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HYDROSPHERE

Total area of the sea floor – 360 million square kilometer (70.78%)
Total land surface area – 150 million square kilometer (29.22%)
Hydrosphere consists of :

Parts of Hydrosphere	% of Hydrosphere
Ocean	97.6
Ice & Snow	2.07
Groundwater down to 1 km.	0.28 – 0·3
Lakes & Reservoirs	0.009
Soil moisture	0.005
Biological moisture in plants & animals	0.005
Atmosphere	0.001
Rivers & Streams	0.0001

Lithosphere

OCEANS

The Oceans cover more than 70% of the earth's surface and play an important role in our global environment. Water has a high heat capacity, meaning that a gram of water can store more energy than a gram of many other compounds. Oceans reduce the extremes in temperature that would otherwise be experienced on the earth. Ocean currents can absorb heat from the atmosphere, thus delaying its warming; warm currents can give up heat to the atmosphere, thus delaying its cooling. The heat storage capacity of oceans leads to a difference between coastal and continental climates.

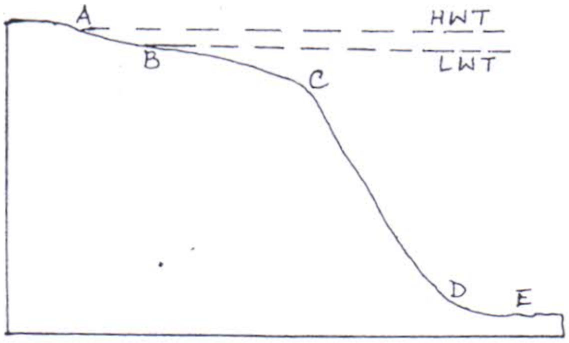
Oceans affect the global cycling of chemical elements. They are a major storehouse of carbon and exchange carbon dioxide rapidly with the atmosphere, and they can play a major role in the rate of global warming.

Oceans are the habitats of numerous organisms, many of which are directly inter related through different food chains. Marine food chains have their effects on the food chains of the coastal people.

Structure

Like the continents, the ocean floor also exhibits an uneven topography with conspicuous elevations and depressions. These elevations may occasionally form submarine mountains and ridges while some of the remarkable depressions have been found to reach a depth of over 10km. below the sea level, particularly below the oceanic trenches.

In the vicinity of the continents, the depth of oceans and seas is seldom appreciable. Away from the shore, however, the ocean floor gradually slopes downwards. The deepest parts of the oceans and seas are, as a rule, to be found to lie at a considerable distance off from the continents. The stretch of the ocean floor, from the coast to the deep sea basin is, therefore, characterised by a typical profile of its own, which can be broadly subdivided into four well defined zones. Along coastal tracts, there always exists a strip of land, which is submerged under water during high tides and is left dry during the intervening low tides. This strip of land exhibiting a very gentle seaward slope is described as the ***Shore Zone*** (***Littoral*** or ***Inter-tidal zone***) and constitutes a distinct border separating the land masses from the water bodies. Depending on the prevalent slope of the country the width of the shore zone may vary within certain limits. Beyond the shore zone, a stretch of shallow water covers the shelves of the continents. This zone of comparatively shallow marine water, with the ocean floor gradually sloping seaward, is known as the *Continental Shelf Zone*. The shelf zone ranges in width from about 15km. to more than a hundred kilometer from the low tide shore line and the average gradient of the ocean floor, within this zone, is found to be less than 1 in 500. The maximum depth of water upon the continental shelves is practically always less than about 200m. Continental shelves, which make up only 10% of the oceans, provides more than 90% of the fish harvest.



HWT - level of water during high tide
LWT - level of water during low tide
AB - Shore zone (littoral zone)
BC - Continental shelf
CD - Continental slope
E - Deep sea zone (abyssal zone)

The steep slope of the ocean floor, lying beyond the fringes of the shelves and linking them with the deep sea basins is defined as the ***Continental Slope Zone.*** The minimum depth of water, in this zone, is never less than 100 to 120m. The deep sea basins, with their uneven floors lying at an average depth of 3000 to 5000m constitute the ***Deep Sea Zone (Abyssal zone).***

