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Water Harvesting and Conservation in Ancient Agricultural Texts[1]

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Abstract

One of the things which make this globe a distinctive planet in this universe is continuous availability of water, a vital prerequisite for existence of life. Ever since man appeared on the surface of this earth he must have understood the importance of water as is apparent from the fact that all the ancient civilizations known to history and archaeology thrived on the banks of rivers. Water is also the essential prerequisite of agriculture, the source of food needed for the survival of life as without it there can hardly be any cultivation. Thus life on earth is wholly and solely dependent on water. By and large Mother Nature has not failed so far in providing an assured replenishment of water supply to living beings on earth. But the rapidly changing patterns of man's lifestyle and various other constraints of modern civilizations have made inroads in our natural resources. It now appears that an assured supply of this precious commodity of 'Nature' can no more be taken for granted. Since science and technology have not yet advanced enough to 'create' or 'manipulate' these natural resources, finding means for wiser, more prudent and sparing utilization of available water is the only course that can be followed to avoid future calamity. This article seeks to survey the ancient texts in Sanskrit dealing with agriculture, which have recorded useful information on the knowledge base and perception of harvesting and conservation of water, and precautionary means and measures adopted by the ancient Indian agriculturists to ensure continued water supply.

So far as our knowledge goes, one of the things which make this globe a distinctive planet in this universe is continuous availability of water, a vital prerequisite for existence of life. Ever since man appeared on the surface of this earth he must have understood the importance of water as is apparent from the fact that all the ancient civilizations known to history and archaeology thrived on the banks of rivers such as Sindhu, Saraswati, Nile, Tigris, and Euphrates. By and large Mother Nature has not failed so far in providing an assured replenishment of water supply to the living beings on earth. Due to rapidly changing patterns of man's lifestyle and various other constraints of modern civilizations it now appears that an assured supply of this precious commodity by nature can no more be taken for granted. Since science and technology have not yet advanced enough to 'create' or 'manipulate' these natural resources, finding means for wiser, more prudent, and sparing utilization of available water is the only course that can be followed to avoid future calamity. For this, can our traditional perceptions and practices of water preservation and utilization offer us any guidance? This paper attempts to take a brief survey of our ancient literature like the Vedas and *Shastras* with special reference to the Sanskrit texts on agriculture and horticulture.

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Successful farming requires careful planning for all farming activities including management of water resources. From the point of view of history of Indian agriculture, it is therefore, important to know how in ancient India rainfall, rivers, and other water resources were utilized by cultivators, what was their knowledge base, and what were their methods and means of water harvesting and conservation to ensure continuity and dependability of water supply for farming.

Fortunately, a number of ancient Sanskrit texts on *krishishastra* right from 4th century BC onwards are available to us today, which are loaded with this valuable information. But obviously it took centuries and millennia for our ancestors to develop their knowledge and technique of farming to the level when it could evolve into a '*shastra'*. What preceded that level? What was the ancestral legacy? What are the factors that contributed to the advancement of the *shastra* in respect of water management? Glimpses have been preserved in Vedic literature (c. 4000 BC to c. 400 BC).

The importance of water to living beings was always understood and has been stated by the Vedic seers as:

"Water is like a mother to this world. It is the sovereign of the world. It holds divine wealth, immortality, pious deeds in its possession for the welfare of the living beings" (Rigveda X-30-10 to 12).

"Water is the basis of all that is good in life. The most beautiful things happen to us because water provides us with vigor" (Rigveda X-9-1).

The same mantra is repeated in the Atharvaveda (I-5-1) and is repeated in our rituals performed even today.

"Water exercises maximum control over the living beings on earth" (Atharva. I-5-4).

But how much did the Vedic people actually know about this 'sovereign of the world', this 'nectar of life'? The following data collected and analyzed from the ancient Sanskrit literature, our precious heritage, may throw some light on the subject.

