DIRECTORATE OF DISTANCE EDUCATION

UNIVERSITY OF JAMMU

JAMMU

SELF LEARNING MATERIAL

B.A. SEMESTER - III

SUBJECT : GEOGRAPHY — **UNIT : I - IV**

COURSE NO. : GO-301 — **LESSON NO. : 1-16**

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COURSE CO-ORDINATOR

Printed and Published on behalf of the Directorate of Distance Education, University of Jammu, Jammu by the Director, DDE, University of Jammu, Jammu.

http:/www.distanceeducationju.in

PHYSICAL GEOGRAPHY

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Printed by : Classic/19/300

GEOGRAPHY

III Semester (B.A.)

Examination to be held in the years Dec. 2015, 2016 & 2017 onwards

Course No. GO-301 (Theory) **Title : Physical Geography-II**

Duration : 3 Hours **Max. Marks : 100**

Theory Examination : 80

Internal Assessment : 20

Credits : 04

Syllabi for B.A/B.Sc. Semester-III Theory Examination

The objectives of the course is to introduce the latest concepts in Physical Geography, especially in Climatology and Oceanography to the students of Geography.

Section - A (CLIMATOLOGY)

Unit-I

1. Weather and Climate, Composition and Structure of Atmosphere
2. Insolation and Global Heat Budget, Vertical Horizontal distribution of temperature
3. Atmospheric Pressure :- Vertical and Horizontal distribution of pressure
4. Winds- Causes and Types (Planetary, Periodic and Local Winds)

Unit-II

5. Atmospheric Moisture – Type of Humidity and Type of Precipitation
6. Atmospheric Disturbances – Air masses and Fronts, concepts and types
7. Tropical and Temperate cyclones – causes and distribution
8. Climatic Classification – Basis and Types of Koppens's Classification

Section - B (OCEANOGROPHY)

Unit-III

9. Configuration of Ocean Floor – Continental shelf, Continental slope, Deep sea plains and Ocean deep
10. Temperature of oceans – Horizontal and Vertical distribution of the temperature
11. Salinity causes and distribution
12. Ocean water circulation:- causes and types of ocean currents: Indian ocean current and Atlantic ocean currents

UNit-IV

13. Waves – definition, origin, types
14. Tides – definition origin and types
15. Coral reefs – origin and types
16. Ocean deposits – origin and types

Note for Paper Setting :

The Question Paper shall comprise of two sections – A&B. Section A shall be compulsory and shall comprise of 8 short answer questions of 2 marks each. Answer should be limited to 20 words. Candidate shall be required to attempt all the 8 questions. Section B shall comprise of 8 questions from 4 Units. Candidate shall be required to attempt one question from each unit and each question shall be of 16 marks. Answer should be limited to 450 words for each question.

Suggested Readings:

Climatology

1. Trewartha, G.T. "An introduction to Climate". International Students Edition, MsGraw Hills, New York, 1980.
2. Barry R.G. & Chorley, R.J. "Atmosphere Weather And Climate" Rpi;;edge, 1998.
3 Critechfield H, General Climatology, Prentice hall New York, 1975.

4. Mallher J.R Climatology, MsGraw hills, New York, 1974.

5. Patterson S-Introduction to Meterology, MsGraw Hill Book Co, London, 1969.

Oceanography

1. Grald S - General Oceanography - An introduction, John Willey and Sons, New York, 1980.

2. King L.C. Oceanography for Geographers, E. Arnold London, 1975.

3. Sharma R.C. & Vatal M, Oceanography for Geographers, Allahabad, 1970.

4. Shepard F.P. Submarine Geology, Harper & Sons, New York, 1948.

5. Thuman H.P.Introductory Oceanography, Charles Webber E Merril Publihing Co. 1984.

Distribution of Internal assessment of 20 marks as under :

(i) Class Test = 10 Marks

(ii) Two written assignments = 10 Marks (05 Marks each)

GEOGRAPHY

Practical III Semester (B.A.)

Course No. GO-301 (Practical) Title - Cartography-III (Practical)

Examination to be held in the years Dec. 2015, 2016 & 2017 onwards

Duration : 3 Hours **Max. Marks : 50**

External Examination : 25

Internal Examination : 25

Unit-I Cartographic Symbols

1.1 Types of Cartographic Symbol - Point, Line & Area Symbols and their application.

1.2 Cartographic Diagrams - Pie-diagram, Proportional Circle, Concentric circle, Sphere and Pyramid.

1.3 Representation of Population and Climatic data by Cartographic diagrams.

Unit-II Cartographic methods and Statistical Data

1.1 Cartographic Methods - Isopleth, Choropleth, Dot, Chorochromatic and Choroschematic. Definition and their application.

1.2 Distribution of Maps - Methods and drawing of distribution maps, Representation of Population (Distribution, Density, Growth, Sex-Ratio) and climate (temperature and Rainfall) data by Choropleth and Isopleth methods.

1.3 Statistical Date - Definition, Types of Data, Methods and Sources of Primary and Secondary data Collection. Tabulation of Data. Sources of data, tabulation and analysis of data.

Instructions for tyhe paper setter :

The question paper will be set out of two units. In all 'Eight' questions will be set : Four questions from each unit. Students will be required to attempt four question i.e. two questions from each unit. Each question carries 5 marks.

Marks Distribution

i) First assessment on the basis of dat to day performance in the laboratory/field = 06 marks

ii) Second assessment on the basis of day to day performance on the laboratory/field = 06 marks

iii) Class Test = 08 marks

iv) Regularity of Attendance = 05 marks

CONTENTS

Course No. GO-301 **Unit-1**

Semester III **Lesson-1**

WEATHER AND CLIMATE, COMPOSITION AND STRUCTURE OF ATMOSPHERE

Prof. Sarita Nagari

1.1 INTRODUCTION

In the case of any academic subject, it is fundamental to have at least a working knowledge of its past, so that it becomes evident how the subject has been developed through ages, and how it has assumed the shape it has at present. We hear about weather and climate all the time. Most of us check the local forecast to plan our days. The earth's climate has changed over time and will continue to change. A place or regions climate is determined by both natural and anthropogenic (human made) factors. Although weather and climate are different, they are much interrelated. A change in one weather element produced changes in the others. The present chapter will establish understanding of difference between weather and climate and methods of measurement and forecasting.

1.2 OBJECTIVES

- To make the students aware of the general distinctions between weather and climate.
- To trace different factors and mechanism affecting climate and weather.
- To familiarize the student with different types of extreme climate and weather events in an integrated manner so that the risks and uncertainties associated with each can be composed and evaluated meaningfully.
- To familiarize the students with the composition and structure of the atmosphere In this chapter you will study about the atmosphere which is a significant component of the biospheric ecosystem because the life on the earth's surface is because of this atmosphere otherwise the earth would have been barren like moon.

1.3 DEFINITION'S OF CLIMATE

1. **Critchfield**, " The process of exchange of heat and moisture between the earth and atmosphere over a long period of time result in condition which we call climate."
2. **G.f.Taylor**, "Climate is the integration of weather, weather is the differentiation of climate."
3. **Koeppe and De long**, " Climate is a summary , a composite of weather conditions

over a long period of time."

1.3.1 Factors affecting climate and weather :- There are various factors that affect the climate and weather:-

a. Latitude

b. Altitude

c. Unequal distribution of land and water

d. Ocean currents

e. Air pressure and wind

f. Mountain barrier

g. Nature of ground surface

h. Different types of atmospheric storms.

1.3.2 Meaning of climate :- The word climate has been taken from the Greek word Klima (inclination/slope). Of all the climatic elements, temperature was considered as the most important by the Greeks. The principal cause of various types of climate found on the earth, according to them was the inclination of the solar rays. Erastosthenes was the first Greek philosopher who gave climatic significance to the angle of incidence of the sun's rays. **Parmenides** _ divided world into 5 climate zones

1. Torrid
2. North temperate
3. South temperate
4. North frigid
5. South frigid

1.3.3 Difference between climate and weather.

1. Climate is how the atmosphere behavior over long periods of time.	Weather is atmosphere conditions for short period of time.
2. Climate is the average of weather overtime and space. In this we take long periods i.e 30 years	In most places, weather changes from minute to minute hour to hour, day to day and season to season.
3. Climate is what you expect, like a very hot summer, a very chilled winter etc.	Weather is what you get, like a hot day. In this we talk about "what will it be like today?""how hot is it right now".
4. Climate include precipitation, temperature sunshine, humidity, wind velocity, fog, frost, hailstorms over a long period of time.	Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, flooding, brizzards excessive heat, heat waves and more.
5. Climate is what you expect.	Weather is what you get.

1.3.4 Human impact and changes on climate and weather.

There is extensive evidence that human activity such as agriculture and industry results in weather modification. Acid rain caused by industrial emission of sulphur dioxide and nitrogen oxides into the atmosphere, adversely affects freshwater lakes vegetation and structures. Anthropogenic pollutants reduces air quality. The undesirable weather conditions pose serious threats to ecosystem, natural resources, food, human health. Climate change caused by human activities that emit green house gases lead to drought, extreme temperature flooding, global warming.

1.3.5 Meaning of atmosphere: - The atmosphere is a thick gaseous envelope which surrounds the earth from all sides and is attached to the earth's surface by gravitational force. The height of the atmosphere is between 16 to 29 thousand kilometers from the sea level 97% of the effective atmosphere is up to the height of 29 kms. It provide all necessary gases to sustain and also filters the incoming solar radiation and thus prevents the ultraviolet solar radiation waves to reach the earth protects the earth from becoming too hot.

1.4 COMPOSITION OF ATMOSPHERE

It is a mixture of numerous gases.

- The density of atmosphere decreases with altitude .
- 97% of the air is concentrated in the lower 29 kms.
- We do not feel its presence unless there is horizontal motion in it. The horizontal movement of the air is known as wind.
- It contains huge numbers of solids and liquid particles, collectively called “aerosols”
- if the suspended particles like water vapour and other gases were excluded from the atmosphere then dry air is very stable all over the earth up to 80kms (altitudinally)
- Nitrogen and oxygen make 99% of the clean, dry air.

Oxygen

- Oxygen is important for all living organisms.
- It is capable of combining with all other elements to form compounds.
- Oxygen is consumed with the burning of any substance.

Nitrogen (78%)

- It is chemically inactive, does not easily enter into chemical union with other substances.
- It is an important . constituent of many organic compound.
- It helps (indirectly) in oxidation of different kinds.
- It regulates combustion by diluting oxygen.

Carbon Dioxide (0.03%)

- Green plants utilize CO_2 and water in the process of Photosynthesis.
- CO_2 is an efficient absorber of heat from the atmosphere and emits half of the absorbed heat (terrestrial heat) back to the earth.
- Thus helps in hear budget.

Ozone ($^{0}3$)

- Its concentration is found between 20-25km in the atmosphere.

- It is formed although in the upper part but transported downwards.
- It protects the earth from the burning ultraviolet rays.
- The ozonosphere protects us from excessive quantities of ultraviolet rays.

Water Vapour

- An important gas.
- It is present in the lower atmosphere.
- About 90% of the water vapours lies below 6 kms. and 1% above 10kms .
- The water vapour content vary from 0.2% by volume in a cold dry area to 4% in the humid tropics.
- It acts as insulator, it absorbs not only the long wave terrestrial radiations but also the incoming short wave solar radiations thus helps in heat budget.
- Water vapour is the source of all clouds and precipitation.
- Condensation produces latent heat of condensation which is the driving force for most of the storms.
- When the maximum quantity of water that the air can hold at any given temperature and the pressure is present, the air is said to be saturated.
- The moisture holding capacity of the air is directly proportional to its temperature.

Dust Particles

- Dust particles include all the solid particles present in air excepting the gases and water vapour.
- It includes sea salts, pollen, various organisms lifted by the wind, smoke and Soot from fires, tiny sand particles raised from active volcanoes.
- The upper atmosphere also receives a very small amount of dust from the disintegration of innumerable maters passing through it.
- Dust particles help in heat budget by the absorbing the incoming solar radiations as well as the terrestrial long wave radiations.
- These are hygroscopic in nature act as nuclear of condensation.

- the blue colour of the sky is also due to the these particles (by scattering).

1.4.1 Structure of the Atmosphere.

According to Peterson the atmosphere is divided into the following more significant spheres.

1. Troposphere
2. Stratosphere
3. Ozono sphere
4. Ionosphere (Mesosphere)
5. Exosphere (Thermosphere)

(1) Troposphere

- the lowermost layer of the atmosphere.
- it is has been considered as the "laboratory" in which the nature is busy in doing one or the other experiment.
- it contains 70% of the gasesous mass of the atmosphere and practically all the moisture and dust particles.
- the term troposphere was first suggested by "Teisserence de bort" –Means "Region ofmixing"
- derived from the Greek word "tropos meaning mixing" or "turbulence"
- it is also called the "convective region", all the convective activities cease at the upper limit of the troposphere.
- the wind velocities increase with height and get maximum at the top.
- its average height is 14kms. however the height varies from 16kms at the equator and 8 kms. at the poles. (the height varies from season to season and from place to place)
- There is decrease of temperature with increasing height at a mean lapse rate of

about 6.5^{0}C per kilometer. This is called Normal lapse Rate.

- the lowest part of the troposphere is further divided into three sub layers.

The laminar Layer – extends only a few millimeters above the earth's surface. Air is held almost stationary around all solid and liquid surfaces by molecular forces. It provides thermal insulation.

The surface boundary layer:- extends up to a few meters above the earth's surface.

