Weekly Science
International Research Journal

ISSN: 2321-7871 Impact Factor : 2.4210(UIF) [Yr.2014] Volume - 3 | Issue - 40 | (14 April 2016)

SPECIAL PROPERTIES OF WATER AND SEA WATER

Medikonda Anil Kumar[1], Daniel Reddy Thota[2], Rajasekhar Medidi[3] and Mulugeta Genanu

[1]Dept. of Meteorology & Hydrology, College of Natural Sciences, Araba Minch University, Ethiopia.

[2]Department of Water Resources Engineering, ArbaMinch Institute of water Technology, AMU.

[3]Department of Chemistry, College of Natural Sciences , Arba Minch University, Ethiopia.

ABSTRACT:

An attempt has been made to highlight the properties which are useful in day to day life of living things as water is considered as the matrix of life which governs all the living processes. The quantification or parameterizations of physical properties of water (which will be modified in sea water) are highlighted though exhaustive treatment is not possible in this review article. Applications of the water properties such as uses in medicine, remote sensing, currents, waves, light and sound propagation in seas, dynamics, and ionic interactions are briefly discussed.

KEY WORDS: water; physical quantification; Osmosis; medicine; solubility; remote sensing;

INTRODUCTION:

To understand and work towards any branch of oceanography and Marine sciences one needs to study fundamental multi properties of water and sea water with differentiation. The properties of water determine those of sea water. The study of Geo-Physical Fluid dynamics is not possible without the understanding of general properties and special properties of seawater which augments theory of fluid dynamics. The studies of water properties are dated back to origin of the water molecules on our planet Earth, but this is an humble attempt to highlight the usefulness of the water properties to understand the basics useful in our daily life in the light of the new developments and outlook. How "every drop of the water will intensively involved in every process (Micro scale to macro scale) of the Earth systems related to all fields '' is the main theme of this article. Water is involving in most of the new scientific investigations which leads to the development of every life in the Earth and universal system. Commonly unknown things about the water is mentioned which is a remarkable thing in this article.

2.1. Properties and attributes of the water: The broad general properties of water are given below taking in to consideration of fundamental entities as a preliminary introduction.1). Water is a highly mobile liquid; 2). Water is a good solvent; 3).Water is a poor conductor of the heat; 4). Water has a high specific heat; 5). Water has high latent heat of the fusion and evaporation; 6). Pure water freezes at 0^0c; 7). Pure water boils at 100^0c; 8).The maximum density of fresh water is at 4^0C; For sea water, it is at its freezing point [-1.9^0C], 9). Ice is less dense than water; 10). Light can only travel a maximum of the a few hundred Meters through water; 11).sound can travel thousand kilometers through water; 12). Water is essential to life.

2.2. Physical quantification of water properties:

1). Specific heat = [(4.18×10^3 J $kg^{-1}c^{-1}$)]; Highest of all solids and liquids except liquid NH3.
2). Latent Heat of the Fusion = [(3.33×10^5 J kg^{-1}]; Highest except NH_3; 3). Latent heat of the evaporation = 2.25×10^6 J kg -1 highest of all substances; 4). Thermal expansion: Temperature of the maximum density decreases with increasing salinity. For Pure Water it is at 4^oC; 5). Surface Tension = [7.2×10^{-2} N m^{-1}] = 72Mn/m at 250C; Highest of all Liquids; 6). Dissolving power: In General dissolves more substances in greater quantities than any other liquid; 7). Dielectric

constant: [(= 87 at 0°C; =80 at 20°C ;)]; Pure water has the highest of all liquids except H_2O_2 and HCN. Relative dielectric constant for both fresh water and sea water is same. Typical Values are: € (distilled water) = 80 = € (sea water); € (fresh water) = 80.81; € (sea water) = 80; € (fresh water ice) = 3 - 4.4; € (sea water ice) = 4-8; 8). Electrolytic dissociation: very small; 9). Transparency: relatively great; 10). Conduction of heat: Highest of all liquids; 11). Molecular viscosity =10-3 Nsm^{-2}. Less than most other liquids at comparable temperature; 12). Thermal conductivity = 1.91 kcal/mh^0C (at 0^0c) = 0.5 kcal/mh^0C at 10^0C for pure water; Specific Heat capacity: Cp = Specific heat capacity = 3985 Jkg-1k^{-1}; Cp (Fresh water) > Cp (sea water) at same temp. Cp is a function of Temperature and Salinity; Cp decreases with increase in temperature.

