

## WATER QUALITY

The modern scientists at one time, used to consider rainwater as pure like distilled water. But later studies have revealed that it is not so. The water of precipitation is characteristically the purest water in the hydrological cycle, but even so it may collect from less than 1 to several hundred milligrams of dissolved material per litre of water during its fall through the atmosphere. Rainwater as it falls to the earth has ample opportunity to dissolve gases from the air and also may dissolve particles of dust or other air borne materials. Rain water becomes a mixed electrolyte containing varying amounts of major and minor cations and anions. Sodium, Potassium, Magnesium, Calcium, Chloride, Bicarbonate and Sulphate are the major constituents. Ammonia and various nitrogen compounds are generally present. Dust particles are added locally in industrial areas, large population centres and desert areas. Among the land based factors which may be significant in altering the composition of rainwater are the sulphur emitted by Volcanoes, Fumaroles, Springs, and Dust particles.

Rainwater close to the ocean commonly contains from 1.0 milligram per litre to several tens of milligrams per litre of chloride but the observed concentration generally decrease rapidly in a landward direction.

In Vedas we get some references to water quality, especially in Atharvaveda. Charaka Sanhita, Susruta Sanhita (both of pre or early Buddhistic era), and Ashtanga Hridaya Sanhita (9th century AD) are the repositories of knowledge accumulated on Ayurveda (Science of Life), during the earlier period dating back to the Vedic age. In all these ancient standard texts discourses on water quality constitute an

important aspect of Ayurveda. Bhavamisra's Bhava Prakash (16th century AD), which is more or less a compilation of all the Ayurvedic texts of earlier antiquity, also elaborately deals with water quality.

In Rigveda the verse (V,83.4) says about the tree plantation, forest conservation and Yajna's so as to create pure & healthy environment and good quality of water for well being of mankind viz.

प्र वाता वन्ति पतयन्ति विघ्नत उदोषधीर्जिह्वे पिन्वते स्वः ।  
इरा विश्वम्भै भुवनाय जायते यत्पर्जन्यः पृथ्वीं रेतसावति ॥ RV,V,83.4 ॥

Likewise verse (VII,50.4) of Rigveda also reveals the importance of Yajna (यज्ञ) in relation to purification of water. In Yajurveda (I,12) we read the contamination of substances by combination and fire as the prime source of purification by breaking the substances into minute particles i.e. yanja, heat and sunrays are the agents to purify the water. viz.

पवित्रे स्थो वैष्णव्यौ सवितुर्वः प्रसव उत्पुनाम्याच्छिण पवित्रेण सूर्यस्य रश्मिभिः ।  
देवीरापो अग्रेगुवो अग्रेषवो य इममघ यज्ञं नयताग्रे यज्ञपतिं सुधातुं यज्ञपतिं देवयुवम् ॥  
YU.I.12 ॥

In Samveda (Previous II,187) we read that the sun rays cause the rain to come in purest form like white curd viz.

इस्मास्त इन्द्र पूरनयो घृतं दुस्त आशिरम ।  
एनामृतस्य पिप्युषी ॥ SU.P,II.187 ॥

A verse of Atharvaveda (V,22.5) directs to take preventive measures against the diseases caused by the areas with much grass, high rainfall and bad water quality viz.

ओकों अस्य मूजवन्त ओकों अस्य महावृषाः ।  
यावज्जातस्तत्तमं स्तावानसि बल्हिकेषु न्योचरः ॥ AV.V,22.5 ॥

In the celebrated epic Mahabharata (XII,184.31 and 224.42) we read about the various qualities of water according to its taste

thus it is clear that atleast they were trying to specify the water quality according to its taste.

रसो बहुविधः प्रोक्त ऋषिभिः प्राथितात्मभिः ।  
मधुरो लवणस्तक्तः कषायोम्लः कटुस्तथा ॥ M.B.XII, 184.3 ॥

In the Uraht Sanhita we find many references to water quality in the 54th chapter named "Dakargala". Sloka 2 states that ground water should be investigated in relation to its environment: viz.