Knowledge base – Vedas

- Vedic people knew that rain was the only source to replenish water in rivers to provide clean and safe drinking water for them and for their cattle, horses, etc. They also knew that water was essential for growing food grains from soil and for green pastures for their cattle, their precious wealth. Their repeated prayers to Indra, Varuna, Maruts, Agni, Savitri, Parjanya, and so on in Rigveda, spread all over the text, for rains make it very evident.
- Earth and sky (*dyavaprithivi*) are referred to as mother and father providing water and food to all living beings (Rigveda I-164-8).
- They had a very clear idea about the water cycle. That the water on earth evaporates resulting in cloud formation and then comes down again in the form of rain was neatly observed (Rigveda I-164-51).
- It was observed that rain lasted for four months of the year starting after the Sun started moving southward (June 21) (Rigveda III-56-4; VI-32-5).
- Rivers were known to increase food production (Rigveda X-43-3).
- Independent *suktas* describing both gentle and fierce forms, the speed, force, vigor, boisterous noise, expanse, helpfulness are addressed to individual rivers like Sindhu **(**Rigveda X-75) and Saraswati **(**Rigveda VI-58).

- Other rivers mentioned are Ganga, Yamuna, Shutudri, Parushni, Asikni, Marutvridha, Vitasta, Arjikiya, Sushoma, Trishtama, Susartu, Rasa, Shvetya (tributaries of Sindhu), Kubha, Mehatnu, and Gomati (Rigveda X-75).
- Existence of dams on the seven rivers is mentioned (Rigveda I-32-12).
- It must, however, be noted here that dams were considered as harmful to human interest and Indra, the rain god is prayed and praised for removing the barriers.
- Clean and safe water is distinguished from impure and unsafe water (Rigveda VI-28-7; IV-57-2).
- Occasional rains in the deserts are referred (Rigveda I-38-7).
- There are references to releasing water by breaking a mountain or by removing a boulder (Rigveda X-68-8).
- There is a reference to clean water in ponds for ensuring good health of cows, to produce healthy calves (Rigveda VI-28-7).
- Water from rain, in addition to irrigating farmlands for food grains also resulted in the growth of medicinal plants, which protected human beings and animals from diseases (Rigveda III-56-4).
- Wells for drinking water were known (Rigveda I-55-8).
- Sumps of drinking water for animals are mentioned (Rigveda X-101-5).
- Irrigation from never-drying pits (shallow wells) is mentioned (Rigveda X-101-6).
- Irrigation from canals drawn from rivers is suggested (Rigveda III-33-12).
- There is a reference to *kulya* (most probably the precursor of *kaalvaa* in Marathi), the ducts or vessels for carrying water (Rigveda V-83-8).

From these observations it is clear that water was a matter of serious concern to the Vedic people and although rainwater is ardently prayed for, other sources of water were also identified and utilized. Pastures for the cattle, food for living beings, water for drinking purposes, everything depended on water. The approach of the Vedic people to the various issues regarding water is understandably holistic.

Rainfall and forecasting – Vedas

The phenomenon of rain is frequently described in the Vedas as the victory of Indra, the rain god, over Ahi, a demon obstructing the flow of water from the clouds. Rainfall was thus viewed as victory of the divine and pious over the demonic and evil forces of nature. The faith in *Rita* (sacred divine law), a Rigvedic concept of dependable cosmic order in nature, was enough to give people a sense of security and propitiating the deities by offering oblations and prayers was considered enough to ensure yearly rainfall and replenishment of water resources. They were most grateful to gods for the divine gift and wanted to express their gratitude by offering them a token of what they received. Sacrificial fire was conceived as the messenger, the mouth of gods. They firmly believed that a continuous flow of the divine gift would continue to bless them if they performed these sacrifices faithfully. This was their way to counter anxiety regarding water security and scarcity which people must have faced occasionally as is evident from the texts.