2.3. Special properties of water:

1).The isotopic varieties of water: A mixture of 18 different varieties of isotopic compounds; 2).

‘Protium water ‘or ordinary water is vital for the life processes. Abundance depends up on source from where it is taken; 3).Ordinary tap water contains 150gms of heavy water per tonne as compared to 165 gm of heavy water per tonne in the Pacific Ocean (sea water). D => ^{2}H => Deuterium, T => ^{3}H => Tritium, Heavy Water => D_2O, Super Heavy Water => T_2O , Isotopes of Oxygen => ^{16}O,^{17}O, &^{18}O; 4). Water forms the essential matrix of the life processes; 5). Water is a dipole system and is a polar liquid. Net Polarity in the water molecule = μ=1.84 Debye. It has astonishing properties & most of the properties are ascribed to extensive hydrogen bonding. A polar covalent bond is present in water. 6).Formation of clusters of water molecules, which last for less than a trillionth of a second (10^{-11} Second), determines the bulk properties of water. In liquid water, the nearest pair of the Oxygen atoms are separated by 2.8 °A. In low density ice it is 4.5^{0}A while in the denser forms it is 3.4^{0}A. Molecular clusters possible types => dimer, trimer, Tetramer, pentamer, hexamer, double pyramid cage, book, prism etc; 7). The strength of the weaker hydrogen bonds varies from 3 - 10 kcal /molecule, where as the covalent bond energy is in the range of the 70 - 110 k cal / molecule. The hydrogen bonds give a slightly ordered configuration to water which behaves like a quasi crystalline compound. The hydrogen bonds exist in ice, liquid water as well as in the vapor phase (persist even up to 350^{0}C in steam). 8).Water molecules exhibit properties of cohesions and adhesion which are collectively responsible for capillarity - the tendency of a fluid to ascend in a tube against gravity. Water can ascend in trees at a rate of 100 meters/ hour; 9). Aquatic life forms can survive in a lake even if the temperature is below freezing point. Anomalous expansion of water 4ºC is due to the hydrogen bonding & this unique tendency near the freezing point is very crucial for the survival of the aquatic life; 10). Electrical polarity of the water molecule and the resultant hydrogen bonds are the reason behind the surface tension and the relatively high viscosity of water. The strong cohesive force among water molecules causes the surface to behave like a stretched string and causes surface tension effects like floating of an Iron or steel needle on the surface. Surface tension of water is (71.97) milli- newton/meter. Adding soap or detergent to water decreases the surface tension. 11). Specific heat of the H_2O => 1 cal /gm C => highest of all the liquids; 12).Water molecules are electrical dipoles. Water is an excellent solvent (universal solvent) because of 13). The Dielectric constant of any solvent is its capacity to weaken the force of attraction between two electric charges immersed in that solvent. Dielectric constant is a measure of the ability to keep oppositely charged ions in solution apart from one another. Dielectric constant of water =80.37;

14) Density of liquid water at 0^{0}c =0.9998 gm/cm^3’ Density of (Ice) at 0^{0}c = 0.9168 gm/cm^3. In normal (Hexagonal) ice: 0-0-0 bond angle =105° ;15). Surface emissivity of seas depends up on temperature and salinity. Emissivity determines the radiated thermal energy and useful in remote sensing applications particularly with satellites for retrieval of sea surface temperature (SST).

