Refractive Index

Water being a transparent medium, the rays of light undergo refraction while passing through it. The value of refractive index is about 1.33 (which is for yellow radiation component) and ranges from 1.28 (red radiation component) to 1.36 (violet radiation component).

Radioactivity

Pure (distilled) water does not possess radioactivity. The presence of uranium, radium and radon (radon is the gaseous emanation produced by radium) causes radioactivity in water. All groundwater with very few exceptions, reveal some radioactivity.

Chemical Properties

In the language of chemistry, water is an inert compound of hydrogen and oxygen. Basically, it cannot effect any chemical action upon other substances as carried out by the acids (HCl, H_2SO_4, HNO_3). However, water subsequently acquires it through the bonds existing between the hydrogen and the oxygen atoms of the molecule of water. The molecules being polar, have some separation of the electrical charge. In the liquid state, the separation in a few molecules is so much complete as to give rise to two oppositely charged particles or ions H^+ and OH^-. Here the hydrogen atom simply moves away, leaving its electron with the bonding pair of electrons on the oxygen atom, and leaving the remaining part of the molecules (OH^-) with an extra negative charge. The H^+ is the hydrogen ion or the ion of the acids, and the OH^- is the hydroxyl or the ion of the bases. When carbon dioxide (CO_2) dissolves in water, it acts with these ions as shown below:

$$CO_2 + HOH = H^+ + HCO_3^-$$

Above-noted reaction is of vital importance in keeping the acidity of blood and in holding CO_2 (formed by metabolism in the body) in solution to be delivered at the lungs. The chemical action of CO_2 and water dissolves limestones to form caves. Water, oxygen and CO_2 are in the closed cycle of life of human beings, with the essential hydrogen atoms shuffled back and forth.

Excellent solvent property of water makes it important in the life of plants and animals. The solvent action is of two types, namely, hydrogen bonding and electrical poles, in both of which, water is outstanding amongst the liquids. Among substances that are liquid at the surficial temperature and pressure, water has an unusually high separation of electrical charges. By the charge interaction, various salts are held in solution. Among them is sodium chloride which man needs for the acid in his stomach, and for the action of blood serum. Polar interaction also dissolves potassium salts which are involved in the muscle action. Water, by its hydrogen-bonding-solvent action, is the medium of transfer in the fluid of blood or in the sap of plants (Hendricks, S.B., Water, The Year Book of Agriculture, 1955, p. 13).

pH

The acidity of water is measured by the concentration of H^+ ions, and it is designated as pH. If the value is greater than 7, water is classified as alkaline, if less than 7, it is called as acidic. In pure (distilled) water the dissociated molar concentrations of H^+ (hydrogen) and OH^- (hydroxyl) ions are equal, each being 10^{-7} moles/litre, which is equivalent to a pH of 7. If the H^+ ions exceed those of OH^- (as in acidic solution), the pH is less than 7. The most common value of pH of water is between 5 and 8. For potable water, it should be between 6.5 and 8.5. Acidity mainly comes from the dissolved CO_2 which ionises into H^+ and HCO_3. Lower values of pH may be due to lightening discharge, which produces nitric acid and other acids in minute amounts. Any increase in acidity increases the rate of chemical action upon materials.

CHAPTER 3

Mode of Occurrence and Distribution of Global Water

Water has attracted attention from different quarters; the researchers, the agriculturalists, the Governmental and the non-Governmental organisations. In literature one comes across such expressions as, "Lot of water has flown under the bridge, Your statement holds no water, Water seeks its own level, Don't throw cold water on my proposition, and so on". A hydrogeologist exclaims in despair, "Water, water everywhere, but not a single drop to drink". Man expresses indebtedness to the Creator of the Universe for providing water on the Earth, and it to be the Elixir of life. At least at present, Earth alone is regarded to contain water, amongst the planets revolving around the Sun. Amongst the several beneficial features possessed by the Earth, water and oxygen top the list. Let us deal with the disposition and the form assumed, and the distribution of water on the Earth (Globe).

FEATURES OF FORM

Water occurs in three phases namely, vapour, liquid and solid, that too at the surficial temperature and pressure. In the vapour state, it constitutes the main constituent of the atmosphere. As a liquid, it forms oceans, seas, lakes and rivers. The solid form of water is the snow and ice. The most extensive phase is the liquid water. The conversion of liquid to the vapour phase and vice versa, is described as the *hydrological cycle.*

DISPOSITION OF GLOBAL WATER

The Earth is considered to be more or less composed of concentric shells or spheres, water and the atmosphere forming the outermost entity. In keeping with the concept of spheres, water is also regarded to form a sphere, and it is named as the hydrosphere. Akin to the atmosphere engulfing the entire Earth, water too could have done it, but for the existence of rugged surface, due to which, some parts have attained elevations and have formed the seas, the rivers and the lakes, and covers 70% of the surface of the Earth, while 20% forms the ice-caps and the glaciers.

