OCENANIC MOVEMENTS: THE OCEAN TIDES

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TIDES

Tides are nothing but rise and fall of sea level, which are formed due to gravitational pull of Sun and Moon on earth. The sea waves generated by tides are called tidal waves. The nature and magnitude of tides vary from place to place. When the sea water rises due to occurrence of a tide and moves towards the sea coast, it formed a high tide. As the sea water falls and moves towards the sea, it result in the fall of sea level to its lowest during a low tide, the difference between a high tide and a low tide is known as tidal range. The height of high and low tides differs at different places and in different oceans as they different in depth, configuration of coast and coastlines etc.

Along a coast all over the world, we observe the sea water moving both upwards and downwards at rates varying from place to place. Such a variation in sea level occurs from hour to hour and from day to day. At the time of a rising sea level, the incoming tide towards the land is spoken of as a flow tide or a flood tide. At the time of a falling sea level after a few hours, we speak of the tide water going out or withdrawn, is an ebb tide (low tide). The flood tide is a high tide and the ebb tide is a low tide. Tides are really the largest waves keeping the ocean water restless. Twice a day regularly at constant intervals, a tide flows in and twice a day it ebbs away. Twice a month, flow tides are higher and the ebb tides are lower than the average. Also twice a month flow tides are lower and the ebb tides are higher than the average.

However, the regular interval between two high tides or between two low tides is 12 hours and 25 minutes and not exactly 12 hours. Each day (in 24 hours) the high tide arrives about 51 minutes later than on the previous day. It is so because each day the rising and setting of the moon also falls behind by 51 minutes. It takes 24 hours and 50 minutes for the rotating earth to bring the same meridian vertically below the moon every day. The timings of the tides at a place on a coast will be clear to you from the following examples.

High Tide	06.00 AM
Low Tide	12.13 PM
High Tide	06.25 PM
Low Tide	12.38 AM
High Tide	06.51 AM next day.

ORIGIN OF TIDES: - The origin of tides in the oceans is primarily concerned with the gravitational forces of the Sun and Moon. It may be pointed out that the earth rotates from west to east and revolves around the earth, along an elliptical orbit, so that the distance between the Moon and the Earth changes during different times in every month, the period when the Moon and Earth are at the farthest distance from each other is called apogee and the period of nearest distance is called perigee.

FACTORS CONTROLLING THE NATURE AND MAGNITUDE OF TIDES: -

There are various factors, which control the nature of Tides. Each point on the ocean is affected by the two forces of the sun and moon, each tending to produce its own tide ellipsoids. These forces can act simultaneously and produce a combination of the above two ellipsoids of they can act opposite, which forms a different tide ellipsoid. Factors influencing tides.

The factors responsible for bringing about such a variation in the regulation and the size of tides are:

1. Irregularities in the configuration of the oceans.

2. Uneven distribution of water over the globe.
3. Changes in position of the sun and moon in relation to the earth.
4. The movement of the moon in relation to the earth.
5. The location of the sun, the moon and the earth in relation to each other which is rarely in a straight line.
6. The distances of the sun and the moon from the earth are not constant.
7. Our globe is not entirely covered with water.
8. The outline or shape of the coast may help or hinder the tides.

Still the tides follow each other with a great punctuality at any given coast. What are the forces that generate the tides? The earth attracts and is also attracted by the sun, the moon and by other planetary bodies. It is called the gravitational force and it operates between the sun, moon and the earth. It sets the ocean waters in motion producing a tidal current. Tides are the proof of such a gravitational pull. The moon and the sun both exert their gravitational force on the earth. The Oceans, Submarine Relief and Circulation sun which is bigger in mass than the moon is also at a greater distance from the earth than the moon. Therefore, the gravitational attraction of the moon is more effective on the earth than the gravitational attraction of the sun. Since the water is liquid and mobile, its bulging in the direction facing the moon is easily noticed, yet a lower tidal bulge also develops on the other side of the earth farther from the moon because of moon's least attraction.