In Yajurveda, importance of sacrifices performed for rains enhanced a great deal. Every detail of the rituals connected with sacrifices was carefully worked out and stringent rules were framed to follow them meticulously. For preparing the sacrificial altars knowledge of basic mathematics advanced further. This helped in the computation of large numbers. In addition to movements of the Sun, Moon, winds, and clouds, the movements of other planets too, were observed and calculations regarding their

velocity and rotation could be recorded. In continuation of the *Rita* concept, planets too, were believed to influence happenings on earth.

Sacrifices like *kariri* were performed specifically for rain.

Thus in Yajurveda we perceive that the faith in the *Rita* concept is supported by human efforts like sacrificial rituals to ensure water security. With the progress in the knowledge of mathematics, astronomy, and farming operations, a base was prepared for further inquiry into rainfall and atmospheric changes on which it depended.

In Atharvaveda, a better and more objective understanding of the phenomenon of rain and other natural forces is noticed (Atharva. IV-15). There is a suggestion of rainwater harvesting (Atharva. III-13). Five sources of water are mentioned: desert (occasional showers), ponds, wells, pots, and seasonal rains (Atharva. I-6-4).

Untimely rain or absence or excess of rain is considered resulting from sin. Prayers to presiding deities of water urge them not to favor the rivals. With the rudimentary knowledge of diseases and herbal remedies rain was sought as ardently for growing plants and creepers having medicinal value as for irrigating farms and refilling of water resources (Atharva. I-6-3; V-24).

Water itself is regarded as a great healer (Atharva. V-24-2).

Thus in the Atharvaveda we notice that a better and more purposeful observation of nature and the surroundings and knowledge of some diseases and their herbal remedies, both for humans and animals gave a further push to investigate into the cause and effect relationship in the facts observed in nature. This is a step ahead in the spirit of scientific inquiry forming a sound basis of the *shastras* of the later days.

Shastras

Krishi-Parashara (Agriculture by Parashara)

Among the available ancient texts in Sanskrit on agriculture this is the oldest and from the contents, modern agriculture scientists place it in the 4th century BC, earlier to Kautilya's Arthashastra. According to Parashara's perception of rain:

- Rainwater is the only source of irrigating farms (V. 10). It should be noted here that although there are stray references to canals and wells in the Vedas for a large area under cultivation rainwater was the only dependable source.
- Knowledge of rainfall is therefore a primary need of agriculture. This is clearly a step ahead of sacrifices and prayers on which the Vedic people depended for ensuring proper rainfall. That which was to be prayed for and propitiated became something to be 'known' with effort.
- This knowledge consists of having advanced information about rainfall. One should know or at least infer, on the basis of several observed facts, the total rainfall of a given year, the parts of the earth where it would rain, the effect of planetary movements with reference to *nakshatras* (constellation of stars) and *rashis* (zodiacal signs) on rainfall, and the indications of famine or unexpected sudden rain. In the absence of any meteorological department ancient *krishishastras* provide such information to farmers through the texts in a simple manner.
- In continuation of the *Rita* concept and the knowledge of planetary movements which had made good progress, astrology became a major factor of the theories of rain forecasting advanced by Parashara. His theories can be briefly stated as follows:
  - Determining the ruling planet, minister planet, and the cloud of the year. [To find them he has recommended some simple mathematical formulae to be worked out with reference to the number denoting the *Shaka* year.] (V. 12–25)

- Noting month-wise, details of rainfall and other meteorological information starting with *Pausha* (January) and ending with *Shravana* (August) (V. 30–64).
- Determining rainfall per month and per day of the year by a technique described in the text (V. 30–32).
- Observing movement of winds by firmly planting a rod in an open place and affixing a flag to it (V. 33).
- Observing in the month of *Vaishakha* (May), the level of river water by planting a rod in the riverbed (V. 48–52).
- Observing movements of planets (V. 71–74).
- Other common observations (V. 66–70).
- Noting the positions of *nakshatras* while the Sun transits through *Mesha* (Aries). [For this the author recommends a chart to be drawn with certain codes associated with it, which are provided in the text.] (V. 54–56)
- Observing the time of equinox (V. 53).