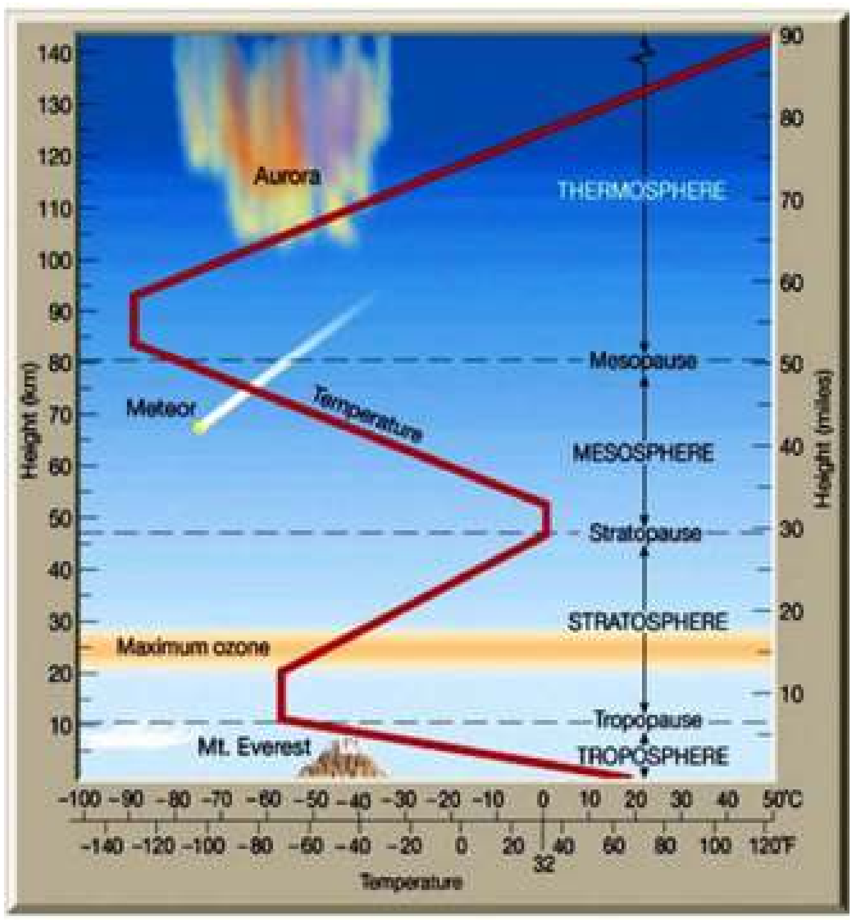
The friction layer: extends about 1km. from the earth's surface. Here the surface topography controls the wind speeed and its direction.Tropopause- shallow layer separating troposphere from the next thermal layer of the atmosphere (stratosphere)the world "tropopause" was first time used by sir Napier Shaw – literally means where the mixing stops.tropopause has its greatest height near the equator about 18kms, so lower temp of the troposphere is directly over the equator and not at the poles.the temperature at the height of 80km. above the earth surface is- 70^{0}c and the width of tropopause is 1.5km.

Stratosphere

- the layer just above the tropopause is "Stratosphere"
- the upper limit it taken to be 50kms, however some other estimated its height upto 90kms.
- There is contrasting views about the change or no change of temperature with increasing height.
- some scientists believe that the stratosphere is Iso thermal, while others said that temperature gradually rises upward and becomes 0^{0}C at the height of 50kms.
- It is more or less devoid of major weather phenomena but circus coulds are found in the lower stratosphere.
- The lower part is very important as there is the concentration of ozone between the height of 15-30km. however it has been discovered upto the height of 80km.
- Ozonosphere is imp, to human life as it protects us from harmful ultraviolet rays.
- Its depletion causes global warming, acid rain, meting of glacier, rise in sea level,

skin cancer to white skinned people, decrease is photosynthesis.

- Ozone is formed by the combination of atmosphere oxygen O2 with individual oxygen molecules $(^{0}2 + 0 - {}^{0}3)$ whereas the breaking of ozone $(^{0}3)$in to o2 and 0 result in the depletion of ozone.
- the main reason of ozone destruction are halogenated gases like CFCs and nitrogen oxides.
- most of the scientist believe that this layer is warm only because of the absorption the ultraviolet rays.



Structure of Atmosphere

Mesosphere

- it extends between 50 -80km.
- temp. decreases with increasing height.
- at the height of 80kms the temperature become 80^0C this limit is known as "Menopause"

Thermosphere

- its upper height is undecided
- temperature becomes 1700^0C
- gases are very light due to low density
- high concentration of atoms of oxygen and nitrogen. It is divided in to two layers Ionosphere – it extends from 80-640 kms .it consist of a numbers of layers d layer (between 60-90) absorbs medium and high frequency waves but reflect low frequency radio waves.It disappears as soon as the sun sets. During increased sun spot activity all medium and high frequency waves stop.

  E layer (90-130 kms) it is called as kennely Heaviside layer. It reflects the medium and high frequency radio waves Sporadic E layer 110km- This layer is characterized by high velocity wind,it affects very high frequency radio waves.It is believed that this layer is caused by meteors and cause aurora lights solar winds.

  E2-layer produced by the reaction of ultraviolet photons with oxygen molecules F_1 and F_2 layers – it is important in long distance radio communication, it appears day time only.it reflects the medium and high frequency radio waves.

  F_2 layer- its maximum development occurs shortly after local noon and during the middle of winter

  G-layer- It is the lastest exploration, because of the interaction of ultraviolet photons with nitrogen atoms, free electrons are produced in the G layer.

Exosphere – It lies between 400-1000 kms

- the density of atoms in the atmosphere is extremely low.

- helium and hydrogen gases predominates in this sphere.
- at the outermost boundary, the temp reaches to a value of $5568^{0}C$
- but one would not feel hot in this sphere because the energy produced at such a great height by the fast moving air particles is insignificant.

Ionosphere

- in this sphere the temperature increase because of the absorption of short waves solar radiation by the atoms of oxygen and nitrogen in the extremely rarefied air of Ionosphere (ultraviolet, X-ray and gamma ray ionsization of molecules and atoms occurs mainly as result of
- ionsization :- A process by which atoms are changed to ions through the removal and addition of electrons giving then and electrical change.
- it is very interesting to note that when the air density is extremely low very little energy is needed to produced rise in temperature
- even the temperature of $1000^{0}c$ is very high but quit different from those experienced near the earth's surface
- since gases at such great heights are very sparse a very little energy is produced by the fast moving air particles
- HOMOSPHERE: represents lower portion extends upto 91km from sea level
- troposphere stratosphere
- called Homosphere because of the homogeneity of the proportion of various gases.
- heterosphere – extends from 90km to 1000kms.
- different layer of this sphere very in their chemical and physical properties.

1.5 SUMMARY

In this chapter, we tried to understand the concept of climate and weather, what are the main factors that affect climate. From a broad perspective, all weather events are now connected to climatic change. Weather is the fluctuating state of the atmosphere around us, characterized by temperature, wind, precipitation, clouds and other weather elements. Over the relatively short period of 250 years, and for the first time in human history, we have changed the composition of the atmosphere. Levels of carbon dioxide have increased around 39% above pre-industrial level, due to burning of fossil fuels. This has increased the global temperature.

1.6 GLOSSARY

- Ecosystem: - Ecosystem is the network of interactions between living organisms and their environment.
- Barren :- Land that is not productive, devoid of vegetation.
- Acid rain:- It is a wide spread term used to describe all forms of acid precipitation (rain, snow, hail, fog) with acidic components.
- Anthropogenic pollutant :- a pollutant is a substance introduced into environment having undesired effects and caused directly or indirectly by humans.
- Drought :- drought is a period of below average rainfall in a given region.

1.7 MULTIPLE CHOICE TYPES QUESTION AND THEIR ANSWERS

1. Composition of the atmosphere.

   a. Varies with season.

   b. Varies with altitude

   c. Remains constant in the lower layers.

   d. Varies from place to place.

Ans. **(c) Remains constant in the lower layers.**

2. The atmospheric layer characterized by selected absorption of ultraviolet radiation is called.

   a. Ionosphere

   b. Ozonosphere

   c. Exosphere

   d. Stratosphere

Ans. **(b) Ozonosphere**

3. The upper boundary of the stratosphere is called:-

   a. Troposphere

   b. Thermosphere

   c. Stratopause

   d. Mesosphere

Ans. **(c) Stratopause**

4. About 50 % of the atmosphere lies below on altitude of :-

   a. 5.6kms

   b. 10 kms

   c. 15kms

   d. 30kms

Ans. **(a) 5.6kms**

5. The atmospheric layer reflecting radio waves is called:-

   a. Homosphere

   b. Ionosphere

   c. Stratosphere

   d. Ozonosphere

Ans. **(b) Ionosphere.**

1.8 EXAMINATION ORIENTED QUESTIONS

Q1. Write short note on :-

   I. Atmosphere

   II. Composition of atmosphere.

Ans I. Atmosphere:- Our earth is surrounded by a blanket of air and this gaseous hanging over the surface of earth is called atmosphere.Various scholars have defined atmosphere as:-

1. "the atmosphere is a thin layer of gases held to the earth by gravitational attraction "- F.J. Monkhouse.

2. "The outer envelope of gaseous end is called as atmosphere " – P.lake.

Ans II. Composition of Atmosphere

The main component gases of dry air are listed in table 1.1.

Table 1.1 Average composition of dry air:-

	Constituent gas	% volume
1.	Nitrogen	78.1
2.	Oxygen	20.9
3.	Argon	0.93
4.	Co_2	0.03
5.	Neon	0.0018
6.	Helium	0.0005
7.	Ozone	0.00006

From the above table , you can see that nitrogen and oxygen together make up about 99% of the volume. Carbon dioxide is important because of its ability to absorb heat. This allows the layers or the atmosphere to be warmed by the sun's heat and by radiation coming from the surface of the earth. The lower parts of the atmosphere up to 10-15 kms, contain **water –vapour** which is largely derived by evaporation from water bodies.

Q.2 What do you mean by structure of the atmosphere and explain characteristics of its various layers.

Ans There are five layers of the atmosphere:-

I. Troposphere: - The troposphere is the lowest layer of the atmosphere. It's height is 8kms near the poles and 18kms near the equator. Temperature decreases with increasing height in this layer at the rate of 1^0c for 165 metres or ascent. This is called **Normal lapse rate.** This layer contain over 90% of dust particles and water vapour. All important weather phenomena prevail over here. There is a boundary between troposphere and stratosphere which is called as Tropopause.The air temperature at tropopause is -80^0c over the equator and -45^OC over the poles.

II. Stratosphere :- The height of stratosphere is 50kms. Upto the height of 20 kms from below, the temperature remains constant . After wards it gradually increases upto the height of 50kms because of the presence of ozone gas.

III. Mesosphere :- The third layer is called as Mesosphere which is upto the height of 80kms. Temperature here decreases with increasing height to-100^{o}C.

IV. Ionosphere :- This layer is between 80 and 400 Kms. It contain electrically charged particles known as ions hence, this layer is called ionosphere. It reflect radio waves and helps in radio transmission.

V. Exosphere :- The uppermost layer of atmosphere above a height of 400 kms is called as exosphere. This layer is rarefied and gradually merges with the outer space.

Q.3 What is the structure of atmosphere based on chemical composition.

Ans. On the basis of chemical composition , the atmosphere is divided into two broad zones:-

1. Homosphere
2. Heterosphere

1. Homosphere :- It represents the lower portion of the atmosphere.It extends up to the height of of 90Kms from sea level. This zone is called homospher because of the homogencity of the proportion of various gases. It consist of three layers :-

   a. Troposphere

   b. Stratosphere

   c. Mesosphere

2. Heterosphere:- It extends from 90 kms -10,000kms. Different layers of this sphere vary in their chemical and physical properties.

Q.4 What are various factors affecting climate and weather .

Ans. The factors controlling the variation of the element of weather and climate from one place to the other are called controls of weather and climate. These factors include- latitude, Altitude,unequal distribution of land and water, ocean currents, air pressure and wind , mountain barrier ,nature of ground surface etc.

1.9 SUGGESTED READING

- *Conrad , v, fundamentals of physical climatology, Harvard university press, 2016*
- *Barry, R.G & R.J Chorley, Atmosphere, weather and climate 2013.*
- *A.Das Gupta and Element of Physical Geography; 2013*
- *Gentilli J, Geography of climate, 2005.*
- *Strahler. A, Physical Geography – John wiley and sons 2002.*

1.10 REFERENCES

- *D.S.Lal, Climatology, Sharda Pustak Bhagwan,2016.*
- *Y.K.Sharma; Physical Geography , Lkshmi Narayan Agarwal education Publishers 2013.*
- *Savindra singh :- Physical Geography; prayag pustak Bhagwan 2013.*
- *Nater singh Raina ; Contemporary Physical Geography, concept Publish company.*
- *Dr. Majid Hussain; Fundamental of Physical Geography Rawat Publications 2012.*

1.11 MODEL TEST PAPER

Note : This Paper has two sections

Section A : Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B: Contains 8 questions. Students have to answer one question from each unit. Each question carries 16marks. Answer should be limited in 450 words.

SECTION-A

Short question type (Compulsory) (8x2=16)

1. Define climate and weather?
2. What is an albedo?
3. What are various types of humidity?
4. Differentiate between tropical and temperate cyclones?
5. Name the cold currents of Indian Ocean?
6. How tides get originated?
7. What are the geographical conditions required for the growth of the coral reefs?
8. What are various types of ocean deposits?

SECTION-B

Long question type (4x16=64)

1. Discuss about the composition and structure of the atmosphere?

   OR

2. What are seasonal winds. Discuss the mechanism of monsoon winds and discuss about the distribution of monsoon winds with special reference to India?
3. What are air masses. What are factors affecting it and also discuss its various types?