एकेन वर्णेन रसेन चाम्भश्च्युतं नभस्तो वसुधाविशेषात् ।  
नानारसत्वं बहुवर्णतां च गतं परीक्ष्यं क्षितितुल्यमेव ॥ Ur.s.54.2 ॥

Soil colour was described as an indicator of water quality viz.

सशर्करा ताम्रमही कषायं क्षारं धारिव्री कपिला करोति ।  
आपाण्डुरायां लवणं प्रदिष्टं मृष्टं पयो नीलवसुन्धरायाम् ॥ Ur.s.54.104 ॥

"that Pebbly and sandy soil containing copper makes water astringent (कसैला). Brown-coloured soil gives rise to alkaline water, pale white soil salt water and blue coloured soil makes water pure & sweet".

A water treatment method was also suggested to improve the quality of drinking water. viz.

अज्जनमुस्तोशरिः शराजकोशातकामलकचूर्णैः ।  
कतकफलसमायुक्तैर्योगैः कूपे प्रदातव्यः ॥ Ur.s.54.121 ॥

कलुषं कटुकं लवणं विरसं सलिलं यदि वाशुभगन्धि भवेत् ।  
तद्वलेन भवत्यमलं सुरसं सुसुगन्धि गुणैरपरैश्च युतम् ॥ Ur.s.54.122 ॥

i.e. a mixture of Anjanam (collyrium, antimony or extract of ammonium), Musta tubers (Nagarmodha), Usira (Khas), Powder of Rajkosataka (Torayi), and Amalaka (आवला), combined with Kataka nuts should be put into a well. If the water is turbid, pungent, saltish, of bad taste and not of good odour will be

rendered clear, tasty, aromatic, and with other good qualities.

Thus Varahamihira at that time presented a simple method for obtaining potable water from a contaminated source of water. All above plant materials have medicinal value and are commonly available in almost all parts of India.

In ancient medical texts are such as Charaka samhita, Susruta samhita and Astangahrdaya samhita (by Vagbhata) collectively known as Brahatrayi (Great triad), and three other ayurvedic texts Madhavanidanam, Sarangadhara Samhita and Bhavaprakasha are collectively known as Laghutrayi (small triad) some references of water quality are available.

In Bhava Prakash many parts had been incorporated from the medical texts of Charaka, Susruta, Vagbhata, and the Tantrik texts. The tenth chapter of Bhava Prakash with 86 slokas named as Vari Vargah deals with different aspects of water. Here some aspects of water quality are presented as given in above text (10th chapter, Vari Vargah part) and also analysed by Prasad (1979).

Sloka 2 states the important properties of water and its usefulness for the living beings.

पानीयं श्रमनाशनं क्लमहरं मूर्च्छापिपासाहरं तन्द्राच्छर्दिविबन्धहृद्दलकरं निद्राहरं तर्पणम् ॥ X.2 ॥

"Water eliminates the fatigue of the body and mind, destroys weakness. It is good for heart, gives satisfaction, soft, clear, origin of rasas, and destroyer of vomiting, sleeping tendency, and constipation.

In Sloka 3 and 4 the classification and nomenclature of different forms of water have been given.

पानीयं मुनिभिः प्रोक्तं द्विविधं भौममित द्विधा ॥ X.3 ॥

द्विविधं चतुर्विधं प्रोक्तं धाराजं करकामवम् ।  
तौषारं च तथा हैमं तेषु धारं गुणाधिकम् ॥ X.4 ॥

Water which rains from sky is called 'Divyam' and when it gets collected on the earth or as ground water it is termed as 'Bhaumam' by sages. 'Divyan' water is divided in four categories: 'Dharajalam' falls as continuous shower from sky, 'Karakabhavam' when it falls like the pices of stones, 'Tausaram' is free from the smoke etc, and 'Haimam' is caused from the snow of Himalayas. Among these 'Dhavajalam' is better having full of qualities.

Similarly sloka 25 gives classification of Terrestrial water (Bhauma Jalam).