2.4. Typical emissivity values:

Thermal infrared emissivity = 0.975; Thermal emissivity of Sea water = 0.986 Emissivity of fresh water = 0.99; Sea foam emissivity = 0.967, 0.990, 0.987 (depends up on sea state) and typical values are given). In normal regular tetragonal angle =109.50 ^{0}. Pure ice is an insulator with immeasurably small Electrical Conductivity. Ice is a mineral and possesses a definite crystalline structure and has fascinating fractal geometry. At least 10 different types of the ice crystals are found in Nature. Under ordinary conditions of atmospheric pressure, ice crystals acquire a hexagonal shape. At low pressures, water vapor may condense in to a cubic form. Many of the high pressure forms of the ice are similar to the structures formed by silica. The high pressure polymers VI and the VII can exist even at 80oc and have higher densities. Ice VII can exist at pressures of over 21,700 atmospheres is called ‘red hot ice' & it melts at 192ºC when the pressure is 32,000 atmospheres. The structure of water in living beings is similar to ice. Up to (-60^{0}c) ice behaves like a quasi-liquid and has more vibration freedom of its molecules at the surface than those of other solids. At extremely low temperatures, the ice surface becomes sticky. Every pure substance except helium has a triple point. The triple point of water occurs at a temperature of 0.01^{0}c and a pressure of 4.58torr (mm of mercury). 1 gm of water contains (3.76×10^{22} molecules). PH (Hydrogen Ion Concentration) of water at 25ºc =7.0 Pure water, blood, tears etc...has PH=7.0). Sea water pH is around 8.0. The normal pH of human blood is (7.4 ± 0.05). If the pH decreases below 7.35, a condition called 'acidosis' occurs & if pH is increased above (7.45) it leads to 'alkalosis'. Both these conditions are fatal to life. 'Acidosis' causes retardation in the oxygen-carrying capacity of hemoglobin & depresses the central nervous system. Leading in extreme cases to coma and death. In addition, it may mimic heart failure, which results from weakening and irregularities in Cardiac function. Blood pH is maintained by carbonate and carbonic acid buffer. (Swelling => Oedema). To combat Energy situation, in loss of blood due to burns which leads to acidosis, (0.9%) sodium chloride and (5% Glucose) is given intravenously to maintain blood plasma sugar and the electrolyte level. Viscosity first decreases with increase in pressure & then after some extent it starts increasing.

3.1.).Osmosis: - is a vital process of life. The formation of the proteinaceous membrane and the genetic materials (DNA& RNA) is considered to be the precursor of life on the Earth. The very first cell came into being when Nucleic Acid and Protein were enclosed in a membrane and a system was formed. This was not an isolated system. It had interaction with its surroundings. This system later on evolved to develop the capacity to exploit the outside resources for its growth and development. Maintaining a proper environment and temperature inside the cell for carrying out the vital life processes is a pre-requisite for life. The chemical homeostasis is regulated through membranes by controlling the exchange of ions and molecules from across the membrane.

3.2.Three quotations are relevant in this context as following:

1). What drives the life is a little electric current kept up by sunshine -- Albert von Szent Gyorgyi ,1960.)
2). Life is a relationship among molecules and not the property of one molecule – Linus Pauling, 1960. There is no greater object of wonder, no greater thing of beauty than the dynamic order, and the organized complexity of life.---- Ariel G. Loewi and Philip Siekevitz, 1969.

3.33. ii).Osmosis and life processes: Blood and other fluids inside living cells contain many different solutes, and the osmotic pressures of those solutions play an important role in the distributions of solutes within the body. One can not simply pass pure water in a patient's of dehydration, intravenously, because that flow would make the patient's red blood cells swell and burst. To prevent this hazard, a solution of isotonic concentration is given with drip, (water and nutrients) normally 0.9 % aqueous sodium chloride solutions. If an intravenous solution, more concentrated than the solution inside a blood cell, were added to blood, the cell would lose water and shrivel up. Osmosis and living cells are classified and related by (a) Hypertonic medium (water goes away and shrinks from cells) eg. Salt Sprayed on leafy vegetables (b) isotonic medium (Equal inflow and outflow of water from the cells) and (c) Hypotonic medium (water flows inside into the cells and swells, as in pulses and the raisins etc…..). Isotonic => Osmotic pressures equal across semi permeable membrane). Our cells has protoplasm, which is the matrix of life and is made up of (65% to 70%) of water. Of all compounds of life, none is omnipresent as water. Most of the bio-molecules and ingredients of life are easily dissolved and transported by water. Hydrogen bonds play a significant role in thermal Homeostasis (losing of heat of vaporization from sweat glands thus cooling or dropping of temperature) because to break these bonds at the surface of the liquid, water needs energy and causes a significant dip in the temperature. Water vapor is also a green house gas (next to CO_2 and methane) and is also responsible for global warming (thus sea level is rising at a rate of >1.5mm per year.) Productivity is more in upper layers of sea surface (up to 10m due to heating owing to longer wave length visible solar radiation and up to 140 m due to heating owing to shorter wave length of solar radiation is absorbed. Thermal solar radiations are absorbed in about a few centimeters depth. 60% of visible wave lengths are absorbed in abut 1metre. Hence the primary productivity and secondary productivity depends on solar radiation and consequent heating and trapping of heat emitted from the Earth's surface in the atmosphere above. Age of our universe => 15 billion years (originated from the quark soup). Age of the earth => 4.6 billion years; age of water => Most of the composition of the our universe => includes hydrogen and helium. Electrons, neutrons and positrons, sub-atomic particles and ultimately quarks. (Theory of the evolution of the life was studied extensively by J.B.S Haldane). On the primeval Earth there were no microbes and a hot smelly Ocean of primordial chemical soup (containing ammonia, CO_2, formal dehyde, methane, H_2S, organic carbon) remained unaffected for a long time. In the primitive environment peptides served as self replicating bio-molecules because they had the ability to reproduce and make more and more copies of themselves. This auto-catalyzing capacity has been the hall mark of early life as has been emphasized recently. Researchers have noted the tendency in some proteins to reproduce and make several hundred copies by auto catalysis in vitro. 1). Turbulence, 2). Molecular viscosity, 3). Kinematic Viscosity, 4). Diffusion & turbulent diffusion, 5).Thermal conductivity, 6).Richardson Number, 7). Eddy coefficients etc. are other physical parameters that Characterize physical processes in the Oceans and the Atmosphere in particular.