   OR

4. What are the causes of tropical cyclones. Discuss about its types and distribution?
5. Discuss about the configuration of ocean floor with suitable examples?

   OR

6. What are oceanic currents. Discuss the oceanic current of pacific ocean with suitable diagrams?
7. What are waves. What are its types and how it gets originated?

   OR

8. Define coral reefs. What are the geographical conditions for the growth of coral reefs and discuss its various types?

INSOLATION AND GLOBAL HEAT BUDGET, VERTICAL HORIZONTAL DISTRIBUTION OF TEMPERATURE

Prof. Sarita Nagari

2.12. References

2.13. Model test papers

2.1 INTRODUCTION

This chapter deals with the incoming solar radiation, energy received and intensity of incoming solar radiation on an object. Solar radiation is electromagnetic in nature and is the radiant energy emitted from the sun .The visible light of sun supports life on the earth. **Insolation** is the quantity of solar radiation energy received on a surface. Incoming heat being absorbed by the earth, and outgoing heat escaping the earth in the form of radiations are both perfectly balanced. If they were not balanced, then earth would be getting either progressively warmer or progressively cooler with each passing year. This balance between incoming and out coming heat is called as Earth heat budget. In this chapter, you will also study about the distribution of temperature, how it changes horizontally and vertically.

2.2 OBJECTIVES

- To make students aware of the mechanism of radiation coming from the sun.
- To familiarize the students about the factors affecting insolation.
- To acquaint students with the global energy budget.
- To make them aware of the temperature inversion, horizontal and vertical distribution of temperature.

2.3 INSOLATION AND GLOBAL HEAT BUDGET

The radiation coming from the sun in the form of short wave solar radiation which moves at the speed of 1,86,000 miles a second is called as solar radiation / insolation.

2.3.1 Mechanism of radiation:

The solar energy is transported to the outer surface of the sun of through conduction and convection from below. The surface temperature of the sun is 6000° C or 11000° F. The solar energy radiated from the outer surface of the sun is the form of electromagnetic radiation. The electromagnetic radiation waves are expressed in terms of wave lengths (L). Wave length is the distance between two successive crests & troughs. The number of radiation waves passing through a certain point per unit time is called wave frequency. There is inverse relationship between wave length and wave frequency i.e. shorter the wave length, higher the wave frequency and its vice –versa

2.3.2 Distribution of Insolation:

The amount of insolation received at the earth's surface decreases from equator towards the poles but the insolation is received differently at different latitudes at different times of the year. At equator, it is maximum and at the poles it is minimum. Poles receive only 40% of the amount received at the equator. The data of insolation as portrayed in table 1.2

Latitudinal Distribution of Insolation

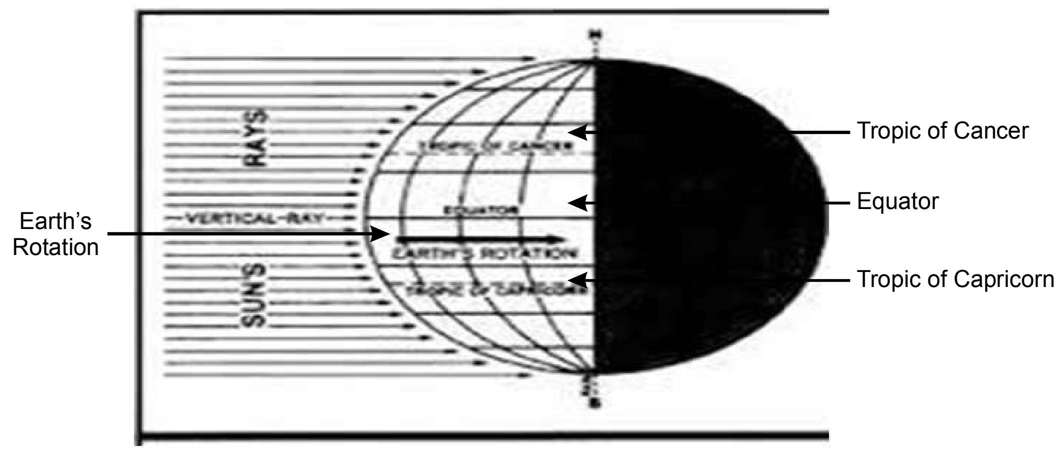
Latitudes	Insolation in %
0	100
30	88
60	57
90	42

2.3.3 Factors affecting Insolation

The amount of insolation received by the earth is governed by many factors: -

1. Angle/inclination of the sun rays.
2. Length of day
3. Distance between sun and the earth
4. Sunspots
5. Effects of the atmosphere
6. Prevailing winds
7. Ocean currents
8. Altitude

(1) **Angle of the sun rays**: - The sun rays are vertical at the equator and become oblique pole ward. Vertical rays are spread over minimum area and thus the energy received per unit area increases. On the other hand, oblique rays are spread over larger area of the earth's surface and hence the amount of energy received per unit area decreases.



Distribution of insolation & angle of sun's rays.

(2) **Length of the day**: Duration of sunshine determine the length of the day which also affects the amount of solar radiation received at the earth surface. The layer period of sun shine supply larger amount of radiation.

(3) **Distance between earth & the sun**: The average distance between earth and the sun is 93 million miles. At the time of perihelion (jan-3) the earth is nearest to the sun, this time insolation is maximum at the earth's surface. On July 4, time of Aphelion, earth is farthest from the sun and therefore earth get minimum insolation.

(4) **SUNSPOTS**: Sunspots are created in the solar outer surface due to periodic disturbances and explosions. The energy radiated from the sun increases when the number of sunspots increases therefore the amount of insolation received at the earth's surface also increases.

(5) **Effects of the atmosphere**: The solar radiation has to pass through thick layer of the earth's atmosphere where it is partly absorbed, partly reflected and partly scattered by the atmosphere and partly transmitted to the earth surface.

(6) **Prevailing winds**: The oceanic winds have the capacity to take moderating influence is cool summers and mild winters.

(7) **Oceanic currents**: Oceanic currents influence the temperature of adjacent land area considerably warm current raised temperature of the coastal area, whereas cold current lower them.

(8) **Altitudes**: Altitude has a direct effect on prevailing tem. This is because the lower layers of the atmosphere are compressed under atmospheric pressure and are closer to the earth's surface. It makes the lower layers warmer than the layers at higher land.

2.4 GLOBAL ENERGY BUDGET

The solar radiation that reaches the ground surface comprises of short wave solar radiation. Earth lost long wave terrestrial radiation. There is a balance b/w the heat coming from sun and heat lost by earth. This gain and loss in heat by way of incoming and outgoing radiation is called as heat budget.

(1) Incoming short wave solar radiation = 100%

(2) Amount lost to space = 35%

(a) Reflected by clouds = 27%}

(b) reflected by ground = 2.00]

(Albedo)

(c) Scattered energy lost to Space 6%]

Remaining solar energy = 100 – 35 = 65%

(A) Heat Budget of earth:

(i) Received through direct ration = 34%

(ii) Received as diffuse day light = 17%

Total = 51%

(B) Heat budget of atmosphere:

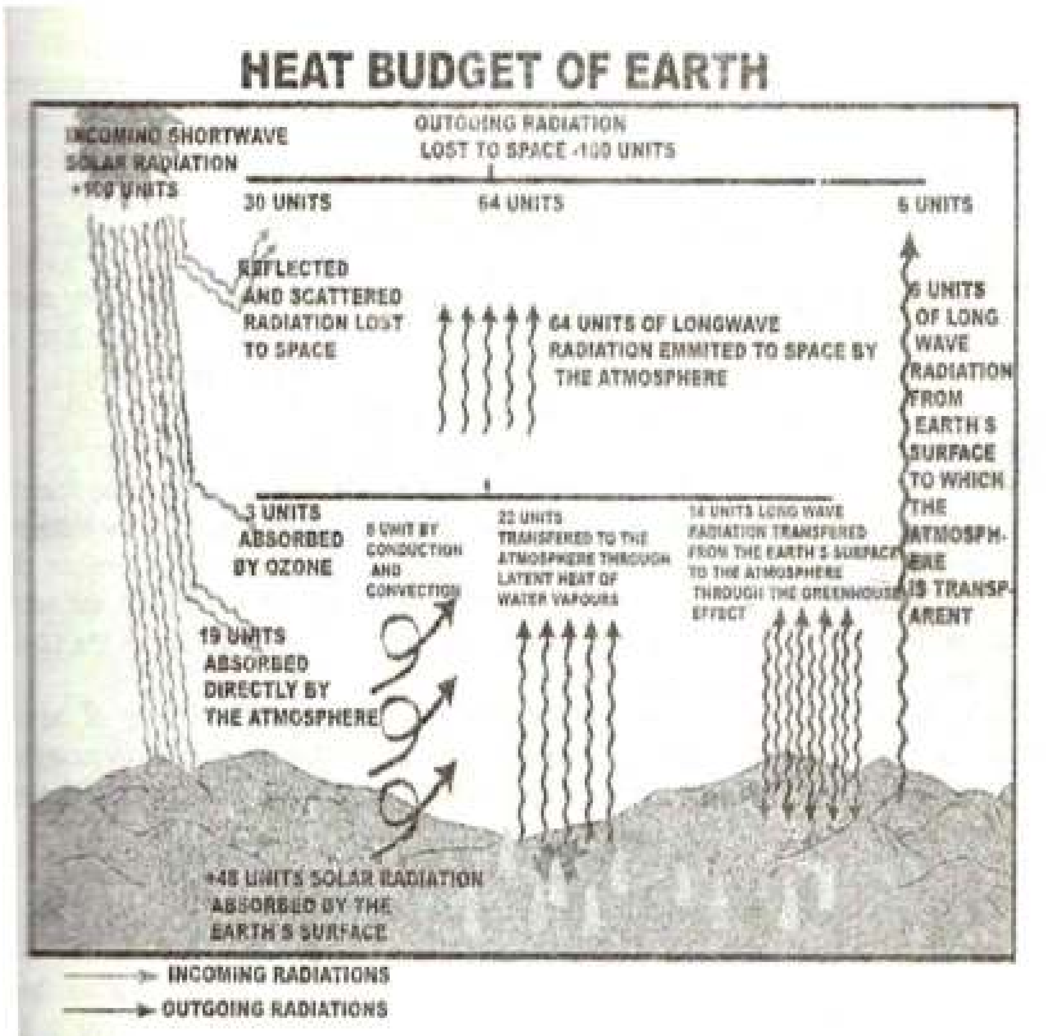
(i) Absorption of incoming solar radiation = 14%

(ii) Received from outgoing terrestrial radiation = 34%

Total = 48%

51 + 48 = 65%

(c) Energy sent back to space = 35% + 17% + 48%



2.5 VERTICAL DISTRIBUTION OF TEMPERATURE

Temperature refers to the degree of the hotness, temperature is different from heat as heat denotes the quantity of energy present in any substance. Temperature decreases with increasing height but the rate of decrease varies with seasons, location & duration of sunshine. On an average the rate of decrease of temperature is 6.5^{o} C for 100 metres. This decrease of temperature is called as **Normal lapse rate.** The atmosphere gets heat from the earth's surface through the process of conduction, radiation and convection.

2.5.1 Reasons for decrease of temperature with increasing height:

(1) Every air layer receives less heat than the air layer lying below, therefore, as the altitude increases, the amount of heat transported upward decreases.

(2) The air pressure is higher in the lower portion of the atmosphere near the earth's surface, therefore of weight of all the air layers lying above and thus the air density is maximum in the lower atmosphere but it decreases rapidly upward and the air becomes thin.

(3) The quantity of water vapour, dust particles, CO_2, water droplets are more in the lower portion of the atmosphere. As they absorb heat from the sun and the earth therefore as their concentration become less in the upper atmosphere the temperature also become low upward.

2.5.2 Temperature Inversion-Temperature decreases with increasing height in the troposphere but sometimes the temperature instead of decreasing starts increasing with increasing height. This is called Negative lapse rate.

2.5.3 Types of Temperature Inversion

On the basis of relative height, temperature inversion is of 3 main types.

Non advectional Inversion	Advectional Inversion	Mechanical inversion
(1) Ground Inversion	(1) frontal Inversion	(1) Subsidence Inversion
(2) Upper air Inversion	(2) Valley Inversion	(2) Turbulence/ Convective Inversion
(3) Surface Inversion		

2.6 HORIZONTAL DISTRIBUTION OF TEMPERATURE

Low latitudes high temperature: This change of temperature rather decrease of temperature is called as temperature gradient. The horizontal distribution of temperature is represented and studies with the help of Isotherms (line connecting the process of equal temperature).

Isotherms: The lines drawn on the map joining the places of equal temperature reduced to sea level are called as Isotherms. There is strong control of latitudes on the horizontal distribution of temperature. Isotherms run parallel to the latitudes in the East-West direction. Generally, isotherms are straight but they bend when there is junction of continents and oceans i.e. of differential heating and cooling of land & water. Isothermal lines are irregular in the Northern hemisphere i.e. of dominance of contents while as they are regular in the Southern hemisphere i.e. of over dominance of oceans. Isotherms are closely spaced in the Northern hemisphere which indicate rapid change of temperature where as there are widely space in the Southern hemisphere which shows slow rate of change of temperature.

2.6.1 Distribution of temperature in January:

(1) The month of January is coldest in the Northern hemisphere while as warmest in Southern hemisphere.

(2) On the continent of the Northern hemisphere, the isotherm for January bend sharply towards the equator.

Ideal conditions for temperature inversion: -

(i) Long winter rights

(ii) Clear sky

(iii) Relatively dry air

(iv) Calm & stable air

(v) Snow covered ground surface

(vi) Slow movement of air

(3) Because of the continentality, winter in the interior of the continent is more severe.