- Parashara mentions water retention in the (rice) fields by constructing small earthen bunds (V. 186–188).

- He recommends draining of water from the fields to avoid flooding of rice crop (V. 193, 194).

- He advises harvesting and storing of water for crops in the fields during *Ashwin* (October) and *Kartika* (November) (monsoon having receded during this period) (V. 196). Unfortunately, however, the methods of harvesting or utilizing harvested water is not mentioned.

The items stated above refer to Parashara's perception of water management exclusively for irrigation purpose. However, a comparison he uses in this context is worth noting. (V. 197) "Storing water for the crop", the author says, "is as important as guarding the honor of a lady for protecting the good name of the family." This is suggestive of the importance of water harvesting and storing in general.

Parashara's unit for measuring rain was '*adhaka*'. His definition of the unit is rather vague and unwieldy (V. 26). [Hence scholars ascribe to him a date earlier to that of Kautilya.] Based on that measurement he states that the distribution of rainfall on earth is as follows: (i) 50% of the total rainfall estimated for the year falls in the ocean; (ii) 30% on the mountains; and (iii) 20% on earth. The agriculturists were required to plan their farming by considering rainfall as equivalent to 20% of the total rainfall.

Parashara thus laid the foundation for further scientific enquiries into weather forecasting. Rainfall, which was earlier viewed as a phenomenon, as a fight between the good and evil forces of nature, as a divine grace, was for the first time viewed as a subject of systematic study.

Krishishasana

This is yet another ancient text of uncertain date and authorship on agriculture. It devotes a complete chapter (Chapter VIII) of sixty-nine verses to rainfall forecasting. However, the portion could be the composition of Parashara himself and is almost identical in contents in most of the aspects.

Like Parashara, this text also affirms in identical words that there can be no agriculture without rain. Curiously, however, when at the beginning of its second chapter it describes "*krishi*" metaphorically as a four-legged entity like a cow, it does not mention 'rain' as one of the legs (Krishishasana II 1–4). In rain forecasting, meteorological changes and planetary movements taken into account are also by and large the same as in Krishi-Parashara. The text was edited and published in 1922 but does not show any advancement in perception of water management either for irrigation or for drinking purpose.

Arthashastra

This work of Kautilya (4th century BC) is important in this context as it contains valuable information on water management in the true sense of the term. Kautilya deals with this topic at length as agriculture was the main source of state revenue. Also, agriculture depends to a large extent on seasonal rainfall. His concern like Parashara's also relates to irrigation of farmlands. He has taken into account the interests of both the ruler and the farmer. Systematic guidelines are provided on water management. His unit for measuring rain is *drona*, which is equal to four *adhakas*. His method of fixing the unit is stated to be more scientific, precise, and free from other imperfections noticeable in Parashara's methods. *Drona* is stated to be equal to 6.4 cm. Kautilya's perception of water management can be summarized as follows (Balakundi, 1999):

