

Ocean Circulation

Questions :

- 1) What is ocean circulation ?
- 2) What is surface water circulation?
- 3) What is Thermohaline circulation ?
- 4) What is Gyre? How many large Gyre exist in the world oceans?
- 5) What is Ekman Spiral?
- 6) Write the importance of surface water circulation ?
- 7) Briefly discuss the global ocean circulation pattern?

Ocean circulation

Ocean circulation is a key regulator of climate by storing and transporting heat, carbon, nutrients and fresh water all around the world. Complex and diverse mechanism interact with one another to produce this circulation and define its properties.

Ocean circulation can be conceptually divided into two main component :

- i) A fast and energetic wind driven surface circulation
- ii) Slow and large density driven circulation which dominates the deep sea.

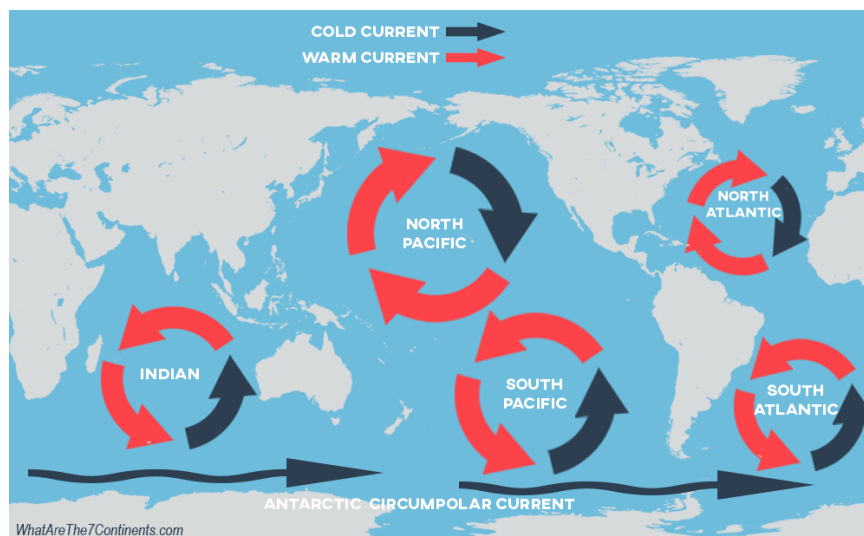
Wind driven surface water circulation

Wind driven circulation is by far the most dynamic. Blowing wind produce currents at the surface of the ocean which are oriented at 90° to its direction(on its right in the Northern Hemisphere and on its left in the Southern Hemisphere) due to the earth rotation. As a consequence it creates zone of convergence and divergence of ocean currents at the point where they meet.

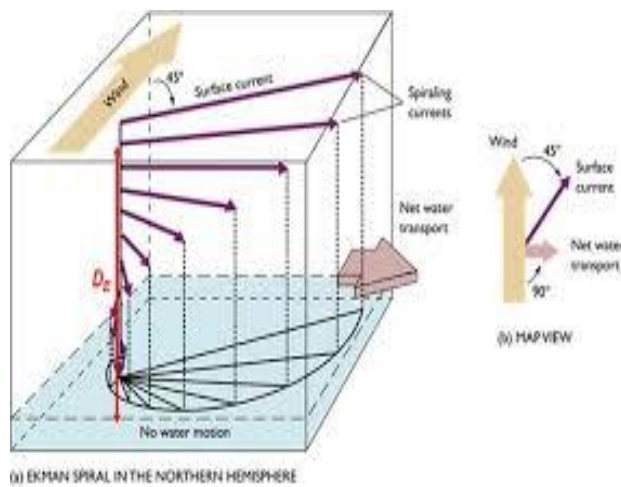
Divergence of currents will create an upwelling phase (interior water reach the surface) and convergence a downwelling phase (surface water sink in the interior of the oceans). Linking surface and interior water.

Continents and basin topography often block continuous flow and help deflect the moving water into circular pattern. This flow around the periphery and ocean basin is called Gyre (Gyros, 'a circle')

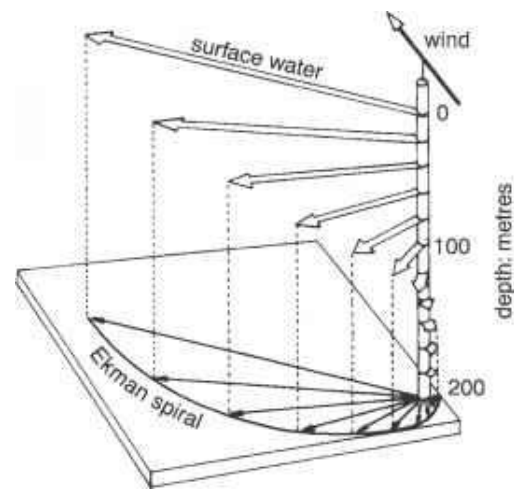
The circulation of Gyres have developed in subtropical zones of Atlantic, Pacific, and Indian ocean in both hemisphere and have been formed and bordered by four surface ocean currents. Namely westward flowing Equatorial currents, west boundary currents, eastward flowing current driven by westerly and east boundary currents. The equatorial currents are driven by trade winds in both hemisphere and most parallel to the equator. The west boundary currents flow along the western boundary of the respective ocean basins like the Gulf stream and Brazil currents. The eastward flowing currents move forward under the influence of the westerlies blowing from south-west to north-east direction in the Northern Hemisphere and from north-west to south-east in Southern hemisphere. Fourth is an East boundary current, which flow along the eastern boundary. the east boundary currents are cold because they come from high latitude while west boundary currents are warm surface because they come from warm tropic oceans.