Composition of Sea water

Most elements present in the oceans exist as dissolved ions, such as chlorides, sulphates or hydroxides. Chlorine readily forms water soluble compounds with most of the metallic and alkali elements. More than three-fourths of the total amount of this element present in the earth's outer crust together with the atmosphere and hydrosphere, is present in the oceans. *Sodium and Chlorine are the two most abundant and uniformly present elements constituting more than 90% by weight of the total dissolved ions in sea water*. Such a great abundance of Chlorine in the ocean as dissolved ions cannot be explained by the weathering processes alone, decomposing the minerals of the outer crust. On the other hand, a ready source of Na is available in the crust in the composition of Feldspar minerals, which are the most abundant of the rock forming minerals. Other major constituents of the oceanic water are Mg, S, Ca, K which occur quite abundantly in the minerals of the earth's crust. Carbon in sea water may be present as CO_2 , HCO_3 , CO_3 or as H_2CO_3 . The elements Br, Sr, B and F are also listed as major constituents, though they occur in very small quantities as compared to earlier mentioned elements. The abundance of Br in rather large amounts in oceans compared to its presence in the earth's crust (2.5ppm.) is perhaps due to submarine volcanism. F, Sr, and B occur in very small amounts as dissolved ions in sea water as compared to their abundance in the earth's crust. While Boron is partly lost as gas, the other two elements are detectable in appreciable amounts in the compositions of shells of marine organisms.

The abundance of other elements is very low in sea water as compared to their abundance in the earth's crust. Certain elements like Si, P, S, Ca which are brought to the oceans in large quantities are utilised by marine organisms in their own life cycles. Similarly a large proportion of Fe and Mn along with Cu, Zn, Ni get precipitated mostly organically, in the deep sea metallc nodules and sedimentary sulphide deposits and iron formations.

Major dissolved constituents of Sea water

Element	gm./litre
Cl	19.4
Na	10.8
Mg	1.29
S	0.9
Ca	0.41
K	0.38
Br	0.067
C	0.025
F	0.013
Sr	0.008
B	0.005
	33.298

Salinity & Chlorinity

Irrespective of the constituents at any level of the ocean depths, the composition of sea water is expressed in terms of two parameters, the ***Salinity*** and the ***Chlorinity.*** Chlorinity is a factor, which denotes the stability of the ratio of abundance of chlorides to that of the conservative or major elements. This ratio is considered to be constant for all practical purposes and it is found that there is a constant relationship between chlorinity and salinity. The salinity of sea water is determined by the total amount of dissolved components and the chlorinity is determined by actually titrating the sea water sample for total chlorides present (using $AgNO_3$ for titration in a litre volume). It is found that the chlorinity of sea water is generally 19‰(parts per thousand or ppt.), while the salinity varies between 34 and 36‰ in a particular zone. Average salinity of ocean water is considered to be 34.7ppt. Since with higher salinity the density of sea water increases, the deeper zone water is more saline as it is denser as well as colder.

Chlorinity is related to the total salt content or salinity (S‰) by an empirical relationship -

S (‰) or Salinity = 1.80655 Cl (‰) or Chlorinity.

An alternative method of determining salinity is to measure the electrical conductivity (or specific resistance) of water. Conductivity, which is measured in Ohms, is the reciprocal of electrical resistivity. Greater the number of dissolved ions in water, greater would be its electrical conductivity (less resistive). Salinity of water, is therefore, directly proportional to its electrical conductivity.

Marine Organisms

The marine organisms that contribute most conspicuously to the sediments of the littoral (shore zone) and shallow water zones belong to a group known collectively as the *Benthos or Benthonic* (bottom dwellers). This includes sea weeds, molluscs, sea urchins and corals, and other forms that live on the sea floor. The organic oozes and red clay of the abyssal (deep sea) zone are distinguished as *Pelagic* deposits (Greek, pelagos, the open sea). The oozes are largely composed of the remains of marine organisms belonging to a group called the ***Plankton*** (the wanderers). Fishes, whales, and other marine animals, which go actively after their food supply are grouped as *Nekton* (swimmers).

Photic zone

By a depth of 1 meter of ocean water, much of the red portion of visible sunlight is absorbed. At 100 meters depth, only dim traces of diffuse, bluish light remain. Beyond, there is profound darkness. The top 100 meters, more or less, is the sunlit portion of the sea and is known as ***photic zone***.

Thermal layers

The ocean waters are thermally layered in low and middle latitudes of the earth. The ***surface layer***, about 500m thick, is warmed by solar radiation and is fairly uniform in temperature because of mixing within the layer, though all the solar heat is absorbed within 10cm of the ocean surface. Below the surface layer lies a thicker layer (upto about 1500m) called the *thermocline*, through which temperature decrease sharply with depth. The ***bottom layer*** includes all water more than 1500m deep and is cold, with temperatures of 5°C down to 1°C near the ocean bottom. In high latitudes (Arctic and Antarctic), the waters are uniformly cold all the way from the surface down to the bottom, which may be as low as –1°C.