3.34.Uses of water in our daily tasks: 1). Soaps are the sodium salts of the fatty acids. They reduce the surface tension of water. So water can reach deep into the fabric of clothes and dissolve the dirt. In hard water, the salts react with soap and thus interfere in soap action. 2). The mechanism of detergent action is different from that of soap action. A detergent molecule has two ends – a hydrophilic end and the hydrophobic end. Dirt and greasy materials are stuck to fabrics. The hydrophilic end gets attached to water & the hydrophobic end is stuck to dirt. During washing, the detergent's molecules pull away the oily and greasy stuff in water. Manual or Mechanical stirring then results in the formulation of emulsion in the water. 3). Water is the most marvelous gift of Nature that nourishes humans in every walk of life. One litre of water would contain (1000/18 = 55.56) molecules. Pure water is thus (55.56) molar in concentration. Since the probability of hydrogen ion in

$H_2{}^{1}(18)$ (18)	$D_2{}^{16}O$ (20)	$T_2{}^{16}O$ (22)	$HD^{16}O$ (19)	$HT^{16}O$ (20)	$DT^{16}O$ (21)
$H_2{}^{17}O$ (19)	$D_2{}^{17}O$ (21)	$T_2{}^{17}O$ (23)	$HD^{17}O$ (20)	$HT^{17}O$ (21)	$DT^{17}O$ (22)
$H_2{}^{18}O$ (20)	$D_2{}^{18}O$ (22)	$T_2{}^{18}O$ (24)	$HD^{18}O$ (21)	$HT^{18}O$ (22)	$DT^{18}O$ (23)

Table1: The isotopic varieties of water.

pure water is (1.8×10^{-9}), the molar of hydrogen ion is (Probability ×Molar concentration). i.e ($1.8\times10^{-9}\times55.56=1.0\times10^{-7}$molar). Similarly the molar concentration of hydroxyl ions would be 1.0×10^{-7} molar. The tendency of water to dissociate is expressed by the dissociation constant, k, as:

$$(K = (H^+)\,(OH^-) / (H_20) = (10^{-7})\,(10^{-7})/55.56 = 0.018\times10^{-16}=1.8\times10^{-14}\text{ Molar.})$$

Similarly one gram of water contains (3.76×10^{22}) molecules. For every (H^+) or Hydroxyl (OH^-) ion in water there are (1.8) billion or ($1.8\times10^{+9}$) water molecules. (PH of water = $-\log_{10} H^+ = -\log(1.0\times10^{-7})$ at 25°C=7.0) [Molecular viscosity of water =10^{-3} Nsm^{-2}, (Less than most other liquids at Comparable Temp)].

3.3.5. Hydrates:- If any compound is heated water vaporizes and the crystalline compound remains along with a certain residual quantity of water. These water molecules are held together in the crystal lattice and are the water of crystallization. Salts containing such water are called 'hydrates'. Some hydrated salts remove water from moist air to form higher hydrates.