- The quantity of seasonal rainfall required for good crop yield on different types of land:
  - Dryland: 16 *dronas*
  - Wet land: 24 *dronas*
  - Ashmaka (southern regions or Marathwada): 13.5 *dronas*
  - Malwa: 23 *dronas*
  - Western *ghats*: Unlimited
  - Himalayan regions and regions with irrigation facilities: Occasional rain
- The time-wise apportioning of ideal rain:
  - Beginning and end (first and the fourth month) of the season: 1/3 part
  - Middle of the season (second and third month): 2/3 part
- For planetary movements, etc. favorable to rainfall and agriculture, the following are considered:
  - *Guru* transiting (from *Mesha* to *Vrishabha*)
  - *Garbhadhana* [cloud formation observed during preceding months starting from *Pausha* (January)]
  - Rising and setting of *Shukra* (Venus)
  - Halo around the Sun
  - Sun indicates healthy seed, *Guru* good crop, and *Shukra* good rainfall
- Land is *devamatrika* (entirely dependent on rain god) or *adevamatrika* (dependent on other resources like rivers, lakes, wells, etc. in addition to seasonal rain); the latter is the best type of land for agriculture (VI-1-8).
- When the natural resources are not sufficient the state should take up irrigation projects by constructing dams (*setus*). Two types of *setus* are mentioned: (i) *Sahodaka setus* are constructed for tanks and wells fed with natural springs of water; and (ii) *Aharyodaka setus* are constructed for reservoirs where water needs to be stored externally (VII-12-4, 5).
- Irrigation is considered a state activity though privately owned irrigation tanks are also mentioned. However, the private ownership was lost if the tank was not used for five years (III-9-32, 34).
- Cooperative effort in building new water works is encouraged especially in a new settlement and it was made compulsory for members to contribute their share of labor and expenses (II-1-22, 23).
- Irrigation was one of the seven sources of state income. The state revenue from land tax was substantially augmented by the rate of water collected from farmers. Depending on the lifting of water from state-owned irrigation works by bullocks or other mechanical contrivances like the Persian wheel, farmers were required to pay taxes in the form of farm produce, in addition to the one-sixth part paid towards land revenue.
- Exemptions on water tax were considered on newly built tanks, for five years; ruined tanks renovated, for four years; and tanks cleared of overgrown vegetation for three years (III-9-33).

In Arthashastra (science of polity), for the first time the economic, political and social dimensions of water management is taken into account. Till this time, individuals or their small groups were taking care of the issues connected with water. The State's involvement in them changed the entire perspective. Kautilya's views on water management are therefore, closer to the present-day perceptions of the subject.

Brihatsamhita of Varahamihira

Varahamihira, the renowned scholar of mathematics and astronomy, treats the topic of clouds and rainfall in three out of 106 chapters of his Brihatsamhita (6th century AD). His rainfall prediction is based on movements of planets and stars with reference to months and lunar days. His successors have framed their theories of rainfall prediction on this basis. He has also expounded theories of formation of clouds and their characteristics (*Garbhadharana* and *Garbhalakshana*) indicating the time and amount of rainfall. These theories also have a strong astrological component. Composers of agricultural sciences like Garga, Kashyapa, and Parashara appear to be his predecessors in this regard. When Parashara recommends taking meteorological and other readings from the month of *Pausha* (January) onwards, he has stated clearly as to which clouds formed in which month indicate future precipitation although the words like *megha-garbhadharana*, etc. are not used specifically. In Chapter 54 named Udagargala, Varahamihira deals extensively on groundwater and its surface indications. This forms the basis of works on horticulture like Vrikshayurveda, Vishvavallabha, and Upavanavinoda which have developed the theories further.

Varahamihira focused attention on searching into the causes of rainfall like cloud formation and connecting it firmly with star movements. He also put forth the importance of yet another source of water, viz., the groundwater currents and provided valuable information on locating them.

Water reservoirs

Kashyapiyakrishisukti
(A Treatise on Agriculture by Kashyapa)

This is another important Sanskrit text (c. 700–800 BC) on ancient Indian agriculture which deals with the subject of water management in great detail. Surprisingly the author is silent about rainfall. He focuses his attention entirely on alternative irrigation schemes. In a way the treatise is complementary to that of sage Parashara. Kashyapa deals with this subject in 180 verses in considerable detail in the first chapter. His perception of water management expressed in the form of counsel offered to the state ruler can be summarized as follows:

- Water reservoirs should be constructed deep, equipped with barriers and in longish, round, semicircular or circular shapes. The level of the ground and the direction should be considered. Strong and safe steps for approaching water should be constructed. They should be equipped with inlets of water and thus should be close to a big lake situated on a higher level or to mountain springs. Constructed on level ground which is firm, they should be big enough to hold abundant water. They may be equipped with natural springs. Safety measures like providing latches should be taken to ward off floods. They should be regularly examined especially in the rainy season. *Nimba* (*Azadirachta indica*), *kadamba* (*Anthocephalus cadamba*), and such other trees should be planted in their vicinity to ensure purity of water (I-61-110).