भौमयम्भौ निगदित्वं प्रथमं त्रिविधं बुधैः ।  
जागडलं परमानूपं ततः साधारणं क्रमात् ॥ X.25 ॥

"Bhaum Jalam is of three varieties viz. Jangalam, anupam, and Sudharanam. Above water divisions are based on the characteristics of the regions which are differentiated according to their environmental conditions.

अल्पोद कौल्पवृक्षश्च पित्तरक्तामयान्वितः ।  
शातव्यो जागडलो देशस्तत्रत्यं जांगलं जलम् ॥ X.26 ॥

बह्मबुर्वह्वक्षश्च वातश्लेष्मामयान्वितः ।  
देशोनूप इति ख्यात आनूपं तद्वभवं जलम् ॥ X.27 ॥

मिप्रचिन्हस्तु यो देशः सहि साधारणः स्मतः ।  
तस्मिन्देशे यदुदके तन्तु साधारणं स्मृतम् ॥ X.28 ॥

जागडलं सलिलं रक्षं लवणं लघु पित्तनुत ।  
वन्धिककफहृत्पथ्यं विकारन हस्ते वह्न ॥ X.29 ॥

आनूपं वार्यभिष्यन्दि स्वादु स्निग्धं घनं गुरु ।  
साधारणं तु मधुरं दीपनं शतिलं लघु ।  
तर्पणं रोचनं तृष्णादाहृदोषत्रयप्रणुत ॥ X.31 ॥

The country having sparse trees and less water and having the bad effect of causing Pitta and Vata disorders are the Jangala region and water originated in this region is termed as Jangala

water. The region having plenty of water and abundant trees and able to cause Vata and Kapha diseases is called Anupam and its water as Anupam water. The regions having the mixed characteristics of above two types is called Sadharanam region, and its water is called Sadharana Jalam. Jangala water is saltish, soft, eliminates Pitta and Kapha, Promotes digestion, and a good diet in diseases. Anupa water is tasty, oily, viscus, hard, retards digestion, promotes Kapha and creator of other disorders. Sadharana Jalam is sweet, promotes digestion, soft, cool, pleasant and eliminates Tridosha. Thus we see here that in study of water a large number of factors of ecology have been considered in line to the modern hydrology.

#### Standards for Water Quality:

In the chapter at various places we get the words such as विशदं (clear, clean, pure, pellucid, etc.), स्वच्छम् (clear), निर्दोष (blemishless), कलुषं (polluted), and निर्मलत्वं (unpolluted), frequently.

Slokas 78-81 describe the characteristics of the contaminated waters. viz.

पिच्छलं कृमिलं किलन्नं पर्णशैवालदककीः ।  
विवर्णं विरसं सान्द्रं दुर्गन्धं न हितं जलम् ॥ X.78 ॥

कलुषं छन्नममभोजपर्णनीलीतृणादिभिः ।  
दुः स्पर्शनमसंस्पृष्टं सौरचान्द्रमरीचिभिः ॥ X.79 ॥

अनात्तवं वार्षिकं तु प्रथमं तच्च भूमिगम ।  
व्यापन् परिहृत्यं सर्वदोषप्रकोपणम् ॥ X.80 ॥

तत्कुर्यात्स्नानपानाभ्यां तृष्णाध्मानचिरज्वरान् ।  
कासाग्निमांघ्राभिध्यन्कण्डूगण्डादिकं तथा ॥ X.81 ॥

\*Waters which are of stiky nature, containing worms and spoilt by leaves and mud, of bad colour thick of bad smell, such waters are not good for health. Muddy and covered by lotus leaves,

grass etc. unilluminated by sunlight or moonlight, lacking movement, caused by untimely rain or the first rain water which gets collected in the ground, such waters are the source of many disorders; thus they should be prohibited. Because the use of such waters for drinking and bathing purposes, cause तृषा, आध्मान, जीर्णज्वर, अग्नमान्द, कण्डू, गण्डा and so on. A critical study of other slokas also clearly reveal the approach of ancient Indians for water quality standard for different uses.

Variation in the quality of water with seasons as also from different sources has been explained in slokas 59-67.

