but under local situations may serve as indicators of certain properties of the soils and rocks.

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It is important to note that what is being presently attempted by modern science of geo-botany was successfully carried out for groundwater exploration by the ancient Indian sages and saints. It is unfortunate that the present-day scientific community has not recognized the significance and certainty of this ancient scientific effort.

Varahamihira's work emphasizes the fact that collaboration and coordination between geological and botanical surveys is essential to achieve significant results in the exploration for natural resources.

Based on the five sample sites and field surveys around Barshi town, it is concluded that the geo-botanical and bio-geological indicators of Varahamihira prove very useful in detecting the groundwater horizons. It would not be appropriate to apply all the techniques of Varahamihira in highly "concrete-world" of cities, because there are hardly any traces of natural vegetation on the surface. However, the present study reveals that Varahamihira's criteria can be applied in the rural and

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remote hilly tracts. The study also indicates the accuracy of Varahamihira in observing minute details of the topography, ecology (plant and animal association in relation to the ecological conditions), and their correlation with groundwater. The practical utilization of Varahamihira's techniques could, therefore, be made for shallow depth detection of groundwater. Today, there are some tribal zones where traditional ways of groundwater detection are being used. Most of these are based on the techniques used by Varahamihira. However, such practices are adopted only in isolated areas all over the country. Varahamihira's techniques should be employed even today for the remote hilly regions where natural vegetation and other geo-biological indicators are available.

Some of the important observations of Varahamihira are given below:

Varahamihira documented more than 100 plant species occurring (i) individually, (ii) in association with termite mounds, (iii) in presence of two or three different species together, and (iv) in conspicuous morphologic or physiologic features. With the aid of specific plants, sources of groundwater were located at depths varying from 2.3 to 160 m in different environments of arid and semi-arid regions.

1. Strong geotropic response of primary and lateral tree roots: The root system, in its early phases of formation, is controlled strongly by gravity. The primary roots at deeper depths and lateral roots at shallow depths are indicative of water availability. The primary roots suggest groundwater from a minimum of 2.3 m (e.g., *durva* or *Cynodon dactylon* grass; *sloka* 47) to deepest of 171.4 m (*sami* or *Prosopis*

cineraria tree; *sloka* 85). The plants are termed as *phreatophytes* [phreatophyte is a deep-rooted plant that obtains a significant portion of the water that it needs from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone], when they serve as hydrologic indicators (often known as the ‘well’ plants). These are rain dependent plant species whose roots can easily be traced to the water table. Varahamihira advocates proficiency while suggesting various plant parts as indicators of direction, depth as well as distance over which water table will be located. Few of the well-illustrated observations of Varahamihira are:

Polarity: The primary roots of an indicator tree, which propagate towards the water table, show preferred direction of physical orientation with respect to the trunk. Primary and lateral roots grow around an impenetrable object after which the root tips tend to reorient to their original direction of growth. The depletion of soil moisture also helps penetration and direction of the roots to groundwater.

Varahamihira had not only observed and suggested the geo-botanical indicators but also pinpointed the depth of groundwater as well as the distance and direction of the indicator plant.

Multi-layered aquifer indicator: Based on the root penetration of trees, Varahamihira has suggested aquifers at different depths (2 aquifers with *kapittha* or *Limonia acidissima*, *slokas* 41 and 42; 3 aquifers with *karanja* or *Pongamia pinnata*, *slokas* 33 and 34).

2. Termite mounds as geo-hydrological

indicators: The locations of termite mounds or their occurrence in the forests or barren topography have been used by Varahamihira as a geo-hydrological indicator. These species are capable of consuming enormous quantities of groundwater and can easily be taken as an indicator of groundwater in association of other supporting evidences. Recently, the termite study in India, although limited, is confined to only few species belonging to genus *Odontotermes* such as *O. bangalorensis*, *O. besus*, *O. redemanni*, and *O. wallonensis*, which are known for building mounds.

3. Symbiotic relationship of different

plant species: Symbiotic relationship of two or more trees has been taken as an indicator of subsurface availability of water. Varahamihira has suggested 11 plant species depicting groundwater conditions at varying depths of 7 to 137 m. He has also used symbiotic relationship between plants and animals as indicators (e.g., termite mounds at the base of the tree, habitat of frogs at the base of the tree, etc.).

4. Color, dwarfness of the trees/shrubs, or plant canopy: Varahamihira, in his *slokas* 49, 61, 77, 85, and 100–102, has used different aspects of vegetation such

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as color of the leaves, height of the shrub, salts deposited on the leaves and their coloration, etc., as hydrological indicators. The occurrence of such indicator plants in the forests or barren topography has been used by Varahmihira as a geo-hydrological indicator.

5. Plant and fruit disorders: Certain plant disorders such as branching palms, flower and fruit disorders are indicative of geo-hydrological horizons (*slokas* 56, 57, and 59).

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