- Canals originating from rivers and deep pools situated at a higher level should be constructed for irrigation. The breadth of the canal should be 4 to 10 cubits (1 cubit = about 45.7 cm). The depth should be planned according to the water flow. Four types of canals are recommended. Canals should also be constructed for the welfare of the villages (110–160).

- Detailed instructions are given regarding digging of wells, foundation, construction of walls, an opening gate, contrivance for lifting water, etc. (161–172). For detecting sources of groundwater, a study of vegetation, etc. indicating currents of groundwater is recommended.

Vishvavallabha (Dear to the World: The Science of Plant Life)

This work on horticulture by Mishra Chakrapani (16th century AD) treats the subject of water reservoirs at great length. One full chapter of the book is devoted to the topic (II-1–39).

- Construction of water reservoirs was a vital need of the arid and semi-arid land of Rajasthan to which region the author belonged.
- Construction of different types of water reservoirs like lakes, dams, wells, etc. are described in the text with different purposes like drinking water for villages, recreation for people, pleasure resorts for kings, and irrigation.
- Techniques of constructing wells for drinking water were well advanced. Strengthening the foundation and the walls, constructing steps, and providing contrivances for raising water were known. Seven types of wells are recommended.
- To ensure safety of drinking water, herbs and other materials were used (II-36–38). These were almost the same as recommended previously by Surapala and Varahamihira.
- In the rocky terrains of Rajasthan, digging wells must have been a challenging job. Often workers stumbled upon hard rocks. Vishvavallabha deals with the technique of breaking rocks without damaging the tools (II-25–31).
- Four types of ponds with specific names are described (II-12).
- Four kinds of potholes in which rainwater accumulated naturally are mentioned.
- Techniques of constructing pleasure resorts of kings in the middle of the water were perfected (II-11).
- The technique of constructing dams on rivers flowing between two closely situated hills was known and such dams were recommended as they could be constructed economically (II-7, 8).

Groundwater

Vrikshayurveda (The Science of Plant Life by Surapala)

This is the first available work (c. 10th century AD) in Sanskrit on the science of plant life dealing with about 175 indigenous varieties of plants, trees, creepers, shrubs, etc. very methodically arranged according to topics expounded in 325 couplets. Land was classified as '*Sarabhu*' and '*Tarabhu*', the former being allotted for agricultural purposes and the latter for tree-plantations. The basis for the distinction is irrigation facilities. *Sarabhu* was a land where plenty of rainwater was available for irrigation. *Tarabhu* on the othe hand was that land which depended more on wells and reservoirs for irrigation. Therefore, we find the writer dealing at great length with surface vegetation indicating groundwater currents. As stated earlier, Varahamihira had already set different models in this matter.

The natural indicators of groundwater according to Surapala are:

- Flora:

  Vetasa (*Salix caprea*), *jambu* (*Syzygium cumini*), *nirgundi* (*Scirpus grossus*), *badari* (*Ziziphus mauritiana*), *badari* and *palasha* (*Butea monosperma*), *kashtha* (*Curcuma xanthorrhiza*) and *udumbara* (*Ficus glomerata*), *bibhitaka* (*Terminalia bellirica*), *kovidara* (*Bauhinia variegata*), *kusha* (*Desmostachya bipinnata*) and *asita* (*Indigofera tinctoria*), *munja* (*Saccharum bengalense*), *kasha* (*Saccharum spontaneum*) and *kusha.*

- Fauna:

  Frog, anthill, fish, shrew, earthworm, white mouse, whitish scorpion, pinkish snake.