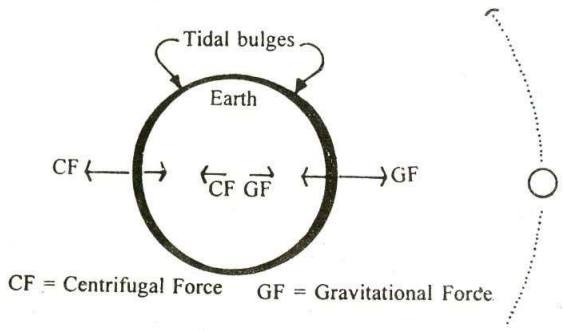

Fig.1- Formation of Tides.

CAUSES OF TIDES: -

1. Gravitational pull of sun, moon. Moon is closer from earth as compared to sun. Therefore, Gravitational force of moon is more on earth compared to sun.
   Tidal Bulge: - Like a magnet, gravitational force pulls away water is known is 'Tidal Bulge.'
2. Centrifugal force due to rotation of earth upon own axis.

TYPES OF TIDES: - Oceanic tides are the result of tide producing forces of the sun and moon, in which there is a huge temporal and spatial variation in the tide producing forces because of different positions of the sun and the Moon with the Earth. Due to variations in intensity of tide producing forces several types of tides are caused.

SPRING TIDES: -

The moon, as it is closer to the earth, exerts twice the gravitational pull of the sun on the earth. When the sun and the moon are in a line as on a new moon (Amavasya) or a full moon day (Purnima) both of them pull together at the same time in the same direction. This combined pull produces an extra-large tide. It is called a spring tide. In its first quarter (Asthmi Shukla Paksha) and the third quarters (Asthmi-Krishna Paksha) the gravitational force of the two heavenly bodies is at right angle. At this time, the two pulls are opposing each other and are not acting in the same direction. In other words, they cancel or neutralize each other's effect. It produces a weak tide which is called a neap tide.

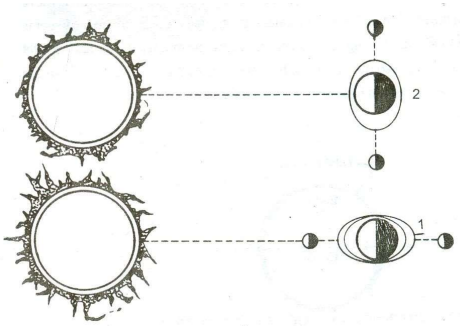

Fig.2- Spring (1) and Neap (2) Tides.

NEAP TIDES: - The sun, the earth and moon come in the position of quadrature (i.e. from right angle) on seventh or eighth day of every fortnight of a month and thus, the tide producing forces of the sun and the moon work in opposite direction, with the result low tides is caused. Such tide, which is lower in height than the normal tide, is called neap tide. The height of neap tides is generally 20 percent lower than the normal tides.

TROPICAL AND EQUATORIAL TIDES: - When there is maximum declination of the Moon to the North of equator, the moon's rays fall vertically on the tide centres (near the Tropic of Cancer) and hence, spring tides are caused. Such tropical tides move westward along the Tropic of Cancer.

Spring tides are also caused along the Tropic of Capricorn, which is opposite to the Tropic of Cancer. Thus, successive high and low water occurring along the Tropics of cancer and Capricorn are of unequal heights. Such tides and ebbs are of higher and lower heights then the normal tides and ebbs respectively. Such tides recur twice every month, when the Moon's rays fall vertically on the Tropics of Cancer (during Northward position of the Moon) and Capricorn (during Southward position of the Moon).

Thus, the tides occurring along the Tropics of Cancer and Capricorn are called tropical tides. There is no diurnal inequality of tides in terms of two neap tides and two spring tides, because the Moon is vertical on the equator every month. Such tides are called equatorial tides.