(4) The Western margin of the continents in the month of January are warmer than the Eastern counterpart i.e. the prevailing Westerlies carry warm temperature from the ocean towards the West.

(5) Lowest temperature is recorded near Greenland and Northern Siberia.

(6) ITCZ (Inter Tropical Convergence Zone) has shifted to the South i.e. of Southward movement of the sun.

(7) Isotherms contributes a more regular behaviour in the Southern hemisphere.

2.6.2 Distribution of temperature in January :

(1) It is summers in the Northern hemisphere and winters in the Southern hemisphere.

(2) The Isothermal behavior is the opposite of what it is in January.

(3) The Isotherms in the Southern hemisphere are more regular and straight than the isotherms of N. Hemisphere.

(4) Thermal equator now lies to the north of geographical equator.

(5) During July, oceans are cooler and land is warm i.e. isotherms move equator ward and lowest temperature over Greenland.

Seasonal distribution of temperature:

2.7 SUMMARY

In this chapter, you have studied about the vital aspects of insolation and heat budget. The sun is a great engine that drives wind on the earth's surface, ocean currents, exogenetic and denudational processes and ultimately sustains life in the biosphere. You have also studied about the atmosphere temperature, its vertical and horizontal distribution. How it varies in different pats of the world in different months.

2.8 GLOSSARY

- Insolation :- incoming solar radiation.
- Electromagnetic radiation:- it refers to the waves propogating through space carrying electromagnetic radiant energy.
- Inclination:- disposition or bent.
- Isotherms:-imaginary lines connecting the places of equal temperature.

2.9 MULTIPLE CHOICE TYPES QUESTIONS AND THEIR ANSWER

1. The isolation reaching the earth's surface is equal to :-

   a. 23 billion horse power.

   b. 15 billion horse power.

   c. 5 billion horse power.

   d. 10 billion horse power.

Ans. (a) 23 billion horse power.

2. The highest temperature are recorded :-

   a. In the late evening.

   b. At midnight

   c. In the afternoon

d. In the morning.

Ans (c) In the afternoon

3. The albedo of the earth is :-

a. 25 %

b. 50%

c. 35%

d. 10%

Ans. (c) 35%.

4. The specific heat of water is :-

a. 1

b. 3

c. 5

d. 4

Ans. (a) 1

5. Isotherms are used to show the horizontal distribution of :-

a. Salinity

b. Temperature

c. Pressure

d. Rainfall.

Ans. (b) temperature.

2.10 EXAMINATION ORIENTED QUESTIONS

Q.1 Define solar insolation?

Q.2 Name the factors affecting Solar insolation .

Q.3 What is temperature. How does the process of conduction, radiation and correction works in heating and cooling of atmosphere.

Q.4 What do you mean by inversion of temperature and discuss about its types?

<u>Types of Temperature inversion:-</u>

The temperature inversion is classified in to following types on the basis of relative heights:-

1. Non advectional inversion.

   a. Ground inversion.

   b. Upper air inversion.

2. Advectional inversion

   a. Frontal inversion

   b. Valley inversion

3. Mechanical inversion

   a. Subsidence inversion

   b. Turbulence inversion.

Factors affecting inversion of temperature:-

1. Long nights
2. Clear sky
3. Stable weather
4. Any air
5. Ice cover
6. Incoming cool air mass.

2.11 SUGGESTED READINGS

- *Dr. Majid Hussain :- Fundamental of physical geography 4th edition Rewat Publications.2012.*
- *Dr. A. Ahmad :- physical Geography, omega-Publication 2010.*
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- *Dr. Y.K. Sharma: Narain's physical geography; 2014.*
- *Dr. Savindra Singh; Climatology; 2012.*

- *Dr. D.S.Lal; Climatology; 2012.*
- *Surjeet Publications; Fundamentals of climatology,2008.*

2.13 MODEL TEST PAPER

Note: This Paper has two sections

Section A: Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B: Contains 8 questions. Students have to answer one question from each unit. Each question carries 16marks. Answer should be limited in 450 words

SECTION-A

Short question type(Compulsory) (8x2=16)

1. Differentiate between weather and climate?
2. What is insolation. Name the factors affecting it?
3. What are local winds. Give suitable examples?
4. Define relative humidity?
5. What is occluded front?
6. Differentiate between tides and waves?
7. Discuss about the vertical distribution of temeprature?
8. What are the basis of koppens classification?

SECTION-B

Long question type (4x16=64)

1. Discuss about the global heat budget with suitable diagrams?

   OR

2. Define winds. Discuss various types of winds?
3. What is temperate cyclones. What are the causes of temperate cyclones and also

discuss its distribution?

OR

4. Give a detailed critical appraisal of koppen's climatic classification?
5. Discuss about the horizontal and vertical distribution of temperature of oceans?

   OR

6. What are the causes and types of Atlantic Ocean currents with diagram?
7. Define tide. What are various types of tides and explain about it's origin?

   OR

8. What are the various types of deposits found at the ocean bottom and discuss about it's source.

ATMOSPHERIC PRESSURE :- VERTICAL AND HORIZONTAL DISTRIBUTION OF PRESSURE

Dr. Rakesh Jasrotia

3.1 INTRODUCTION

Air being a physical substance is an admixture of several gases present in the atmosphere and hence has its own weight. Thus, the air exerts pressure through its weight. Air pressure is defined as the force per unit area or total weight of mass of column of air above per unit area at sea level.

Air pressure is measured in terms of height of mercury in the glass tube in a mercurial barometer. The standard air pressure at sea level is 1013.25mb or 29.92 inches or 76 cm at a temperature of 15°C at the latitude of 45°. Air pressure is measured with the help of mercurial barometer, aneroid barometer, altimeter, barograph, microbarograph etc.

The lines joining the places of equal pressure at sea level are called isobar. Air pressure decreases with increasing altitudes at the rate of o.1 inch or 3.4 mb per 600 feet but this rate is confined to the altitude of a few thousand feet only i.e. 1800 feet.

The standard atmospheric air pressure varies both horizontally and vertically, seasonally and diurnally.

3.2 OBJECTIVES

1. To give the knowledge of atmospheric pressure and causes of variations in atmospheric pressure to the students.
2. To explain the vertical and horizontal distribution of pressure.
3. To aware the students about the general pattern of atmospheric pressure.

3.3 PRESSURE GRADIENT

A pressure gradient is the rate of change (gradient) of atmospheric (barometric) pressure with regard to horizontal distance at a given point in time. The value is usually expressed in mb per 100 mi. Generally pressure gradient is defined as decrease of pressure between two isobars of different values i.e. from high pressure to low pressure.

Pressure gradient is also called as barometric slope. Closely spaced isobars denote steep pressure gradient while widely spaced isobars are indicative of gentle or low pressure gradient. The wind velocity depends upon pressure gradient.

3.3.1 Pressure Types

Air pressure is generally divided into two types, namely high pressure and low pressure which are indicated by the shapes of isobars. Since there are much variations in the size and duration of high and low pressures displayed by almost closed isobars and hence these are termed as pressure systems which are again divided into:

1) **High Pressure Systems:-** These are characterized by highest air pressure in the centre of almost closed isobars wherein the pressure decreases from centre outward and the lowest pressure is found at the outer margin of the high pressure system. The high pressure in the centre is called high and is displayed by H on weather maps. This system is also called as anticyclone. These are most common in the sub tropical high pressure belt and absent in the equatorial region. These are further divided into cold high pressure system (which indicates high pressure in the Polar Regions due to very low temperature and snow covered surface) and warm high pressure system (which is developed due to the subsidence of the air from above in the sub tropical areas).

2) **Low Pressure Systems:-** These are also called as low or simply L or cyclones or depressions. These are the centres of low pressure having increasing pressure outward and closed air circulation from outside towards the central low pressure in such a way that air blow inwards in anti clockwise direction in the northern hemisphere and clockwise direction in the southern hemisphere. They range in shape from circular, elliptical to V shape. Due to coriolis force and the Ferrel's law the winds are deflected to their right in the northern hemisphere and cross the isobars at very low angle and the spiral pattern of wind circulation becomes anti clockwise in the northern hemisphere while the trend is reversed in the southern hemisphere. They are further divided into heat lows which are thermally induced and dynamic lows which are dynamically induced. Low pressure systems are indicative of humid weather conditions.

3.3.2 Variations in Atmospheric Pressure

Air pressure varies both spatially and temporally, horizontally and vertically. As regards temporal variations in atmospheric pressures, diurnal and seasonal variations are climatically more important. The 24-hourly average of atmospheric pressure at sea level is called daily mean pressure which is more or less constant.

1) **Daily variations** of air pressure is controlled by heating of the ground surface and boundary air layer by solar radiation, called as insolational heating, and cooling of the ground surface and boundary air layer by outgoing terrestrial radiation, called as terrestrial cooling. The insolational heating results in the development of low pressure due to ascent and expansion of warm air while radiational cooling results in high pressure due to descent and contraction of cold air. The difference of time between the occurrence of daily maximum temperature and lowest pressure on the one hand, and minimum daily temperature and highest pressure is termed as pressure lag. Daily pressure is characterized by two maxima at 10 a.m. and 10 p.m. and two minima at 4 a.m. and 4 p.m. This is called semi-diurnal oscillation.

2) **Seasonal pressure variations** are related to changes during summer and winter seasons. Seasonal pressure variation is also called annual pressure variation. The equatorial zone displays smallest seasonal variations in the pressures because the amount of insolation received at the ground surface remain almost constant throughout the year. The tropical and sub-tropical areas receive the largest seasonal variations of atmospheric pressure due to extreme weather conditions during summer and winters

3) **Vertical pressure variation** denotes decrease of air pressure with increasing altitude because of decrease in air density with increase in height from sea level. The density depends upon volume of air and the volume depends upon expansion and contraction of air which are the result of heating and cooling of air respectively. The extending air expands aloft and becomes less dense resulting in the decrease of air pressure but the rate of decrease of in pressure is not constant, rather the rate of decrease also varies with altitude.

3.4 VERTICAL DISTRIBUTION OF AIR PRESSURE

The air pressure decreases with height. This fact is easily experienced by mountaineers. The mountaineers experience breathing and other troubles while they are scaling high peaks. Due to low pressure, blood oozes out of their nostrils and their lungs work feverishly. If the pressure is very low the mountaineers fall down and lose consciousness.

The study of air pressure at high levels was made with the help of balloons which are fitted with meteorological instruments. Man has also ascended in balloons. Adams and Stevens tried to reach a height of 21,945 meters in 1935. Major Simon created a world record by reaching a height of 30,937 meters in 1958. It is necessary for meteorologists to study the upper air of the atmosphere.

Vertical Distribution of Air Pressure

Height (Meters)	Height (Feet)	Air Pressure (Inches)	Air Pressure(Mb)
5486	18,000	14.94	5.56
5181	17,000	15.56	
4907	16,000	16.21	
4572	15,000	16.88	
4267	14,000	17.57	
3962	13,000	18.29	
3656	12,000	19.03	
3351	11,000	19.79	
3048	10,000	20.58	666.8
2743	9,000	21.38	
2438	8,000	22.22	
2133	7,000	23.09	
1828	6,000	23.98	
1524	5,000	24.89	
1219	4,000	25.84	875.1
914	3,000	26.81	
609	2,000	27.82	
304	1,000	28.85	
Sea Level	Sea Level	29.92	1013.2

3.5 HORIZONTAL DISTRIBUTION OF PRESSURE AND PRESSURE BELTS

The horizontal distribution of air pressure on the globe is studied on the basis of isobars.

Air pressure is generally divided into two type's viz. (i) high pressure also called as high or anticyclone, and (ii) low pressure, also called as low or cyclone or depression. The regularity of pressure belts is distributed due to unequal distribution of land and water. The pressure belts are discontinued in northern hemisphere and several centres of pressure belts are developed but they are more are less regular in southern hemisphere. If the air pressure would have been the functions of temperature alone there should have been regular increase of pressure from equator towards poles but this is not the case as there are sub polar low pressure belt.

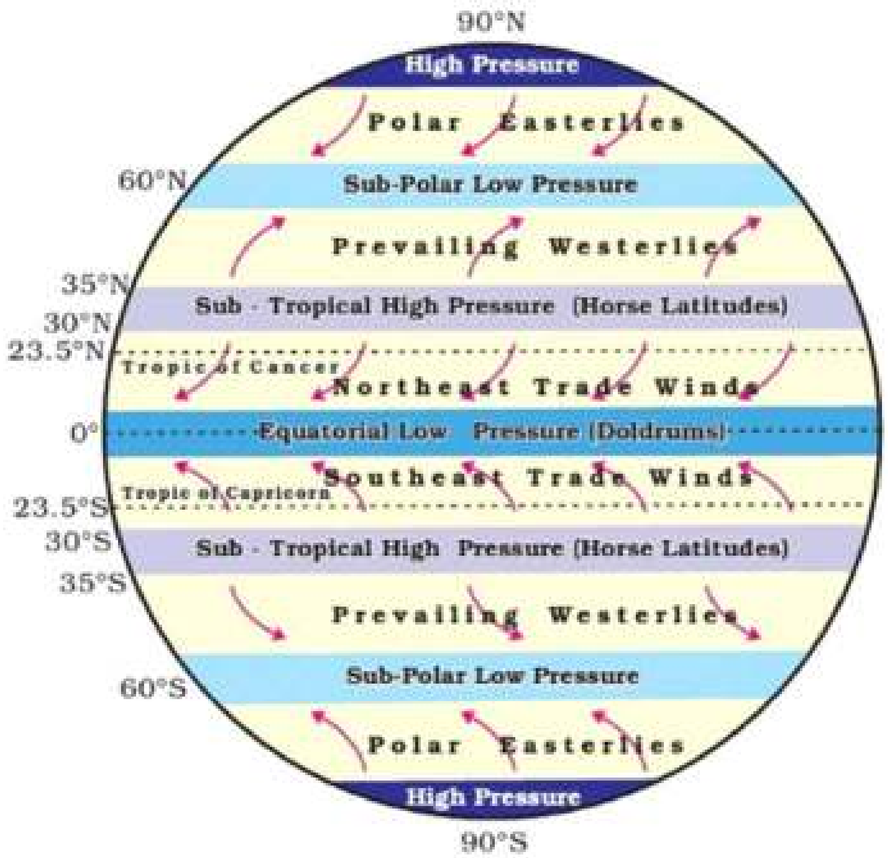
3.5.1 Latitudinal distribution of pressure

There is no definite trend of distribution of pressure from equator towards the poles. If the air pressure would have been the function of air temperature alone then there should have been regular increase of pressure poleward because temperature regularly decreases from equator towards poles but this is not the case. There is low pressure near the equator due to high mean annual temperature but the existence of high pressure belts near the tropics of cancer and Capricorn cannot be explained on the basis of temperature because the tropics record very high temperature and hence there should have been low pressure if the temperature would have been the only control of air pressure. The air pressure should increase poleward from the tropic of cancer and Capricorn because there is rapid rate of decrease of temperature poleward but we find low pressure belt near 60° latitude.