- Subsoil indications:

  Soil color: Yellow, whitish yellow, tawny, bluish grainy, black, red, white.

  Soil texture: Granular, sandy.

  Rock color: Saffron, ruby, pigeon.

After taking into account these factors, the depth, direction, taste, and force of the underlying water currents and the length of time they would last are inferred and based on this data, a spot for digging wells for irrigation is selected.

Vishvavallabha

This is yet another work on the same subject of horticulture, comparatively of a later date. We can notice advancement in various aspects of the science in this work. Irrigation is a topic of prime importance to the author and he devotes the first two chapters (out of nine) to it. In the very opening verse he says, "I propose to expound in this book the science of plant life but without water there can be no plants. Hence I will first explain the sources of water."

In the first chapter he recommends several surface indications of groundwater on the lines of Varahamihira and Surapala but has added several more plants/trees as water indicators. Besides, he deals with this topic after first classifying the type of land. Arid, wet, semi-arid desert, and hilly lands are separately dealt with for this purpose. It is evident that the vegetation would vary with the type of land. This brings many more varieties of trees under the scope of the topic. As the author belongs to Mewar region, modern scientists could corroborate the recommendations made by the author with the geological and meteorological conditions of Mewar where they have not undergone drastic changes (Nene, 2004).

Various colors of rocks and soils are also newly added as indicators of water. It is reported that the ruler Rana Pratap in those days had forbidden farming on the level ground and had insisted on agriculture in the hilly regions due to the political situation. This work reflects the need of the time. Surface indicators of groundwater in the hilly regions recommended by Chakrapani must have fulfilled this need of the time.

Chakrapani's contribution to the technique of constructing water reservoirs has been already referred to.

Drinking water

The sources discussed so far refer to management of water mainly from the point of view of irrigation. There are passing references to wells for drinking water for villagers and ensuring safety of drinking water for humans and animals. However, it is yet another source which contains enormous and valuable information on this topic.

Sushritasamhita

Sushritasamhita is a text on Ayurveda by Sushrita (c. 2nd to 3rd century BC). The 45th chapter of the Sutrasthana of this text is devoted to the subject of water for human consumption. Sushrita's perception of the subject is summarized below:

- Main source of water is *antariksha* (atmosphere).
- Before coming in contact with earth it is classified into two types:
  - *Ganga* (pure) and *Samudra* (contaminated with atmospheric impurities):
  - *Ganga* is of four types: *dhara* (rain showers), *kara* (originating from hale), *taushara* (stored rainwater), and *haima* (originating from snow).

  - Whether the rainwater is pure or impure can be judged with a simple test. Keep a ball of rice flour (made from unpolished rice) in a silver plate in the open and collect rainwater in it for 48 minutes. If its color remains the same the water is *ganga* or pure and if the color changes it is *samudra* or impure.
  - Water of rain in the month of *Ashwin* (October) is always pure.
  - Pure water should be stored in gold, silver, or earthen pot and should be consumed for the whole year as it is free from *tridoshas* and from germs causing diseases like indigestion and fever.

- After coming in contact with earth it is called *bhauma* (earthly) water.

- This *bhauma* water is available in several water bodies like river, lake, pond, big well, small well, water potholes, stream, spring, basin, and pool.

- Water that is contaminated by mud or moss, unexposed to sunrays or moon rays, characterized with smell, taste, or color is impure and must not be consumed.

- Methods of purifying water:

  - Boiling
  - Heating in the sun
  - Dipping red hot iron ball
  - Dipping heated brick
  - Application of perfumes of *naga* (*Mesua ferrea*), *champaka* (*Michelia champaca*), *utpala* (*Nymphaea nouchali*), or *patala* (*Stereospermum suaveolens*) flowers.

- Water recommended for drinking as per the seasons is:

  - *Varsha*: Rainwater or springs
  - *Sharad*: Clean water from any good source
  - *Hemanta*: Lake or ponds
  - *Vasanta*: Wells or streams
  - *Grishma*: Wells or streams
  - *Pravrit*: Small wells without construction.