THEORIES OF OCEAN TIDES: -

Numerous theories have been put forth from time to time to explain the origin of ocean tides. These theories include Equilibrium theory by Issac Newton (1687), Dynamical theory by Laplace (1755), Progressive wave theory by William Whewell (1833), Canal theory by G.B. Airy (1842), Stationary

wave theory by R.A. Harris etc.

PROGRESSIVE WAVE THEORY: -

The 'progressive wave theory' of William Whewell propounded in the year 1833 and 'the canal theory' of G.B. Airy postulated in the year 1842 to explain the origin of ocean tides are based on the following facts:

(i) The earth is a heterogeneous body and not a perfect fluid.

(ii) Tide occurs at different times at different places on same longitude.

(iii) There is a lagging of time of tides away from the source.

(iv) There is variation in the magnitude and amplitude of tides at different places.

(v) Tide is in the form of tidal wave which travels from east to west.

The crests and troughs of such tidal waves become tides and ebbs respectively. These waves are originated in the oceans under the influence of tidal force of the moon. The length and velocity of tidal wavesdepend on the depth of seas and oceans. In a globe completely surrounded by water the tidal waves would travel freely from east to west but the position of land and water hinders the velocity and direction of these waves.

Since the continents roughly stretch from north to south and hence they hamper the free movement of tidal waves. These waves are least hampered in the oceans surrounding the Antarctic continent, thus, tidal waves are generated in the Southern Ocean in the southern hemisphere under the influence of tide-producing force of the moon. These waves are called primary waves which move from east to west in the form of forced waves. These waves are obstructed by the continents and are consequently refracted northward.

Secondary waves are generated when the west ward movement of primary waves is obstructed by land masses. These northward moving waves are called secondary waves or derived waves which also move from east to west. Further minor waves are generated from these secondary waves. These secondary and minor waves progressivelymove northward though there is gradual decrease in their magnitude and amplitude but these waves generate tides every- where.

It may be pointed out that the primary waves are influenced by the moon but the minor waves move freely. It is, thus, apparent that the tidal waves after being originated in the Southern Ocean progressively move northward with continuous lag of time and dissipation of wave energy. In other words, the arrival of these progressive waves at successive places northward along the same longitude is also progressively delayed.

This is why there is difference of time of tide at different places on the same longitude. In other words, the time of tides is progressively delayed northward along the longitude. These progressive waves become ineffective after reaching North Pole. The crests and troughs of these waves after reaching the coasts cause tides and ebbs respectively. depicts the **co-tidal lines** (the lines joining the points of high waters occurring at the same hour are called co-tidal lines) of the Atlantic Ocean.

STATIONARY WAVE THEORY: -

R.A. Harris of the U.S. Coast and Geodetic Survey propounded the concept of stationary waves as opposed to the progressive waves. This theory offers almost satisfactory explanation for local differences in tides, their types and their age. According to Harris tide phenomena are not due to progressive waves which originate in the southern oceans as claimed by William Whewell but are due to stationary waves which originate independently in each ocean.

In other words, tide phenomena are regional phenomena. The stationary wave theory can be explained with the help of an experiment. If a rectangular tank or '**developing tray'** containing water is rocked from one side to the other or is simply tilted, the water level rises along one side of the tray but falls along the other side. This generates oscillation in the water contained in the tray. Such oscillations in the water are called **stationary waves**. There is such a centre in the middle of the tray where there is no change in the level of water. This point is called **nodal point**. The water level moves rhythmically from one end of the tray to theother end along a line which is called **nodal line.**

The period of oscillation of water in the tray depends on the length and depth of the tray and the force of shocks applied to the tray. The aforesaid example is the case of **uninodal** system (fig. 2) but there may also be **binodal** oscillation system.