It is obvious that pressure belts are not only induced by thermal factor but they are also induced by dynamic factor.

On the basis of mode of genesis pressure belts are divided as:

1. Thermally induced pressure belts:-
   - (i) Equatorial low pressure belt
   - (ii) Polar high pressure belt
2. Dynamically induced pressure belts:-
   - (i) Sub-tropical high pressure belt
   - (ii) Sub-polar low pressure belt



Major Pressure Belts and Wind System

(a) Equatorial low pressure belt:-

The equatorial low pressure belt is located on the either side of the geographical equator in the zone extending between 5° North to 5° South latitude but this zone is not stationary because there is seasonal shift of this belt of this belt with the northward (summer solstice June 21st) and southward (winter solstice 22nd Dec) migration of sun.

This belt is thermally induced because the ground surface is intensely heated during the day due to almost vertical sun rays. Thus the warm air expands become light and consequently rise upward causing low pressure. This belt represents zone of convergence of northeast and southeast trade winds. There are light feeble and variable winds within the convergence belt because of frequent calm conditions this belt is called belt of calm or doldrums.

(b) Sub-tropical high pressure belt or horse latitude:-

This belt extends between 20°-25° latitude in both the hemisphere. This belt is not thermally induced, because besides due to three winter months, receives fairly high temperature throughout the year. Thus belt owes its origin to the rotation of earth and sinking and setting down of wind. Thus it is dynamically induced. The convergence of winds at higher altitude above this zone results in the subsidence of air from higher altitudes. Thus decent of winds in the contraction of their volume and ultimately causes high pressure that is why this zone is characterized by anticyclonic conditions which cause atmospheric stability and aridity. This is one of the reasons for the presence of hot deserts of the continents in a zone extending between 25°-35° latitude in both the hemispheres. This zone of high pressure is called horse latitude because of prevalence of frequent calms. This zone of high pressure is not continuous belt but is broken into number of high pressure centres and cells.

(c) Sub-polar low pressure belt:-

This belt is located between 60°-65° latitude in both hemispheres. This low pressure does not appear to be thermally induced because there is low temperature throughout the year and as such there should have been high pressure instead of low pressure belt. Thus this belt is dynamically induced. Infact surface air spreads outwards from this zone due to rotation of earth and low pressure is created. Thus, due to verification of this belt there is low pressure instead of high pressure.

(d) Polar high pressure belt:-

High pressure persists at the poles throughout the year because of low temperature throughout the year. Infact both the factors thermal and dynamic operate at the poles. There is thinning out of layers of air due to diurnal rotation of earth as the air spreads outwards due to this factor but this factor is over shadowed by the thermal factor and high pressure is produced due to very low temperature.

Isobaric horizontal distribution of air pressure

Isobars are the imaginary lines on a map joining places of equal pressure at sea level.

The seasonal (annual) horizontal distribution of air pressure is represented and studied through isobars for the months of July and January in the northern hemisphere.

3.5.2 Meridional distribution of pressure

Meridional pressure distribution means average seasonal sea level pressure for all the longitudes. It may be mentioned that sea level pressure for all the longitudes for a latitude are averaged to show the meridional seasonal pressure profiles for the study of seasonal variations in pressure belts in summer and winter hemisphere.

Shifting of pressure belts

The surface pattern of air pressure seldom remains stationary in its latitudinal zone. There are daily, seasonal and annual changes in the air pressure because of northward and southward movement of the overhead sun, contrasting nature of the heating and cooling of land and water etc. The lowest pressure is developed between 2 to 4 p.m. during the day due to maximum temperature while the highest pressure is recorded between 4-6 a.m. due to minimum temperature during night. Coastal lands record low pressure while adjoining oceanic area has high pressure during the day. This situation is reversed during the night.

3.5.3 The Horizontal Distribution of air pressure in January- A study of the weather map of this month reveals the following facts-

(1) Equatorial Low Pressure belt situated in the south of the equator because the sun shifts south of equator this month. The main low pressure cells are situated in Australia, South America and Africa.

(2) In Southern hemisphere sub tropical highs are clearly visible in oceans because it is the summer season and water is colder than the land. In Northern hemisphere high pressure cells are not properly developed in semi-tropical areas but appear as a long high pressure ridge.

(3) The low pressure trough in semi-tropical bet in southern hemisphere is deep and continuous but there are two low pressure cells in the sub tropical areas of northern hemisphere which exist in the northern Atlantic and northern Pacific ocean.

(4) In eastern central Asia there is a fully developed and broad based high pressure cells which has all the characteristics favourable for intense heating. No such cell

with such a high pressure is found in Northern America.

3.5.4 Horizontal Distribution of air pressure in July- The following facts emerge out from a study of the world map depicting pressure in the month of July:

(1) The equatorial low pressure trough has shifted towards the north of equator in summer following the corresponding shift of the sun.

(2) The whole of the pressure system has shifted to the north following the shift of the sun.

(3) The sub polar high pressure system extends in the form of a long trough in southern hemisphere but the low pressure cells in northern hemisphere are very feeble.

(4) Centres of low pressure have developed in Asian continent and north-west North America. This disrupts the sub-tropical high pressure system.

3.6 SUMMARY

Air pressure is invisible element of weather which influences the other weather elements in a significant way. Air pressure is closely tied to other elements of weather in cause-and-effect relationship. Variations in the air pressure from place to place are responsible for the movement of winds which serve as a means of transporting heat and moisture from one region to another. Like any other material object the air also has weight. The pressure of air at a given place is defined as a force exerted in all directions in consequence of the weight of all air above it. Thus, the mass of a column of air above a given point determines the atmospheric pressure at that point. Air pressure, therefore, is defined as the force exerted against a surface by continuous collision of gas molecules. The amount of pressure exerted by air at a particular point is determined by two factors, namely, temperature and density. It is obvious that pressure belts are not only induced by thermal factor but they are also induced by dynamic factor. On the basis of mode of genesis pressure belts are divided as Thermally induced pressure belts and Dynamically induced pressure belts.

3.7 GLOSSARY

Equatorial zone: Latitude zone lying between 10^0S and 10^0N and centred on the equator.

North East Trade winds: Surface winds of low altitudes that blow steadily from the north east.

North Pole: Point at which the northern end of the earth's axis of rotation intersects the earth surface.

Pressure gradient force: causes air to move from areas of higher barometric pressure to areas of lower barometric pressure due to pressure differences.

Pressure: force per unit area.

3.8 SHORT ANSWER QUESTIONS

Q1. Define Air Pressure?

____

____

____

Q2. Define equatorial trough.

____

____

____

Q3. What is Horse latitude?

____

____

____

3.9 EXAMINATION ORIENTED QUESTIONS

1. Define Air pressure. Give the Horizontal distribution of air pressure.
2. Discuss in detail the major pressure belts of the world.
3. Define Air pressure. Give the horizontal distribution of air pressure in the months of January and July.

4. Discuss in detail the causes of variations in the air pressure.
5. "The air pressure decreases with height". Elaborate this statement.
6. Disuss the general distribution of pressure over the globe and show its effects on wind system.

3.10 SUGGESTED READINGS

Singh, Savindra.,2013, Physical Geography, Pravalika Publications, Allahabad.

Husain, Majid., 2001, Fundamentals of Physical geography,rawat publications, Jaipur and New delhi

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Strahler,S.,1996, Physical Geography, New York, John Wiley & Sons.

Lal, D.S., 2000, Climatology, Sharda Pustak bhawan, Allahabad.

Tikka, R.N., 1994, Physical Geography, Kedar NathRam Nath & Co, Meerut.

3.12 MODEL TEST PAPER

Time allowed- 3 hours **Maximum marks-80**

Note: This paper has two sections.

Section A: Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each.

Section B: Contains 8 questions. Students have to answer 4 questions from each Unit. Each question carries 16 marks. Answer should be limited in 450 words each.

Section A

All questions are compulsory

1. Distinguish between Insolation and Albedo.

2. Define Horse Latitudes.
3. Define relative Humidity.
4. Define Cyclone.
5. What a continental slope.
6. Define Gulf Stream Current.
7. Define Perigean tides.
8. What are Oozes deposits?

Section B

Attempt one question from each unit.

UNIT I

1. What is Global Heat Budget? Explain diagrammatically.
2. Elaborate the causes of winds motion and direction. Discuss the types of winds.

UNIT II

3. Define Fronts. Explain their formation. Discuss the types of fronts.
4. What are the bases of Koppen's climate classification? Discuss the Koppen's scheme of the World Climate Regions.

UNIT III

5. Define Ocean salinity. Elaborate the factors controlling this salinity. Discuss the horizontal salinity of Oceans.
6. What are Ocean currents? Discuss the ocean currents of the Indian Ocean.

UNIT IV

7. Define Ocean waves. How do they originate. Discuss the types of waves.
8. What are different sources of ocean deposits? Discuss the types of ocean deposits on the basis of their origin.

Course No. GO-301 **Unit-1**

Semester III **Lesson-4**

WINDS- CAUSES AND TYPES
(PLANETARY, PERIODIC AND LOCAL WINDS)

Dr. Rakesh Jasrotia

4.1 INTRODUCTION

Wind has been defined as air in motion. Wind is the horizontal movement of the air that is caused by differences in pressure. Air flows from areas of high pressure to areas of low pressure. Horizontal movement of the air is called wind. Air flows from areas of high pressure to areas of low pressure. Horizontal movement of the air is called wind. According to Byres, "the wind is simply air in motion, usually measured only in its horizontal component". According to Threwarth, "Wind is simply air moving in a direction which is essentially parallel with the earth surface. In meteorology the term 'wind' refers to the horizontal movement of air relative to the earth's surface. Winds are the means by which uneven distribution of pressure over the globe is balanced out. Winds have been considered by meteorologist as an essential part of the thermodynamic mechanism of atmosphere which serves as means of transporting heat, moisture and other properties from one part of the earth to another.

The winds move fast where the pressure gradient is steep. Weak pressure gradient gives rise to the feeble winds which blow slowly. An instrument known as Anemometer is used to measure wind speed.

Winds are caused by the uneven heating of earth by the sun. Winds can be characterised on the bases of their direction, deflection and, speed. Wind Direction can be measured with the help of wind vane.

4.2 OBJECTIVES

1. To aware the students about the wind pattern.
2. To familiarise the students with the direction and velocity of winds.
3. To explain in detail about the various types of winds to the students.

4.3 FACTORS AFFECTING DIRECTION AND VELOCITY OF WIND

Direction and speed of wind are controlled by a combination of factors. These are the pressure gradient force, the coriolis force, altitude, latitude, rotation of earth, the centripetal acceleration and friction.

4.3.1. Pressure Gradient: The greater the difference in pressure between two points, the steeper is the pressure gradient and the higher is the wind speed. Since the direction of the force is from higher to lower pressure area and perpendicular to the isobars, the wind blows parallel to the gradient and at right angles to the isobars.

4.3.2. Coriolis Force: The earth rotates on its inclined axis. If it did not, winds would follow the direction of the pressure gradient. But the rotation produces another force other than the pressure force. It is called the 'Coriolis force', which deflects the air.

The deflection is the least at the Equator and greatest at the Poles. This tends to turn the flow of air by changing its direction from its original straight path. The wind starts deflecting to its right in the Northern Hemisphere. In the Southern Hemisphere it starts deflecting to its left from its original path. Thus a wind blowing from north becomes north-easterly in the Northern Hemisphere. A wind blowing from south becomes south-easterly in the Southern Hemisphere, e.g. North East Trade winds. This is due to maximum speed of rotation at the Equator, hence the deflection is less.

4.3.3. Rotation of the Earth: The rotation of the earth causes the air at the Poles to be thrown away towards the Equator. In theory, this should result in air piling up along the Equator to produce a belt of high pressure, whilst at the Poles low pressure should develop. But what actually happens is explained under the heading Pressure Belts in this Chapter. It is to be noted that temperature and rotation together affect the pressure pattern.

4.3.4. Altitude: Vertically, pressure decreases with increase in altitude. The rate of decrease with height is however, not constant. Many factors like the slope of the land, presence of winds and the temperature affect the pressure of air vertically. As stated above, at ground level the pressure varies between 940 mb to 1040 mb. At a height of 3000 metres, the pressure may be just 700 mb. This means the rate of decrease is 100 millibars per 1000 metres of height gained. At high altitudes, there is a cover of thin air which has both low pressure and a low capacity to hold heat. This is one of the reasons that mountaineers take oxygen supplies with them while going up high altitudes.