हेमन्ते सारसं तोयं ताड़ागं वा हितं स्मृतम् ।  
हेमन्ते विहितं तोयं शिशिरेपि प्रशस्यते ॥ X.59 ॥

वसन्तग्रीष्मयोः कौप वाप्यं वा निर्झरं जलम् ।  
नादेयं वारि नादेयं वसन्तग्रीष्मयोर्बुधैः विषवद्धनवृक्षाणां पत्राद्यैर्दूषितं यतः ॥  
X.60 ॥

औदभिद चान्तरिक्षं वा कौपं वा प्रावधि स्मृतम् ।  
शस्तं शररि नादेयं नीरमंशुदक्तं परम् ॥ X.61 ॥

दिवा रविकरैर्जुष्टं निशि शतकरांशुभिः ।  
नीयमंशुदक्तं नाम स्निग्धं दोषत्रयापरम् ॥ X.62 ॥

अनभिष्यन्दि निर्दोषमान्तरिक्षजलोपमम् ।  
बलयं रसायनं मेध्यं शीतं लघु सुधासमम् ॥ X.63 ॥

शरदि स्वच्छमुदयाद्यास्त्याखिलं हितम् ॥ X.64 ॥

पौषे वारि सरोजातं माघे तन्तु तडागजम् ।  
फाल्गुने कूपसंभूतं चैत्रे चौज्यं हितं मतम् ॥ X.65 ॥

भाद्रे कौपं पयः शस्तमारिवने चौज्यमेव च ।  
कार्तिके मार्गशीर्षे च जलमात्रं प्रशस्यते ॥ X.67 ॥

"Water belonging to ponds and tanks during the season हेमन्त (winter November - January) are good; during शिशिर (the cool season, January - March) also the same waters are superior. During वसन्त (Spring: March - May) and ग्रीष्म season (summer: May-July) the water

belonging to wells, stepped deep wells, and rocky springs are good. During वसन्त and ग्रीष्म seasons waters of rivers should not be used for drinking get during these seasons the river waters become contaminated with the leaves of poisonous trees etc. During rainy season aubhida water (ground water of artesian character) or Antariksha water (the atmospheric precipitation) are good. During शरद season waters of to rivers and waters, illuminated by the sun during day time and by the moon during nights are called amsudakam are good. Ansudak water is destroyer of the Tridosha, not causing abhisyanda and is free from bad qualities. It is equal to akasodakam, good for brain, soft and cool. During शरद season after the rise of star Agastya in the sky all waters become pure. Uridha Susruta said that during the month of Pusya waters from lakes or ponds, during Magha waters from tanks, during Phalguna waters from wells, during Chaitra Chaunjya (velley stream water) water, during Vaisakha Nairjhara water etc. during the months of Jyestha the water of artesian character, Asadha the well water, and in Kartika and Margasira all kinds of waters are good".

#### Factors affecting water quality:

As seen from above slokas of Bhave Prakash we can identify some factors affecting the quality of water.

हेम जलम् i.e. glacial water भूमि जलम् i.e. Ground Water, नाट्य जलम् (River water), औदभिद जलम् (Ground water flowing with artesian character), निर्झर (Water falls water), तडाम जल (Pond Water), कूप जल (Wells Water), वीज्य जल (i.e. Valley Stream Water, Sloka 65) and their qualities have been described in Bhave Prakasha with detail, indicating the knowledge of the effect of geographic condition on the quality of water. These conditions are related to the differences in the earth as अनुप, जंगल and साधारण regions as described before in slokas 26-27-28. The effect of agricultural soil on water quality (कैदार जल, Sloka 57) is also described, viz.

कैदारः क्षेत्रमुद्विष्टं कैदारं तज्जलं स्मृतम् ।

कैदारं वायुर्यभिष्यन्दि मधुरं गुरु दोषकृत ॥ X.57 ॥



It also describes the effect of decaying vegetation on water quality. Also the effect of stagnation, lack of the penetration of sun light (due to depth) on water quality have been described (Slokas 78 to 81). Thus the modern hydrologic concepts related to water quality are fully satisfied in this Sanskrit work.