Examples: $MgSO_4.7H_2O$; Ba(OH) $2.H_2O$; $CaCl_2.2H_2O$; $CuSO_4.5H_2O$; $FeSO_4.7H_2O$; $FeSO_4$ $(NH_4)_2$ $SO_4.12H_2O$ (Mohr's Salt); K Al (SO_4) 2 .12 H_20; $Na_2SO_4.10H_2O$ (Glauber's salt), Na_2 $B_4O_7.10H_2O$ (Borax), sodium tetra borate deca - hydrate. Gas hydrates form under water in seas. (Illustrate with examples.). Gas hydrates (also known as clathrates, methane hydrates) are the naturally occurring solids composed of water molecules forming rigid lattice cages, each containing a molecule of natural gas, mostly methane. Gas hydrates exploration in the seas has potential for meeting future energy needs. The dissolution of the any solute in water produces either homogeneous mixtures (solution) or heterogeneous mixtures (colloids and suspensions). Colloidal particles causes scattering of visible light in all directions, the phenomenon being called "tyndall effect". The colloidal particles constitute the dispersed phase. The continuous matter in which the colloidal particles are scattered is called the dispersion medium. Solutions that adopt

semi-solid foam are called 'gels'. Solubility: The solubility of the gases generally decreases with increasing temperature and salinity, and increases with increasing Pressure. Hence dissolved oxygen content (DO) is high in the bottom of the ocean. The distribution of gases at deeper levels in the oceans is achieved mainly by the currents and the by turbulent rather than molecular diffusion. Biological activity plays an important role in the redistribution of oxygen and carbon-dioxide below the surface and largely determines the form of their concentration profiles. It takes a long time for the effects of changes in the processes that control gas exchanges at the air-sea interface to be transmitted through out the oceans. [From this special solubility quality one can say that water has hidden in it self the key to many micro level chemical processes].

4.1. Color of the Oceans:

The coastal waters are greenish or bluish green due to the presence of chlorophyll and gelbstuff (or yellow matter) due to the presence of phytoplankton and other pigments. The open oceans are more clear and the appear blue due to scattering of sunlight by the sea water. The light intensity decreases exponentially with distance from the source. The exponential decrease of the light intensity is called attenuation and the due to absorption and scattering. The absorbers in the sea water are (a) algae (phytoplankton) using light as the energy source for photosynthesis and (2) Inorganic and organic particulate matter in the suspension (other than algae), (c) dissolved organic compounds and the (d) water itself. a) and (b) are collectively called seston. The greater the amount of the suspended matter (i.e more turbid waters), the greater the degree of the absorption and scattering. Coastal waters tend to be particularly turbid due to suspended load brought in by rivers and also supply of nutrients. Waters are clear in the central oceanic regions especially where concentrations of nutrients are low and where there is little biological production. In the surface waters upto about 200 meters where light penetrates is known as photic (or euphotic) zone and is where more biological production occurs. Between photic and ocean floor is the aphotic zone where plants cannot survive. The region below depth of 1000 meters and the photic zone is called the disphotic (or dysphotic) zone, where day light is absent. Instruments used for under water light measurements are 1) Beam transmissometrs, (2) Irradiance meters and the (3) turbidity meters or nephelometers. Water appears as blue because absorption at the short wave length (blue) end of the spectrum is relatively low While at the long wave length (red) end it is high. Absorption is so strong in the red that a 1m thick layer of the pure water will absorb about (35 %) of the incident light of wavelength (680nm). The red color occurring sporadically in some coastal areas, the so called ‘red-tide’ is caused by the blooms of species of phytoplankton of reddish – brown color. (HAB => harmful algal blooms).

4.2. Sound waves in the Ocean:

$$V=f\ (P, S, T).$$

The Wave Lengths of acoustic energy that is of interest in the Ocean range from the about 50 meters to 1mm. The velocity of sound in sea water is (35 o/$_{oo}$, to 15°C) approx. 1500 meters/s. The frequency ranges that propagate in sea water is 30Hz to 1.5 M Hz. Acoustic Impudence of Sea Water is $Z = \rho c = 1.55\times10^{6}$ Kgm^{-2} /s. Acoustic velocity in fresh water at15deg.C =1481 m/sec. The acoustic energy emitted in sea water decreases in intensity due to (1) Spreading loss and (2) Attenuation due to absorption and scattering. Scattering is independent of frequency where as absorption is not. At high frequencies viscous absorption predominates, and in fresh water this is dominant cause over much of frequency range. However, in sea water at intermediate and low frequency, the principle mechanism is dissociation of the $MgSO_4$ ion pair and of the $B\ (OH)_3$ complex and the process of absorption of acoustic energy from the passage of sound waves is known as “relaxation”. At very low frequencies absorption by in homogeneities in the water column predominates.