4.3.5. Latitude: When the temperature of a place rises, air expands; this makes the air less dense, and so its pressure decreases. When the temperature falls, air becomes dense and its pressure increases. Temperature and pressure are inversely related. It is because of high temperature that we find a belt of low-pressure around the earth at the Equator. At the Poles, because of extremely low temperature, high pressure exists. There are in-blowing winds and uplifting air currents in the hot regions of low pressure. There are out-blowing winds and sinking air currents in the cold regions of high pressure. The uplifting air currents are called convection currents. The more the pressure, the more is the speed of the wind. Because of the 'migration' of the sun, the heat zones are not constant. So the winds direction and speed are affected.

4.3.6. Friction: Near the earth's surface wind does not move freely in a horizontal plane due to irregularities in the earth's surface. Friction determines the angle at which the air will flow across the isobars. It may also alter wind direction. Over relatively smooth ocean surface, friction will be low and the air will move at comparatively lower angle to the isobars and hence at a greater speed. Over rugged terrain, friction will be high and therefore, the angle of the air flow will also be high and the speed much reduced.

4.4 TYPES OF WINDS

1. **Permanent or Prevailing or Planetary Winds**
2. **Periodic Winds**.
3. **Local Winds.**

Permanent or Prevailing or Planetary Winds

There are some winds which blow throughout the year from one latitude to the other in response to the latitudinal differences in air pressure. Planetary winds comprise winds distributed throughout the lower atmosphere. The winds blow regularly throughout the year confined within latitudinal belts, mainly in north-east and south-east directions or from high pressure polar-regions to low pressure regions.

Periodic Winds

Certain winds reverse their direction periodically with season and are called

Periodic Winds.

Local Winds

There are certain winds in different parts of the world which flow in comparatively small area and have special characteristics. The local winds include the sea and land breeze created due to the pressure difference between the air over the sea and the land regions. These are called Local Winds.

4.5 Description of winds

4.5.1. Permanent winds

a) The Trade Winds

The winds blowing from the Sub-Tropical High Pressure area (30°N and S) towards the Equatorial Low Pressure belt are the extremely steady winds known as the trade winds. The Trade Winds are a result of a pressure gradient from the Sub-Tropical Belt of High Pressure to the Equatorial Belt of Low Pressure.

In the Northern Hemisphere, the wind moving towards the Equator is deflected by the earth's rotation to flow south-west ward. Thus, the prevailing wind there is form the North East, and it has been named as the 'North East Trade'. In the Sothern Hemisphere, deflection of wind is towards the left, this causes the 'South-East Trades'. They are also known Tropical Easterlies, and they blow steadily in the same direction. They are noted for consistency in both force and direction.

Characteristics of Trade Winds: They blow from Sub-tropical High Pressure to Equatorial Low Pressure.

(i) Since they are warm winds, they pick up moisture and are responsible for heavy rainfall on eastern sides of tropical lands.

(ii) They are called North-East Trades in Northern Hemisphere and South East Trades in Southern Hemisphere. The winds and pressure belts move a few degrees north and south along with the movement of the overhead sun.

(iii) They have fixed velocity and are regular.

(iv) They are permanent or prevailing winds.

b) The Westerlies

The Westerlies or the Prevailing Westerly Winds blow between 35° and 60° North and South latitudes from the Sub-Tropical High Pressure Belts towards the Sub-Polar Pressure Belts.

In the Northern Hemisphere, the Westerlies generally blow from the south-west to the northeast, and in the Southern Hemisphere from the north-west to the south-east. These are **on-shore winds** on the west coasts and **off-shore winds** on their east coasts. The on-shore winds bring rainfall while the off-shore wands do not bring rainfall.

Westerlies bring heavy rainfall to the eastern coasts of continents lying within the Tropics. On the western coasts of continents, these winds do not bring any rainfall. Therefore, the western areas within the tropics suffer from aridity. The great deserts of the Sahara, Kalahari, Atacama and the Great Australian Deserts all lie on the western margins of the continents, within the tropical latitudes. ‘

Characteristics of Westerlies

(i) They blow from Sub-tropical High Pressure to Sub-polar low.

(ii) They are very strong winds, and most often blow from the western side of land mass.

(iii) They are interspersed by cyclones and cause light drizzle.

(iv) They arc stronger in the southern hemisphere as there is absence of land mass.

c) The Polar Easterlies

The winds that originate in the North and South Polar regions and blow towards Circum-polar Low Pressure Zone are known as Polar Winds. They start from Polar High Pressure Zone, and originate from ice capped land-mass in Arctic and Antarctic latitudes. In the Northern Hemisphere, they blow from the north-east, and are called the North-East Polar Winds; and in the Southern Hemisphere, they blow from the south-east and arc called the South-East Polar Winds.

Characteristics of Polar Winds

(i) They are very cold winds.

(ii) They are also referred to as Polar easterlies from the direction in which they blow.

(iii) When they blow over oceans they become warm.

4.5.2. Periodic winds

Periodic winds blow at regular intervals or in regular cycles. They are winds that result from localised differences in pressure and temperature. For example, land Sea breezes and the Seasonal winds.

a) LAND AND SEA BREEZES

They are caused by differential rate of heating of the land and the sea.

In day time land gets heated faster than the adjoining sea. This creates a low pressure zone on the land and high pressure zone over the sea. Thus the winds blow from sea to land and are called Sea Breezes. At night reverse of this happens and winds blow from land to sea and are called Land Breezes.

Monsoons are periodic seasonal winds blowing in the regions of South East Asia and Northern Australia. The word 'monsoon' is derived from the Arabic word Mausim meaning 'season'. They develop because of differences in heating conditions of the continent and the oceans. They are divided into two wind systems—the Summer Monsoon and the Winter Monsoon.

b) SUMMER MONSOONS

In summer the land gets more heated than the sea. Hence there develops a centre of low pressure on the land. Over the adjoining sea the air is comparatively cool, and a high pressure develops there. This causes the winds to blow from the sea to the land. It is the 'Summer Monsoon'.

In May, June and July, the plains of India and China are heated by the vertical rays of the sun. The intense heat develops a continental low pressure. During these months, over the Indian Ocean, a high pressure area develops. So, the winds blow from the Indian Ocean northward and north-westward into Asia . As they blow from the sea to the land, they bring heavy rainfall to South-East Asia. The summer monsoon winds blow south-west; so they are known as the 'South-West Summer Monsoon.'

c) WINTER MONSOONS

During winter season, the conditions are just reverse of those of summers. A high pressure develops over a big land mass stretching from Central Asia upto north-west Indian plain. At the same time a low pressure zone develops in the Indian Ocean. As the winds blow from the land to the sea, they bring cold dry weather. They are incapable of producing rain.

When these winds blow over seas and pass over the adjoining land, they bring some rainfall. The Southern Coromandel Coast (Tamil Nadu) in India and the Vietnamese Coast and the west coast of Japan get rain from winter monsoons. The winter monsoon winds blow north-cast; so the monsoon is known as the 'North-East Winter Monsoons'.

4.5.3 Local Winds

Local winds are restricted to a certain place only. They may be warm or cold depending upon the area from which they blow. The local winds in general are developed as a result of local temperature, pressure and humidity variations. The main causes for the development of local winds are:

1. Unequal heating of land and sea resulting into the land and sea brezzes.
2. Heating and cooling of the mountain slopes.
3. Local winds originating of the deformation of air currents, crossing of mountain ranges, valleys and physical barriers.
4. Convectional local winds, caused by steep pressure gradients and steep variations in local temperatures.

- **Loo:** In the plains of northern India and Pakistan, sometimes a very hot and dry wind blows from the west in summer in the afternoons. It is known as loo. Its temperature invariably ranges between 45°C and 50°C. It may cause sunstroke to people.
- **Foehn and Chinook**: A strong warm wind develops on the leeward side of the Alps. Due to regional pressure gradient, stable air is forced to cross the barrier.

As the air ascends the southern slopes of the Alps, it expands and cools. Condensation takes place when the air is saturated, causing rain and snowfall on the higher slopes. However, on descending the northern slopes, the wind experiences an increase in pressure and temperature. Due to this air is compressed and warmed. Most of its moisture is lost and it reaches the valley bottom as a dry. hot wind, called the Foehn. The temperature of the wind is from 15°C to 20°C. The wind is of use for melting snow and it hastens the ripening of grapes. Similar kind of wind in the USA and Canada move down the west slopes of the Rockies and are known as chinooks. The word chinook literally means 'snow eater.

- **Santa Ana:** Santa Ana is a warm and dry local wind that occurs in the United States of America. It resembles Chinook.the wind occurs when cold air accumulates in the Great basin and starts overflowing through the mountain valleys and spreads out onto lowlands. Santa Ana types winds are so warm and dry that they pose a great threat to California orchards. Under their impact the trees get dried up and there are large scale forest fires.

- **Sirocco:** Sirocco is the local name given to hot, dry and dusty winds blowing from Sahara Desert over central Mediterranean and southern Italy in front of an advancing depression. In general, the term Sirocco is applied to any hot and dry wind associated with the warm sector of an advancing extra tropical cyclone and heated by passing over hot and dry land area.

- **Khamsin:** It is a hot, dry, southerly wind that blows in Egypt in spring time. Since these local winds have their origin in hot deserts, they are not only hot but also carry a lot of fine sand particles. Whenever temperate cyclones pass over the Mediterranean, such dust storms originating in the hot deserts occur on their forward side.

- **Simoom:** Simoom is an intensely hot and dry wind of the Asiatic and African deserts. They take their origin from the warm tropical continental air masses. These winds are very dusty and suffocating. They produce very oppressive weather.

- **Mistral:** During winter, areas adjacent to highlands may experience a local cold wind which originates over the snow capped mountains or highlands and blows down the valley. These winds have been given local names. The most famous is the mistral that blows from the Alps over France towards the Mediterranean Sea. Even though the skies are clear, the mistral brings down the temperature below freezing point.

- **Harmattan:** Harmattan is a dry, dusty wind of the west coast of Africa blowing from the deserts. These winds also originate in Sahara Desert in winter. These dry and dusty winds blowing towards Guinea, where the air is hot and humid, provide some relief to the inhabitants of the affected area. In hot and humid regions, harmattan has a cooling effect because of the process of evaporation taking place in them.
- **Blizzard:** it is a violent and extremely cold wind laden with dry snow picked up from the ground. Blizzard represents a severe weather condition characterized by very low temperatures, strong winds, and a great amount of snow. These cold winds have subfreezing temperature and carry abundant supply of ice- crystals and snow. Such blizzards are of common occurrence in the Antarctic.
- **Bora:** In the region of eastern shore of the Adriatic Sea, a cold, dry north easterly wind blowing down from the mountains is called Bora. These winds blow in very strong gusts with velocities ranging from 128 km to 196 km per hour.

These local winds often have a considerable effect on climatic conditions, notably on the temperature of a place.

4.6 SUMMARY

Wind refers to the horizontal movement of air relative to the earth's surface. Even though horizontal as well vertical movements of air are equally important; far more air is involved in the horizontal movement. Winds are the means by which uneven distribution of pressure over the globe is balanced out. Winds have been considered by meteorologist as an essential part of the thermodynamic mechanism of atmosphere which serves as a means of transporting heat, moisture and other properties from one part of the earth to another. There are numerous factors which affect the wind motion. Some of the most important are pressure gradient, rotation of the earth, frictional forces, centrifugal action of wind, altitude etc. Wind movement in the atmosphere may be classified into three broad categories, Planetary winds, Periodical winds and local winds. Trade winds, Westerlies and Polar easterlies together form the planetary winds. Periodical winds consists of monsoons, land

and sea breezes etc, and local winds include all those local winds which are produced by local causes and which only affect the weather and climate of a particular locality and area. According to Trewartha the winds are not so important as weather elements, rather they become crucial to all life forms on the earth as controls of temperature and precipitation.

4.7 GLOSSARY

Atmosphere: Envelop of gases surrounding the earth, held by gravity, synonymous with air.

Dust Storm: Heavy concentration of dust in a turbulent air mass, often associated with a cold front.

Monsoon: derived from the Arabic word Mausim, meaning "Season" refers to an annual cycle of dryness and wetness, with seasonality shifting winds produced by changing atmospheric pressure systems.

Velocity: Speed in a specific direction.

Weather: Physical state of the atmosphere at a given time and place.

Wind vane: A device to determine wind direction.

Wind: The horizontal movement of air relative to earth's surface, produced essentially by air pressure differences from place to place, also influenced by Coriolis force and surface friction.

4.8 SHORT ANSWER QUESTIONS

1. Define Wind.

   Answer : ____

   ____

   ____

2. Give the characteristics of Polar winds.

   Answer ____

   ____

3. What is Coriolis Effect?

Answer : ____

____

____

4.9 EXAMINATION ORIENTED QUESTIONS

1. Describe the permanent winds of the earth. What brings about changes in the ordinary circulation of the winds?
2. Describe the main causes and characteristics of the permanent winds of the Northern hemisphere.
3. Describe the main types of the winds. Discuss their origin.
4. What are local winds? Explain their mode of origin and their effect on local weather system.
5. Name and describe the permanent winds of the earth. What brings about changes in the ordinary circulation of the winds.

4.10 SUGGESTED READINGS

Monkhouse, F.J., 1993, Principals of Physical geography, Kent, Hodder and Soughton.

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4.12 MODEL TEST PAPER

Time Allowed- 3 hours **Maximum marks-80**

Note: This paper has two sections.

Section A: Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each.