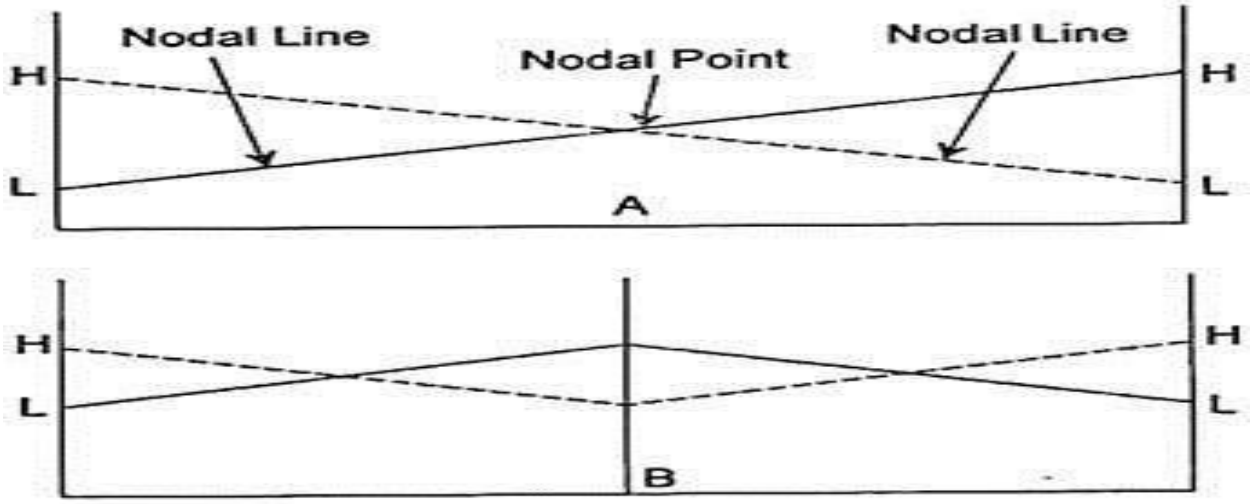

Fig.3 – (A) Uninodal and (B) binodal oscillation system

Based on above analogy, different oceans of the earth are like giant water containing trays. The tidal forces of the sun and the moon cause oscillations in the oceanic waters but the oscillations do not occur along straight limes as in the case of the tray rather they occur around a central point because of the rotational force of the earth, with the result several amphidromic points are generated.

The oceanic water remains calm and stationary at these points whereas water level changes around them. This mechanism results in the formation of waves which move in anti-clockwise direction around these amphidromic points. Such oscillatory mechanism of water occurs in every ocean and is collectively called as oscillation system. Numerous stationary waves are generated from these amphidromic points

Every stationary wave has a definite time of its oscillation. The oscillation system and mechanism are affected by the depth, configuration and length of the ocean basins and the rotational speed of the earth. The stationary waves after being originated from the amphidromic centres move towards the coasts.

The forward movement of these waves is hampered by the continental peninsulas, islands, bays etc. When these waves reach the coasts, their crests and troughs cause tides and ebbs respectively. There is positive correlation between the depth of the oceans and the height of tides. In other words, if the depth of the ocean becomes greater, higher stationary waves are generated and high waves generate high or spring tides. Low tides are caused in shallow seas because of lower height of stationary waves. length of the ocean basins and the rotational speed of the earth. The stationary waves after being originated from the amphidromic centres move towards the coasts.

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EFFECT OF TIDES: -

The phenomenon of tides, which is so universal has been of immense value to man for ages. Tides act as link between the port and the open sea. Some of the major ports of the world, such as London port on the river Thames and Kolkata port on river Hugli are located on the rivers away from the sea coast. The tidal current clear away the river sediments and slows down the growth of delta. It increases the depth of water which help ships to move safely to the ports. It also acts as a source for producing electricity. Tides make the rivers navigable for ocean going ships, clear sediments, retard formation of delta and are a source of producing electricity.