Halocline - 33 - 35
Pycnocline - 1 - 1.05

UNDERGROUND WATER

A part of the water, reaching the earth's surface, percolates through the soils and rocks to form what is known as ***Sub-surface water or Underground water.*** This percolation is possible since the rocks, forming the earth's surface, do always have some openings present in them. These openings may occur either in the form of pore spaces or as cracks and fissures within the rocks, along which water can conveniently sink downwards. Underground or subsurface water is present universally and constantly moistens the rocks within its range. As a result, some of the constituents of the rocks are removed in solution. The affected rocks are, therefore, rendered weak and yield readily to the forces associated with the other natural agencies operating upon the surface.

Underground water travels through and accumulates within the openings present in the country rocks. At very great depths, however, the enormous pressure of the overlying rocks effectively reduces the number and extent of these openings, thereby fixing a lower limit below which subsurface water cannot occur. It may be safely assumed, therefore, that the extent of occurrence of underground water is restricted within a comparatively shallow zone of the earth's crust. The principal factors, which control the distribution of underground water, within the shallow zone, are the porosity and permeability of the country rocks, the climatic condition and the topography of the terrain. The ***porosity*** of a rock is defined as the amount of void or open space contained in it and is expressed numerically as the percentage of void space existing in a given volume of rock. ***Permeability*** of a rock is the property by virtue of which it allows the water to travel through its pore spaces or other openings and is found to be proportional to the square of the diameter of the grains forming the rocks.

In permeable rocks underground water can continue to percolate downwards only upto a certain depth below which no further percolation is possible due to lack of connections between openings within the rocks concerned. The percolating water, therefore, has no other way than to accumulate there, saturating the pore spaces and other openings of the rocks. With more of supply of water, saturation of openings continues to proceed upward. In porous and permeable rocks there is, therefore, a completely saturated zone of underground water upper surface of which is known as ***Water Table.*** The water that occurs below the water table in the ***Zone of Saturation*** is known as ***Groundwater.*** Above the water table and below the surface of the earth the pore spaces within the rocks are partially filled with percolating underground water and the zone is known as ***Zone of Aeration*** and the water occurring in this zone is known as *Vadose water*.

Underground reservoirs of water lie within the solid rocks and loose soils forming the country and are sometimes exposed to the surface in the form of natural seepage and springs. Ordinary wells, tube wells, artesian wells, etc. are some of the common devices of drawing water from natural reservoirs underneath the surface of the earth. A geological formation or structure, which is porous and permeable to the extent of maintaining a steady supply of sufficient amount of water to the wells or springs is known as an ***aquifer.*** Aquifers may be **unconfined** or **confined**. The common rock types, which act as aquifers or natural reservoirs of groundwater, are sandstone, grit, conglomerate, gravel, alluvium etc. The shear zone, fault planes, joints etc. in igneous or metamorphic rocks may also act as aquifers. Rocks, which are neither porous nor permeable, are known as ***aquifuges,*** which do not allow underground water to percolate into them. Igneous rocks such as Granite, Syenite, Gabbro etc. and metamorphic rocks such as Quartzite are aquifuges. ***Aquiclude*** is a rock, which is porous but practically impervious and thus lies in between aquifer and aquifuge.

The different types of underground water which occupy the pore spaces above the water table are **soil** water, **pellicular** water, **vadose** water, **perched** water and **capillary** water. Soil water occurs within the soil and is available to the roots of the existing vegetation on the surface. Pellicular water sticks to and moistens the surfaces of the openings in rocks and does not move downward under gravity. Vadose water or gravity water moves downward under gravity and tries to reach the water table. Perched water occurs above a suitable aquiclude or aquifuge, within the zone of aeration. Capillary water exists within very fine openings, just above and in contact with the water table. The different types of underground water which occur below the water table and in the zone of interconnected openings (zone of saturation) are known as **free water, confined water, fixed ground water and connate water**. Free water can move freely below the water table within the unconfined aquifer. Confined water occurs below the water table and is confined between impervious horizons. Fixed groundwater exists within extremely small openings in aquicludes and cannot move under gravity. Connate water is that water which is held within the rocks since they were formed. Underground water occurring at a very great depth within the zone of disconnected openings, is known as **internal water**. Of the different types of underground water, only the perched water, free water and confined water can be utilised, under favourable conditions, as adequate sources of water supply.