- Soil and its effect on taste of water:

  - Red soil: Sweet
  - Tawny: Sour
  - Pale yellow: Saline
  - Blue: Bitter
  - Yellow: Pungent
  - White: Astringent

In addition to all these valuable hints, texts on Ayurveda recommend water as a part of treatment for some diseases. This is applicable to trees and plants too.

Conclusions

To sum up, in the Vedas, water was deified as Aapodevi and prayers and oblations were offered to propitiate her. Rainfall is viewed as a phenomenon, as a victory of justice over evil forces, and as divine gift for living beings. At the same time several facts like the water cycle, utility and indispensability of rivers, the cycle of seasons one of which was the rainy season, and dependence of food grains and pastures on rain were clearly understood. Prayers and offerings through sacrifices were believed to ensure continuous yearly rainfall. Vedas provided the knowledge base.

On this basis further progress was made which was documented in works of sages and scholars in different fields like agriculture, Ayurveda, astronomy, mathematics, science of polity, horticulture and so on. The rich heritage that they passed on to us may be summed up as follows:

Aantarikshodaka (Rainwater):

- Rainfall is studied, on the basis of observations of meteorological changes and planetary movements. Several theories were formulated forecasting rainfall (Parashara, Varahamihira). Ideal rainfall for various types of soils was determined (Kautilya). Time, duration, amount, and distribution of rainfall was predicted and farming operations were planned accordingly.

- Rainwater was directly utilized for irrigation and drinking or harvested and stored for both the purposes. Storage tanks were constructed for the purpose (Kautilya, Kashyapa).

Bhaumodaka (Surface water):

- Rivers, lakes, and ponds were identified and used as sources of water. Pure water was distinguished from impure water. The water bodies were used for irrigation and drinking purpose (Kashyapa).

- Devices for canalizing water from the sources to the place of use were invented (Kashyapa).

- Four types of water reservoirs were in use:

  - Tanks to be filled with water from external sources (*Aaharyodaka*) which were constructed close to the source and at a lower level (Kautilya).
  - Tanks to be filled with internal springs, water currents, etc. (*Sahodaka*) (Kautilya).
  - Ponds and pools where rainwater accumulated naturally due to land levels (Kashyapa).
  - Dams constructed on rivers (Mishra Chakrapani).

Adhasthodaka (Groundwater currents):

- Flora and fauna, soils, and rocks were identified as surface indications of groundwater currents. Spots for digging wells were selected accordingly (Varahamihira, Surapala, Mishra Chakrapani).

To conclude, it would be naive on my part even to suggest that the data from the ancient sources as analyzed in the foregoing pages offers any direct and immediate solutions to the present problems regarding water security and water scarcity faced by our scientists, ecologists, engineers, political and social thinkers, or water-supply departments. Nor do I aim at oversimplifying them by setting back the hands of the clock. It would serve the purpose of this paper if it can help these present-day thinkers to recapitulate the past, bridging up the wide gap that exists today between the past and the present and to build the future on a sound basis of modern scientific and technical knowledge visualized and utilized in a proper perspective.

Modern multi-million irrigation projects besides being a heavy burden on the state exchequer are also known to have led to ecological problems. It is learned that participation of private sponsorship is under active consideration of the states. Off late bunds on river water have given rise to discord in inter-state relations. If things continue on the same line it may not be difficult to believe someone's prediction that the fourth world war will be fought on the issue of water. But these and such other comments coming from me, a novice and non-authority in the field, may not carry the weight and attention they deserve from the concerned. I therefore, end this paper citing an opinion of an authority in the field. In the opinion of this modern scientist which is documented in an official government report:

"Traditional water harvesting systems, being simple and sustainable, need to be respected, encouraged and maintained. . . . They carry a great deal of historical significance besides contemporary relevance."

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