When water driven by the wind, the top most layer of the ocean water in Northern hemisphere flows about 45° to the right of the wind direction. It is known as Ekman spiral. This concept proposed by Swedish oceanographer V.W.Ekman. the surface layer displaced 45° right to the Northern Hemisphere and 45° left in Southern hemisphere and successive deeper layer are further displaced so that at a given depth the water motion opposite to wind direction. Current velocity decreases with depth because of the loss of momentum associated with the transference of motion from layer to layer.



Northern Hemisphere



Southern Hemisphere

Importance of surface water circulation :

- 1) **Modification in the coastal climate :** Surface ocean currents while flowing along the coasts modify their climatic condition in a number of way. The most effective impact of ocean currents are seen on the temperature, of affected coastal land. The effect are both positive and negative for flora and fauna. The warm currents when they reach colder areas do not allow their temperature to fall rather they keep the relatively warmer in winter months. The origin of ideal and favorable European type of climate of the western coasts of Europe due to the effect of the North Atlantic warm currents.

Ocean currents help maintaining the temperature balance of ocean water as the warm currents transport warm water from tropics toward pole and cold currents bring cold water of high latitude to the low latitudes area. It creates homogeneity of temperature distribution.

Cold current on the other hand lower down the temperature and causes snowfall. Labrador, Kurile, Folk land cold current responsible for heavy snow fall.

The convergence of warm and cold currents causes dense fogs which obstacles in navigation. Near New found land due to convergence of warm gulf stream and cold Labrador currents.

- 2) **Effects on fishing :** ocean currents act as distributing agents of nutrients, oxygen, and other elements necessary for fish. Ocean currents transport planktons from one area to another area. These planktons useful food for fish. Gulf stream carries planktons from Mexican gulf to the coasts of New foundland and north western Europe. So many significant fishing ground developed.
- 3) **Effects on Trade and Navigation :** Ocean currents determine major ocean routes for navigation of commercial ships in ancient times but present times power motored ships do not care for the ocean currents and prevailing winds. The occurrence of fog due to convergence of warm and cold currents pose seriously threats to navigation.

Deep circulation or Thermohaline circulation

The density driven sub surface currents involving movement of extensive water masses bellow the pycnocline layer are called deep circulation or Thermohalinr circulation. Science deep currents are originated due to density variation and density of ocean water is the function of temperature (thermo= temperature) and salinity (haline = salt) of the ocean water and hence deep ocean currents are called thermohaline circulation of sub surface water mass.

Low temperature or high salinity both increases the density of sea water and denser surface water of the ocean sinks, the process of which called downwelling. The high density of sea water results from the following two factors and process :

- i) Increases in density through decrease in temperature and increase in salinity of ocean water.
- ii) Increase in salinity due to excessive evaporation of water or through the process of ice formation.

The empirical studied have shown that increase in density due to lowering of temperature of surface water of the ocean due to minimum amount of insolation and increase salinity of ocean water due to formation of ice occurs in the high latitude and hence the source area of origin of sub surface water mass and deep currents are the sea surface of high latitude region. It is clear that high density surface water sinks through the process of downwelling beneath the surface water, and originated deep currents which takes sub surface rout. It become free from several physical process such as insolation, heating, evaporation, reflection etc. so result there is homogeneity in terms of temperature and salinity of sub surface ocean water.

Characteristic :

- Deep ocean currents are infact sub surface water mass.
- These currents originated due to downwelling of cold denser surface water in high latitude area.
- Deep ocean currents are very sluggish in forward movement as they move at the speed of 10-20 km. per year.
- Deep ocean currents complete cyclic path ways. This cyclic path begins from the sinking of dense surface water passes through bottom of the ocean and is completed by mixing of deep water with surface water.



Cyclic pattern of thermohaline circulation :

The thermohaline circulation of deep ocean currents and water mass takes a cyclic path way starting from downwelling of dense surface water in high latitude areas, horizontally flow covering thousand of km. between less dense surface and more dense bottom water and ending with upwelling of deep water. Complete the cyclic process takes about 1000 years because the movement of sub surface water mass is very slow.