4.3. Currents, waves and Oscillations:-

The currents in the Ocean are mainly 1) Geostrophic currents, (2) Thermo-haline currents and (3) wind driven currents. The currents transport water over wide regions of the Oceans and constitute circulation. The Ocean circulation pattern is due to movement of water masses. Well defined seasonally varying current systems and water masses are seen in our Earth system. The other important factor is wave phenomenon in the sea water is dependent on the generating mechanisms. The waves associated are 1) wind generated waves, 2) gravity waves, 3) shelf waves, 4) internal waves, 5) planetary waves (viz. Rossby waves), 6) Kelvin waves, 6) Poincare waves, 7) Alfven

waves, (7) Magneto−Hydrodynamic waves, (8)Tidal waves, (9) Tsunami waves, (10) Coastal trapped waves, (11) Seismic waves etc. The interaction between currents & waves lead to mixing processes in the water over wide scales. All the above phenomenon's are studied quantitatively by utilizing the mandatory physical and other properties of sea water.

4.4. Remote Sensing: Since Electromagnetic waves are highly attenuated in the seas where as sound waves are propagated over long distances, under water communications are made with acoustic waves. Only surface and the near surface phenomenon are studied using Electromagnetic Remote Sensing Techniques. Acoustical remote sensing techniques are used in the seas and oceans to obtain currents (using latest types of acoustic Doppler current profilers i.e. ADCP) and mapping bottom structures (i.e sea floor mapping) and also in Ocean acoustic Tomography System (OATS) for large scale spatial monitoring of the Oceans. Remote sensing satellites are increasingly used at present to study phenomenon on synoptic scales.

4.5. Variability: Daily (day and night) or diurnal variations in temperatures in the oceans can be observed and these variations are attributed to solar heating during the day and radiant cooling at night. The annual range of temperature variations decreases from poles towards the Equator. Salinity variations are less than those of temperature. Near land, decreases occur due to local precipitation and to river run off associated with Monsoons. Increases of salinity are due to evaporation. Seasonal variations of both temperature and salinity can be shown with T-S-t diagrams. (T=temp, S=salinity, t=time). T, S indices determine most of the phenomenon including water mass structures, sound velocity in sea water which is a vital parameter for the oceans too.

4.6. Types of ionic interactions in sea water:

Most of the dissolved constituents in sea water are in ionic form. The ions are kept apart because water has high dielectric constant, and each ion is surrounded by a sheath of water molecules called a 'hydration sphere', which has a diffuse outer boundary. The size of the hydration sphere depends on the radius and charge of the ion, which determine the charge per unit area, or charge density.

1. Anions: - Typically have lower charge densities than the cations, because they are generally larger than the parent atom or molecule, having gained one or more electrons. Cations: - are generally smaller than the parent atom, because they have lost one or more electrons, and so cations have larger hydration spheres relative to their size than anions. The greater the charge on an ion of given radius, the larger its hydration share relative to the size of the ion.

Ion	Radius	Hydration sphere relative to its size
Mg^{+2}	r = 66pm (pm = picometer =10^{-12} m)	larges
Na^{+}	r = 97pm	medium
Cl^{-}	r = 181pm	smallest

The form or 'chemical speciation' of the dissolved constituents in sea water is very important in determining how they interact, and this is turn determines how long they remain in solution.

4.7. Interactions between the dissolved species of ions:

Sea water is indeed a biogeochemical solution. Cations and anions in solution experience electro-static attraction and/or repulsion depending on their ionic charges. Such interactions are inversely proportional to the square of the distance separating the ions, and will be vanishingly small in very dilute solutions, where the ions are widely separated. In solutions as saline as sea water, however, interactions between dissolved ions cannot be ignored. It is these interactions which determine the speciation of dissolved constituents, and their overall effect is to decrease the availability of ions for chemical reactions, whether inorganic or biological. Three main types of interaction between ions in solution are (1) non-specific ion-ion interaction, (2) ion-pair formation and (3) complex-ion formation. There is a considerable degree of ion-pairing between several of the eight most abundant dissolved ions in sea water: Mg^{2+} ,Ca^{2+} , Cl^- , $H\ O_3^-$,CO_3^{2-} and SO_4^{2-} , which between them make up over (99%) of the total.