SURFACE WATER

Lakes and ponds

Ponds are generally considered to be small temporary or permanent bodies of water, shallow enough for rooted plants to grow over most of the bottom. ***Lakes*** are inland depressions that hold standing fresh water year round. Maximum lake depth range from a few meters to over 1600 meters (e.g., Lake Baikal in Saiberia). Surface areas vary in size from less than one acre to large inland seas, such as Lake Superior or the Caspian Sea covering hundreds of thousands of square kilometers. Both ponds and lakes are relatively temporary features on the landscape because they eventually fill with silt or are emptied by cutting of the outlet stream through the barrier that creates them.

While lakes contain nearly one hundred times as much water as all rivers and streams combined, they are still a minor component of total world water supply. Their water is much more accessible than groundwater or glaciers, however, they are important in many ways for humans and other organisms.

Running water (River water)

A part of water that reaches the earth's surface can neither evaporate nor sinks down into the earth, flows down along the slopes of the earth's surface forming the ***surface run off.***

The surface runoff commonly starts in the form of a thin sheet of water in motion. This is known as ***rainwash***. As soon as rainwash accumulates within valleys it becomes a ***stream***. Further down, a number of streams unite along converging valleys to form a ***river***. Along its seaward course, a river procures a few tributaries or itself joins a more powerful river as its tributary, and in this manner a ***river system*** is gradually developed. All streams and rivers flow along their own channel and the amount of water passing through the channel per unit time is defined as the ***discharge*** of the river or stream concerned. The discharge of a river is seldom constant. It increases to a maximum during monsoons, while in summers and winters it dwindles down to a considerable extent. The channel of a river adjusts itself periodically in respect of its shape and size depending upon the seasonal fluctuations in the discharge. ***Meandering*** is a common feature of most of the rivers in plains. ***Ox-bow lakes*** are formed in abandoned meander channels. Many rivers are often flooded and ***floodplain*** is the area on the two sides of a river channel, which is readily submerged under water during floods.

There are two types of streams or rivers, Effluent and Influent. In an ***Effluent river*** flow is maintained during the dry seasons by groundwater seepage into the stream channel from the sub-surface because the water table lies at a higher level than the stream/river bed. An ***Influent river*** is entirely above the groundwater table and flows only in direct response to precipitation. Water from an influent stream seeps down into the sub-surface.

A river transports downstream the products of its erosion which range in size from boulders and pebbles on the one hand to fine sand, silt and clay on the other as also the dissolved ions. All these are collectively known as ***load*** of the river.

The Hydrologic Cycle

The *hydrologic cycle* (water cycle) describes the circulation of water as it evaporates from land, water and organisms; enters the atmosphere; condenses and is precipitated to the earth's surfaces; and moves underground by infiltration or overland by run off into rivers, lakes and seas. The total amount of water on earth remains about the same from year to year, and the hydrologic cycle simply moves it from one place to another. This process supplies fresh water to the land masses while also playing a vital role in creating a habitable climate and moderating world temperatures. Movement of water back to the sea in rivers and glaciers is a major geological force that shapes the land and redistributes materials. Plants play an important role in the hydrologic cycle, absorbing groundwater and pumping it into the atmosphere by transpiration. In tropical forests, as much as 75% of annual precipitation is returned to the atmosphere by plants.

Solar energy drives the hydrologic cycle by evaporating the surface water. On bright, cold, windy winter days, when the air is very dry, snowbanks disappear by sublimation even the temperature never gets above freezing.

In both evaporation and sublimation, molecules of water vapour enter the atmosphere, leaving behind salts and other contaminants and thus creating purified fresh water. We used to think rain water as a symbol of purity, a standard against which pollution could be measured. Unfortunately, increasing amounts of atmospheric pollutants are picked up by water vapour as it condenses into rain.

The amount of water vapour in the air is called ***humidity***. Warm air can hold more water than cold air. When a volume of air contains as much water vapour as it can at a given temperature, it is said that it has reached the ***saturation point***. ***Relative humidity*** is the amount of water vapour in the air expressed as a percentage of the maximum amount (saturation point) that could be hold at that particular temperature.

When the saturation concentration is exceeded, water molecules begin to aggregate in the process of condensation. If the temperature at which this occurs is above 0°C, tiny liquid droplets result. If the temperature is below freezing, ice forms. For a given amount of water vapour, the temperature at which condensation occurs is the ***dew point***. Tiny particles called ***condensation nuclei*** floating in the air facilitate this process. Smoke, dust, sea salts, spores and volcanic ash all provide such particles. Even apparently clear air can contain large numbers of these particles, which are generally too small to be seen by the naked eye. Sea salt is an excellent source of such nuclei, and heavy, low clouds frequently form in the humid air over the oceans. Some nucleating agents are so efficient at accumulating water that they can cause precipitation even when the air is far below its saturation point.