Section B: Contains 8 questions. Students have to answer 4 questions from each Unit. Each question carries 16 marks. Answer should be limited in 450 words each.

Section A

All questions are compulsory

1. Define Air Masses.
2. Distinguish between Weather and Climate.
3. Define Relative Humidity.
4. What is relative humidity?
5. What is Continental Slope?
6. Define ocean deposits.
7. Define waves.
8. Give the types of Tides.

Section B

Attempt one question from each unit.

Unit I

1. Give the composition of the Atmosphere.

2. Define Air pressure. Give the Horizontal distribution of air pressure.

Unit II

3. Define cyclones. Give the distribution of temperate cyclones.

4. Discuss in detail the Koppen's scheme of the World Climate Regions.

Unit III

5. Define temperature of oceans and give the horizontal distribution of temperature.

6. What are Ocean currents? Discuss the ocean currents of the Atlantic Ocean.

Unit IV

7. Discuss in detail the origin and types of Waves.

8. Define Coral reefs. Give the types of coral reefs.

ATMOSPHERIC MOISTURE

Dr. Abdul Qayoom

5.1 INTRODUCTION

The air contains water vapor. The water vapor present in the air is known as humidity.Humidity refers to the amount of water vapor present in the air. The amount of water vapor present in the air varies widely from place to place and time to time. It ranges from almost nothing in the cold, dry air of arctic region in winter to as much as 4 or 5 percent of a given volume of air in the warm wet equatorial regions. The maximum quantity of moisture that can be held at any time in the air depends on the air temperature. Warm air can hold more water vapor than cold air. Air at room temperature20^{0}C (68^0 F) can hold about three times as much water vapors air at freezing temperature (0^0 C or 32^0 F). This spatial and temporal variation variability of humidity is of great importance for several reasons.

I. It is the major element in the energy balance of the earth.

II. It transferred the energy from the surface of the earth to the atmosphere.

III. It is the base of precipitation.

IV. It absorb the earth's radiation and it regulate the rate of heat loss from the earth.

V. Humidity is also an index of atmospheric potential for yielding precipitation.

VI. Humidity can be measured by instruments, like Hygrometer and Sling Psychrometer.

5.2 OBJECTIVES

It is imperative for man and the institutions, active in the field of science and technology to become familiar with different facts which control and made possible the survival of different kinds of life over the surface of the earth.It is generally, possible for us to know that a person can not live with out air. Man eat food two to three times a day and drink water more frequently but breath every few seconds. Air is essential to the survival of all organisms. Some organisms like man may survive for some time with out food and water but can not survive even a few minutes with out breathing air. This shows the reasons how much the atmosphere is essential for the survival of different organisms, that is why we should understand the atmosphere in greater detail.Atmosphere is mixture of different gases and it envelopes the earth all around.It contain life giving gases like oxygen for humans and animals,carbon dioxide for plants. The air is an integral part of the earth's mass and 99 % of the total mass of the atmosphere is confined to the height of 32 kilometers from the earth's surface. The air is colorless and odorless and can be felt when it blows as wind.

5.3 ATMOSPHERIC MOISTURE

Water vapor in the atmosphere, initially,is added by cooling of hot gaseous earth. After the condensation, heavy rainfall occurred continuously for many years and the low and depressed parts of the earth were filled up with water. This collected water in the water bodies began to evaporate due to heating by the sun and water vapors added to the atmosphere.Thus the moisture in the atmosphere is derived from water bodies through evaporation and from plants through transpiration. There is a continuous exchange of water between the atmosphere, the oceans and the continents through the processes of evaporation,transpiration,condensation and precipitation.

5.4 TYPES OF HUMIDITY

Water vapour present in the air is known as humidity.It is measured or expressed in different ways

These ways or methods are given below.

I. Specific humidity

II. Relative humidity

III. Absolute humidity

I. SPECIFIC HUMIDITY :

Specific Humidity is defined as the mass of water vapor contained in a given mass of (moist) air including water vapor and dry air.In other words, it can be stated as the ratio of the water vapor to moist air and is expressed as grams of water vapor per kilogram of air (g/kg).

SH =mw/mt

Where, SH =Specific Humidity, mw=mass of water vapor and mt =mass of moist air.

Specific humidity is related to the mixing ratio (and vice verse) by :

(a) SH = MR / 1+MR

(b) MR = SH / 1- SH

Specific humidity is more constant property of air and is often therefore, is used to describe the moisture characteristics of a large air mass. For example,the extremely cold, dry air over arctic region in winter may have specific humidity as low as 0.2g / kg ,where as the extremely warm,moist air of equatorial regions often hold as much as 18 g / kg. Specific humidity is measure of the quantity of water in the atmosphere that can be extracted as precipitation. Cold moist air can supply only a small quantity of rain or snow but warm moist air can supply a large amount.

II. RELATIVE HUMIDITY :

This is the most commonly used measure of humidity. Relative humidity can be defined as the percentage of moisture present in the atmosphere as compared to its full capacity at a given temperature is known as the relative humidity. It is expressed in percentage. When the relative humidity is 100 percent, the air is called saturated air. It means that the said air is not having capacity to hold further moisture.

$$R.H. = \frac{\text{Actual water vapor content of the air}}{\text{Maximum water vapor capacity of the air}}$$

With the change of air temperature the capacity to retain moisture increases or decreases and the relative humidity is also affected. It is greater over the oceans and least over the continents. Change in relative humidity takes place in to two ways.

(I). When the moisture is added to the air by evapotranspiration and precipitation, the relative humidity increases up and vice versa .

(ii). When the capacity of the air to hold moisture is changed through cooling of the air, the relative humidity increases up and when the capacity is increased through increase in temperature of the air, the relative humidity declines.

Moreover, the relative humidity practically varies in time and space. Diurnally it is higher in the morning, evening and night rather than day.Because in these periods the temperature is lower and relative humidity rises up. As the sun rises up, the temperature shoots up and the relative humidity begins to decline due to the increasing capacity of the air to hold moisture. It is high in humid tropical regions then dry tropical regions. The equatorial region shows more than 90 percent relative humidity through out the day rather than tropical desert, where it occur randomly.

III. ABSOLUTE HUMIDITY :

The actual amount of water vapour present in the atmosphere is known as the Absolute Humidity. It is the weight of water vapour per unit volume of air and is commonly measured in terms of grams per cubic meter. It can be expressed in any mass unit per any volume unit, e.g., grains per cubic foot or pounds per cubic foot as in the U.S.A. The ability of the air to hold water vapor depends entirely on its temperature. This expression of humidity is rarely used because it varies with expansion and contraction of air or air pressure even though the amount of water va pour remains constant.

Absolute Humidity can easily be determined by condensing one cubic meter of air in to a container and weighing the liquid water . Absolute Humidity can be expressed by the following formula :

$AH = mw/Va$,

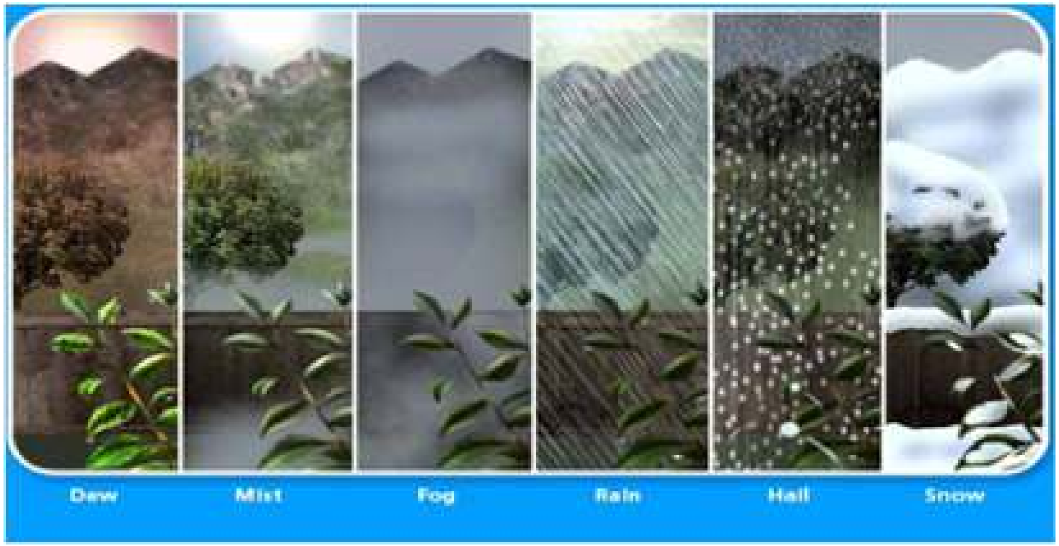
where, AH = Absolute Humidity; mw = mass of the water vapor and Va = unit volume of air.

For instance, a given air with 2 cubic meters volume has 100 gram moisture at given temperature. Due to decrease in temperature,volume reduces to 50% size, that is 1 cubic meter and the absolute humidity may be expressed as 100 grams per cubic meter now against 50 grams per cubic meter earlier, through no addition of moisture is made.Hence, it is not suitable expression for meteorological study.

5.5 PRECIPITATION

Condensed droplets of water within the clouds formations do not fall to the earth because of their general buoyancy and the upward movement of the air. On account of their small size, gravitational pull on them is insufficient to pull them down. However, when the droplets of water or ice coalesce and develop their mass to great to be held in the atmosphere, they fall on to the earth. This process is called precipitation. Thus the word precipitation refers to any of the various forms of water particles and droplets that forms in the earth's atmosphere and then falls on to the Earth .

Forms of Precipitation :



All Precipitation moisture falling from the atmosphere to the ground can take various forms depending on the following conditions:

(i) the temperature at which condensations takes place,

(ii) the conditions encouraged by the precipitation as it passes through the air during its ground ward descent,

(iii) the types of clouds and there height from the ground, and

(iv) the process of formation of precipitation.

These are numerous forms of precipitation which are also called hydrometeors.About 50 specific types of hydrometeors have been identified. Of these the more common types are: rain, drizzle, snow, sleet, hail, glazed frost, dew, rime etc.

Rain :

Rain, consisting of droplets of liquid water, is by far the most common form of precipitation. Average rain drops have diameters of about 0.04 to 0.1 inch or 0.5mm to 5.0mm. They can reach to a maximum diameters of about0.25inch. Above this level they become unstable and break into smaller drops while falling. Smaller drop<0.5mm of liquid water can be called rain if they are widely scattered and less in number.

Rainfall can be defined,as the total amount of precipitation that falls on the ground over a period, as measured in a rain gauge. It includes melted snow, hail, dew, frost and rime.

When the rain drops from high altitude clouds, some of them evaporate while passing through a layer of dry air. Sometime, falling rain completely evaporate before reaching the ground. Such streaks of rainfall are called Virgae. On the other hand, when the rain bearing clouds are very thick the lower air is moist, there occurs a heavy downpour and the raindrops are numerous and large in size.

Rain drops are formed as mentioned earlier, by collision and coalescence of cloud droplets. It has been estimated that one rain drop is formed due to the coalescence of about one million cloud droplets. Rain can come in many ways as a brief shower, a steady three day rainfall or the deluge of a tropical rainstorm. Precipitation bearing clouds yielding rain include numbostratus (Nj) altrosatus (As), Stratocumulus (Sc), Altocumulus (Ac), Castellanus, Cumulus (cu) and Congestus.

Drizzle :

Drizzle is afairly uniform form of precipitation in which the water droplets are veryfine (less then 0.5mm) and are close together . It falls continuously, is associated with a warm front. Normally, drizzle is produced by stratus and stratocumulus clouds. Drizzle forms when the air mass is only slightly below dew point. It is so light that it is greatly affected by the direction of air currents and the variability of winds. Consequently drizzle almost never falls vertically. The average fall, speed of drizzle is about 0.8m per second.Freezing rain or Freezing drizzle is rain / drizzle that freezes onimpact with the ground, with objects at the earth's surface, or with aircraft in flight.

Snow :

Snow is the second most common form of precipitation. It is a form of precipitation of white and opaque crystals of ice delicate and feather light . It is produced when condensation takes place 'at a temperature below freezing points,so that the minute crystals (spicules) of ice form directly from water vapour. These may fall as they are, but more commonly they combine together to form snow flakes, which display an infinite variety of patterns like prism, plate, star or needle, all basically, hexagonal in shape. If the temperature is sufficiently low the snowflakes will reach the ground. Otherwise they melt and turn into rain on passing through warmer air.

When the temperature is near or at Zero Degree the snowflakes tend to aggregate forming large wet flakes, on the other hand , if the temperature is very low, as in Antarctica, Siberia, Ladakh, Greenland, Tibet, etc. the flakes tend to be small and dry(point snow). With the former, a depth of about 6mm is equivalent to 1mm of rainfall, but with the latter the ratio is about 30 to 1.

Air is trapped between the crystals in snowflakes causing internal reflection of light at the crystal surfaces and giving snow its sparkling whiteness.

Snow pellets are composed of white and opaque grains of ice. The grains are mostly spherical, with a diameter of 2-5mm. They are brittle and on striking a hard surface bounce and break up. They are also called softhail.

Snowgrains are very small (<1mm) grains of white, opaque ice. They are also called Graupel.

Sleet :

In the U.S.A, sleet refers to a form of precipitation consisting of small pellets of transparent or translucent ice, 5mm or less in diameter. In other word, sleet in the U.S.A refers to frozen rain, formed when rain, in falling to the earth, passes through a cold layer of air and freezes. The result is the creation of solid particles of clear ice.

Elsewhere, sleet refers not to this phenomenon of frozen rain but rather to a mixture of rain and snow, or a partially thawed snow which is formed when the upper air temperature is below freezing point and allows snowflakes to form and the lower air temperature is around 2to 4 degree which allows partial melting.