4.8. TDS (Total Dissolved Salts):

1) For Rain Water, TDS = 7.1mg / litre, 2) For River Water, TDS = 118.2 mg/ litre,
3) For Sea Water, TDS = 34.4.gm/ litre. The averages of the principle TDS of rain water and river water conceal considerable variations, but the basic pattern is the same all over the world. Rain water is about 5,000 times more dilute than sea water (i.e. = $34.4/(7.1\times10^{-3})$) and river water is about 300 times more dilute than sea water (i.e. = $34.4/(118.2\times10^{-3})$). Dissolved salts in rain water is of marine origin due to bubbles breaking at sea surface & aerosols. Composition of rain water and sea water is similar & striking as the former originated from later.

4.9. Quantification of viscosity: The viscosity plays an important role in the dynamics of ocean processes and main parameters involved are described in brief as below:

$$\text{Friction stress: } t = \mu \times \partial u/\partial z \quad \rho \times \upsilon \times \partial u/\partial z$$

Fluid flows obeying above Newton's law are called "Newtonian". Otherwise if they don't obey the law, the flows are called 'non-Newtonian'.

μ coefficient of (molecular) dynamic viscosity,
$10^{-3}\,kgm^{-1}\,s^{-1}$ for sea water at 20°c
$\upsilon \quad \mu / \rho$ co-efficient of (molecular) kinematic viscosity.
$10^{-6}\,m^2s^{-1}$ for sea water at 20^0c

Values vary from about 0.8 to 1.8 times these values in the ocean. These values are for smooth laminar flows with Reynolds number,

$$Re \quad UL/\upsilon < 1000$$

In the ocean, where the motion is generally turbulent, the effective values of kinematic viscosity is given by: Eddy viscosity A_x or A_Y $10^{5}\,m^2s^{-1}$ for horizontal shear (eg. $\partial u/\partial y$, $\partial v/\partial x$).

{ A_z (upto 10^{-1} m s for vertical shear (eg. $\partial u/\partial z$). }

The eddy friction stress Tou $\rho \times A_z \times (\partial u/\partial z)$; *Wind stress magnitude* T_n $\rho_a \times Cd \times W^2$

where ρ_a The density of the air, Cd 1.4×10^{-3} (Non-dimensional) & W wind speed in ms^{-1}. Az=0.014m^2s^{-1} for W 10 ms^{-1} &Az 0.055 m^2s^{-1} for W 20 ms^{-1} (Typical values). With increase in temp. Viscosity decreases; viscosity of fresh water (at 40°c = 1.54 Centi poise) < viscosity of sea water (at 40°c = 1.810 centipoise); All the foregoing properties of water and sea water are briefly described and the references cited below describes to some more extent. But an exhaustive treatment is not possible here and one has to refer to other scientific literature.

4.10. CONCLUSIONS:-

Water is a part of the global earth system and found in rivers, streams, oceans, on land, underground and in atmosphere in different forms of phases of matter. Water is essential for the existence of all living flora and fauna and is a must for existence of life on any planet. Water exists on earth because of its correct placement, distances wise and temperature wise, in our solar system. As water is considered and is a matrix of life, we should use water judiciously and preciously for the betterment of all humans. All water resources should be conserved and the useful property that nourishes human life should be advantageously utilized to full extent.

5.1. ACKNOWLEDGEMENTS:-

DR.M.ANIL KUMAR completed PH.D work under the CSIR-NET-SRF-Fellowship award I Council of Scientific and industrial Research (CSIR), INDIA. Special tanks are due to Dr. K.K. Mishra author of the book mentioned at reference at no. 3 below for taking material from the popular article for the benefit of many readers.

5.2. REFERENCES:

1).“Descriptive Physical Oceanography, An introduction”, George L. Pickard, William J. Emery, 5th edn.1990; Butterworth Heinmann, Oxford, UK, pp.320.
2).“Sea water, Its composition, properties and behavior”, open university, 2ndEdn., 2002, Butterworth Heinemann, UK, pp.168.
3).“ Water the matrix of life”, K.K.Mishra; National Book Trust, New Delhi, India, 2000, pp.111.
4).“Assessment of water quality and the related instrumental techniques”, .J.Krishnama charyulu, Ch. Kesava Rao & M. Dileep Kumar; Special issue on water, MAEER’s MIT Pune Journal, Vol. III, Nos.9 &10, Feb.- July, 1994, 127-134, (pp.151).