There is an exchange of water molecules between the hydrosphere and the atmosphere during the process of evaporation of the oceanic water and the rainfall. Therefore, some part of the water is held up in the atmosphere. According to Klimentov (1983), the envelop of atmosphere is made up of three

The above given data pertaining to the surficial extent of land clearly reveals that the landmass II is as much as 2.7 times bigger than the landmass I. Landmass II, therefore, has been designated as a Mega continent. In percentage, the Mega landmass constitutes 71.42, the other landmass is 28.57. Major portion of South America lies in the Equatorial Belt Region, while that of the Mega continent lies to the north of the Tropic of Cancer (Fig. 3.2). There is yet another glaring difference between the two landmasses. Scrutiny of Fig. 3.3 discloses that (i) landmass I (the two Americas) extends more in a NNW—SSE direction, and is remarkably less in the E—W direction, while (ii) the Mega landmass extends more in a ENE—WSW direction, but is remarkably less in the E—W direction, while (ii) the Mega landmass trends more in a ENE—WSW direction, but is remarkably less in the N—S direction.

EXTENT OF RAINFALL VIS-A-VIS LOCATION OF CONTINENTS

According to Soumya Kerbart Sivakumar (op. cit.), 45% of water occurs in America, 28% in Asia, 15.5% in Europe and a meagre 9% in Africa. It is of interest to note that though South America and Africa are situated in the Equatorial Belt Region, the former continent receives heavy rainfall (more than 200 cm), while the latter continent receives a moderate (100–200 cm) rainfall. Africa even though is situated in the Equatorial Belt Region, its major part, however, receives a low (25–50 cm) rainfall. Another glaring feature of contrast is that South America is a water-rich continent, while World's largest Sahara desert lies on the northern border of Africa. Low rainfall in Europe (Fig. 3.2) is certainly the result of its location further north of the Tropic of Cancer. The American continent has become a water-rich landmass because, (i) it has a long N—S trending eastern and western coasts, (ii) it is situated amidst the vast expanse of oceans, the Pacific on the west and the Atlantic on the east, and (iii) its N—S extent (15,834 km) is almost double of its E–W extent (9267 km). Africa though located in the Equatorial Belt Region, its extensive area receives a low rainfall of 25–50 cm. This is probably because of its extremely large size of 30,355,000 km^2 as against small size of 17,800,000 km^2 of South America.

It may, therefore, be surmised that the intensity of rainfall over the globe depends upon the location, size and shape of the continent with respect to the oceans, as well as on the direction and intensity (speed) of wind. Of late, the phenomenon of global warming is causing concern, because it is feared that it will certainly affect the climate of the globe, which in turn will affect the rainfall pattern of the Earth.

Aquifuse: This is an impermeable formation and the pores are not inter-connected, hence cannot transmit water.

Hydrogeologic Complex: It is an assemblage of aquifer systems bounded either from their bottom, or from the top and bottom, by thick impermeable formations that are regionally continuous throughout the corresponding artesian basin.

Water table: It is the surface of a zone of saturation where the body of groundwater is not confined by an overlying impermeable formation.

Main Water table of Phreatic Surface: It is the limit of zone of saturation above the first impermeable or almost impermeable formation.

Natural Water table: It is the surface at which the hydrostatic pressure of the groundwater is equal to the atmospheric pressure.

Perched Water or Perched Groundwater: It is the groundwater of a limited aquifer embedded in different depths, but lower than verkhovodka (noted by Sarbhukan, M.M. 2001, Water Resources Planning, p. 3) on small impermeable lenses.

Isobath: It is the measure of depth of water table with respect to the groundwater.

MODE OF FORMATION OF GROUNDWATER

The major source of groundwater is the rain which also gives rise to the oceans, seas, lakes and the rivers that constitute the surface water. The other modes of formation are, (a) Infiltraton, (ii) Condensation, (iii) Sedimentation, (iv) Juvenile, (v) Connate, (vi) Phreatic, (vii) Vadose, (viii) Meteoric, and (ix) Pellicular.

(i) **Process of Infiltration:** This mode has been initiated by Marcus Vitruvius Pollio, who was a Roman Architect and Engineer. He had proposed it in the First Century BC. This received support in the 18th and 19th centuries and scientific substantiation from F. Perault, E. Mariotte, A. Vallisnieri, E. Hally, M.V. Lomonosov and others (Klimentov, p. 120). The term "infiltration" inadvertantly conveys that the rainwater gets filtered through the crustal rocks and forms the groundwater. Instead the term "percolation" sounds more appropriate, because the rainwater percolates along the fractures, fissures and other openings, and during this movement, acquires the ingredients (Na, Ca, Mg, etc.). Infiltration or percolation is active because of gravity, which takes the ingredients towards deeper parts of the Earth's crust.

(ii) **Process of Condensation:** Greek philosopher Aristotle is the pioneer in introducing this hypothesis, as early as the 4th Century BC. In the 19th century, O. Folger (1877) strongly advocated it. The atmospheric air containing water vapour, percolates into the pores in soils, and the underlying rock formations where it comes in contact with the cooler surface of rock particles, and communicates them, a portion of its own moisture. Thus the condensation of vapour contained in the air takes place on the surfaces of rock particles, similar to the dew that precipitates in the morning at the cooled off surfaces of the ground (Klimentov, p. 121).

(iii) **Process of Sedimentation:** This emerged in ancient times owing to the attempts to establish the direct relationships between the oceanic water, sea water and the underground water. The lithification hypothesis could not explain the origin of high salinity waters and brines found in deep sedimentary strata. The sea water either was concurrently formed during the sedimentation (syngenetic water) or has percolated into the older sediments from marine basins (epigenetic water) or has been strongly metamorphosed during the diagenesis of sediments in natural environments (Klimentov, p. 122).