The knowledge of the hardness of water has been described in many slokas (7,19,21,24,29 and 43) quoting the properties of various waters according to origin.

धारनीरं त्रिदोषधनमनिर्वेश्यकरं लघु ।  
सौम्यं रसायनं बल्यं तर्पणं ह्लादि जीवनम् ॥ X.7 ॥

करकाजं जलं रुक्षं विशदं गुरु च स्थिरम् ।  
दारुणं शीतलं सान्द्रं पित्तहृत्कफवातकृत् ॥ X.19 ॥

Here सौम्यम् (Saumayam) means soft and रुक्षं (ruksam) or दारुणं (darunam) means hard water.

Diseases in relation to water have been described which is clear from the verses X.27-31, X.78-81 and some others. This discourse on water quality and related subjects is quite scientific and shows broad outlook of ancient Indians.

**Water Treatment:**

Sloka 5,6 suggest collection of water in golden, silver, copper and glass vessels or earthen pots, after filtrating from cloth. It reveals the attention paid to get clear water.

सौवर्णे राजते ताम्रे स्फटिके काचनिर्मिते ।  
भाजने मृण्मये वापि स्थापितं धारगमूच्यते ॥ X.6 ॥

In sloka 82 we get that water treatment for drinking purpose should be done by heating or boiling and filtration, sloka 83 reveals the treatment by the aid of heated sand, stones etc. and use of aromatic materials viz.

निद्धितं चापि पानीयं त्वथितं सुर्यतापितम् ।  
सुवर्णं रजतं लोहं पाषाणं सिकतामपि ॥ X.82 ॥

भ्रशं सन्ताप्य निर्वाप्य सप्तधा सार्धितं तथा ।  
कर्पूरजातिं पुन्नागपाटलादिस्सुवासितम् ॥ X.83 ॥

शुचि सांद्रपटस्त्रवि द्यूत्रजन्तुविवर्जितम् ।  
स्वच्छं कनकमुक्ताद्यैः शुद्धं स्याददोषवर्जितम् ॥ X.84 ॥

पर्णमूलं विसर्गंधिमुक्ताकनकशैवलैः ।  
गोमेदलं च वस्त्रेण कुर्याद्विष्प्रसादनम् ॥ X.85 ॥

"Contaminated water can be purified by boiling, by exposure to the sun's rays or by quenching with fire heated gold, silver, iron, stone or sand and flavouring it with the smell of Camphor, Jati (chameli; *Jasminum grandiflorum*), Punnaga (Nogkesar; *Calophyllum inophyllum*), Patala (Padhar; *Coccoloba banducella*) etc. and then filtration through clean cloth makes water free from small germs. Purifying it with gold, pearl, etc. also makes it free from pollution. Water should be made free from leaves, roots, stalks of lotus leaves, gold, pearls, cloth etc".

From above treatment procedure we gather that the positive effects of intense sunlight, heating, filtration, aeration, and addition of aromatic components is clearly revealed in above treatise. The bad effects of stagnation of water, contamination of water by leaves, algae etc. are also described. The treatment methods given need no costly inputs and no desirable qualities of water will be changed, which is a measure draw back of the modern chemical methods of water treatment.

From this chapter it can be concluded that the water quality in relation to taste, soil, rock, season, source etc. was known to ancient Indians. Water classification and viewing its quality in relation to environment satisfies the modern concept of ecology. Yajna as the medium of water purification by means of breaking it into small particles and the hydrological cycle as the main source of water purification by

evaporation, were realized. Water quality standards, factors affecting water quality, effect of decaying materials on quality of water, lack of aeration in stagnating and deep water bodies etc. were known which are in accordance to modern science. Water treatment methods using filtration, pots of different materials like earthen, silver, gold etc., quenching with hot stones, sun heating, aeration, addition of aromatic compounds etc. were adopted. These methods are frequently used even now a days and are better than the chemical disinfectants as there will be no change in the desirable qualities and odours of the water.