Hail (Hailstone) :

Hail is a small ball or piece of ice with a concentric layered structure, falling separately or agglomerated from cumulonimbus cloud at the passing of a cold front resulting from the uplift of air by convection currents. It has diameter usually ranging between 5 and 50mm (0.2 to 2 in.) In some cases their sizes may be exceptionally large, like a baseball. The largest hailstone ever recorded fell on Coffeyville, Kansas (U.S.A) on September 3, 1970. Its diameter was 14cm (5.6 inch) and its circumference 44 cm. It weighted 766grams (1.67 pounds). It was surpassed by the hailstone weighing 2.25 pounds (1.02Kg) on April 14, 1986 in Gopalganj (Bangladesh).

Hail is more common in areas with warm summers where there is sufficient heat to trigger off the uplift of air, Hail does not occur in the polar regions where thunderstorms are rare and in the Equatorial region, where the air temperature so high that any hail that may be formed melts before reaching the ground.

Hailstones are caused by the fast ascent of moist air in which frozen droplets of ice are carried ever higher by the force of violent upright, their size grows as additional water vapour freezes on them. They may be thrown up several times by the convectional currents, until their mass overcomes the force of the ascending air current and then they fall to the earth. on the way the sometimes gather more ice from supercooled water droplets In flew mist air. Hail Is the most dreaded and destructive form of precipitation. Hailstone can be highly destructive to crops, orchards and other vegetation. They even have been known to kill animals and humans.Hailstorms are mainly common from march to June in temperate latitudes.

Dew :

Dew means the deposition of water droplets on the ground .and objects, such as plants, near the ground which occurs when the temperature of the ground surface falls during night and the air in contact with it is cooled below its dew point. Water vapour in the air or diffused from the soil then condenses and is deposited as droplets. The condition favouring dew formation is moist air, light winds, and clear night skies to ensure maximum cooling by radiation.

5.6 TYPES OF PRECIPITATION

Precipitation occurs from clouds and the most important cause of cloud formation is the adiabatic cooling resulting from the upward movement of moist air. Adiabatic cooling lowers the temperature of a large air mass (by expansion) to its dew point in order to produce sufficient condensation for precipitation.

There are three major ways in which a parcel of air may be forced to rise. Each of these produces its own characteristic type of precipitation. These three ways are:

(1) Displacement of warm air upward in a convectional system, producing convectional precipitation.

(2) Forced ascent of an air mass on encountering a land barrier like a mountain, producing Orographic precipitation,

(3) Upward movement of a warm, lighter air mass on encountering a colder and denser air mass, producing cyclonic or frontal precipitation. These three types of -precipitation, based on the type of ascent and precipitation characteristics, are given below.

Convectional Precipitation :

Convectional precipitation results from a convection cell —a vertical column of rising air that is often found above a warm land surface. Air rises in a convection cell because it is warmer, and therefore, lighter that the surrounding air. The updraft of air, which having been warmed by conduction from a heated landsurface, expands and rises. In doing so it is adiabatically cooled and eventually the dew point is reached, causing condensation which is followed by convectional precipitation with further cooling. For convectional precipitation to occur, two conditions should be fulfilled: (a) intense heating of the surface which causes the air to expand and rise, and (b) abundant supply of moisture the air to provide it with a very high relative humidity.

For a comprehensive understanding of convectional precipitation two relevant terms need to be comprehend. These are (a) stable air, and (b) unstable air. An air parcel having higher temperature and lower density and consequent)

a rising tendency relative to the surrounding air is called unstable air and the condition is called instability. Conversely, the air which has a temperature lower than that of the surrounding air and is denser and has a tendency to remain in its position or has a tendency of subsidence is referred to as stable air. This condition is called stability.

Let us apply the concepts of stability and instability in understanding convectional precipitation. Assume two cases (a) a parcel of relatively dry air, and (b) a more humid air parcel.

Let both these air parcels be heated at the surface. Instability occurs and both the air parcels rise due to convection. In both, the lapse rate in the free atmosphere is the same, and it is especially high during the first few thousand feet but slows to the normal rate after that. In case (a) the dry adiabatic lapse rate (5.6degree F./1000 feet) applies through out its ascent. By the time the air reaches 400 feet it has cooled sufficiently to reach air layers having the same temperature and density as this rising air parcel (a). Here the convectional lifting ceases and the air at this elevation is stable.

In case (b) the rising air parcel (which is still unsaturated cools at the dry adiabatic lapse rate (5.6°F/1000ft) for the first 2000 feet ascent. As the air parcel is humid, the dew point is soonreached in the rising column, condensation takes place, and cumulus clouds begin to form. The heat locked up in the water vapour is released as the latent heat of condensation which heats the rising parcel of air. This greatly reduces the adiabatic lapse rate of cooling so that the rising air is now cooling at the wet (saturated) adiabatic rate which is lower than the atmospheric lapse rate (3.2degree F./1000feet). Hence, the temperature of the rising air remains more than the surrounding air. So it continues rising (i.e, it is unstable) until most of the water vapour has condensed, yielding convectional precipitation. After that the dry adiabatic lapse rate is restored.

Convectional precipitation is most common in the humid equatorial and tropical areas that receive sufficient solar radiation throughout the year, and during summers in middle latitudes.

Convectional lifting results in the heavy precipitation, thunder, lightening and tornadoes of summer afternoon thunderstorms. When the convectional currents are strong in the characteristic cumulus clouds, even hail can result.

Orographic Precipitation :

Orographic precipitation or relief rainfall is the precipitation that is caused by moisture ladden air being forced to rise over a relief barrier such as a mountain range, hilly region , or even the escarpments (steep edge) of plateaus or table lands, which serves to provide the initial thrust in the lifting mechanism. As the air rises it cools and if the dew point is reached, condensation occurs forming clouds and precipitation.

Orographic (meaning related to mountains) precipitation is particularly important in areas where moist prevailing winds off the sea meet a highland coast lying at right angles to them, e.g. British Columbia (Canada) and Scotland. On such coasts, precipitation will increase with altitude on the windward slope. After passing over the mountain summit, the air starts to descend the leeward slopes. It is compressed and begins to warm up according to the adiabatic principle. Cloud droplets and ice crystals evaporate or sublimate. Because evaporation and sublimation take up latent heat, at first the warming follows the wet adiabatic rate. Eventually the air clears, and as it continues to descend, it warms further at the dry adiabatic rate. At the base of the mountain in the far side, the air is warmer and drier. This effect causes a rain shadow on the leeward side of the mountain-a belt of dry climate that is found on the leeward slope ofmountain and extends even beyond. Several of the earth's great deserts are of type. The effect of Orographic precipitation and the rain shadow are well connected in the patterns of vegetation. For this reason the Zabarwan Hills Kashmir Valley) are capped with vegetation on the windward (the Dal Lake facing) slopes and are bare on the leeward side (facing Zewan and Khunmoh), hence the name Kharebaal (meaning bare hill) as the hill is called in Pampore area. Moreover, the same mechanism explains why the area is a little drier and warmer as compared with the adjoining are.

In monsoon areas Orographic rainfall greatly augments the normal monsoon rains as occurs, for example, at Cherrapunji on the windward slope of the Khasi Hills in Assam (India), which receives the highest mean annual rainfall (1244cm) in the world.

Cyclonic or Frontal Precipitation :

Cyclonic or frontal precipitation, also knows as convergence precipitation is associated with a cyclonic activity and occurs along the frontal zones of convergence. A front is a zone of contact between relatively warm and relatively cold air masses. When two different air masses of different densities and temperatures meet, the warmer one is lifted above the colder. As the warm moist air rises above the front, adiabatic cooling takes place resulting in the frontal precipitation.

In tropical regions where opposing air currents have comparable temperatures, the lifting is more or less vertical and is usually accompanied by convection. In middle latitudes, frontal convergence is characterized by more . gradual sloping ascent of warm air over cooler. Slow ascent occurs resulting in expansion cooling and condensation, eventually producing a precipitation that is less violent than tropical thunderstorms but is more continuous, steadier (of long duration) and covers an extensive area. Thus whereas the Warm- Front results in prolonged drizzling rain, the cold front is characterized by heavier bursts of rain (thundershowers) of shorter duration. In Europe and North America and northern parts of India (J&K, HimachalPradesh, Utttarakhand), most of the winter precipitation is frontal in origin.

5.7 GLOSSARY

1. **Adiabatic Lapse Rate :** The rate of change of temperature of ascending or descending air which i 10º/1000 mts. befire dew point and 5ºC/1000 mts. after dew point.
2. **Dew :** Direct deposition of water vapour in thye form of water without hygroscopic Nuclei on the surface of the objects on ground.
3. **Frot :** Transformation of gaseous form of water directly into solid form.
4. **Latent Heat :** The heat energy spent during the evaporation process and its conversion into water vapour.
5. **Relative Humidity :** Ratio of amount of water vapour actually present in the air having definit volume and temperature.

5.8 EXAMINATION ORIENTED QUESTIONS

Short Questions

Q1. What is Humidity?

Q2. Define Absolute Humidity.

Q3. What is Heat?

Q4. Discuss conventional Precipitation.

Long Questions

Q1. Write in details the different types of Humidity.

Q2. What is Precipitation? Describe the various forms of Precipitation.

Q3. Differentiate between different types of Precipitation.

Q4. How is the Humidity different from Precipitation. Elaborate.

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ATMOSPHERIC DISTURBANCES

Dr. Abdul Qayoom

6.1 INTRODUCTION

In addition to the general circulation of atmosphere, there is a secondary circulation that involves circulation of air towards a low pressure centre which are called as depressions or lows.

6.2 OBJECTIVES

The main objective behind the present chapter is to familiarize the students in the Air masses and Fronts. The basic concept behind these phenomenon and their types.

6.3 AIR MASSES

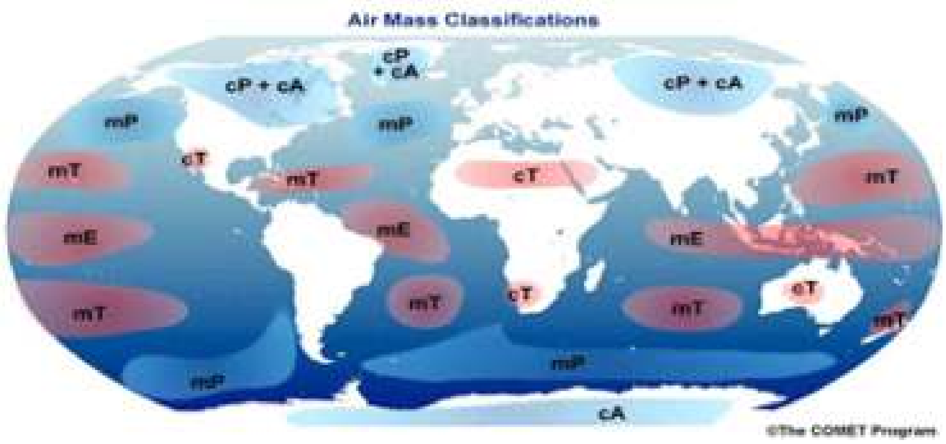
An air mass is large, horizontal, homogeneous body of air that may cover thousands of square kilometers and extend upward for thousands of meters to the top of troposphere. It has more or less, uniform temperature, lapse rate and humidity characteristics and moves over the earth's surface as a distinct entity. An air mass is bounded by frontal surfaces. An air mass is distinguished from other parts of the atmosphere by the fact that it is relatively homogeneous in terms of temperature and humidity at a given level within the air mass. Of course, since an air mass may extend over 200 or 300 of latitude, there are slight modifications in temperature and moisture, which arise due to contact with differing land surfaces. Air masses range Widely in temperature— from searing hot to icy cold, and moisture content from extremely oily continental tropical (cT) and very cold, very dry continental arctic (cA) to warm, very moist maritime equatorial (mE).

The similar characteristics of temperature and humidity within an-air mass are determined by the nature of its source region— the place where- the air mass is formed. Only a few areas on the earth's surface make good source regions. A source region must have fairly homogeneous surface conditions of temperature and moisture content throughout to impart homogeneity to the air mass. In addition, the air mass must have sufficient time to acquire the characteristics of the source region. Hence gently settling, slowly diverging air over a vast land surface or oceans can turn into an air mass while converging, rising air will not. The properties of an air mass depend upon the nature of the source region. For example, an air mass with warm temperatures and a high moisture content develops over a warm equatorial ocean. Over a large tropical desert, slowly subsiding air forms a hot air mass with low humidity. Likewise, a very cold air mass with low humidity, forms over cold, snow covered land surfaces in the arctic zone in winter.

Air masses move from one region to another under the influence of pressure gradients and upper-level wind patterns. They are some times pushed or blocked by high-level jet streams. When an air mass leaves its source region and moves to a new area, its properties will begin to change according to -the new surface environment. It may lose or gain water Vapour content and/ or temperature.

The concept of air masses was given by Vilhelm Bjerknes and Jacob Bjerknes (father and son) Air masses can be classified on the basis of latitudinal position and nature of the underlying surface of their source region (Geographical classification). They can also be classified on the basis of thermodynamics and mechanical modifications which they undergo after leaving their source regions. Latitudinal position primarily determines surface temperature and the environmental temperature lapse rate of the air masses, while the nature of the underlying surface-continent or ocean usually determines the moisture continent.

Classification of Air Masses on the Basis of Latitudinal Position:



On the basis of latitudinal position, five types of air masses can be distinguished. These are shown in the following table.

Air Mass	Symbol	Source Region
Arctic	A	Arctic ocean and fringing lands
Antarctica	AA	Antarctic
Polar	P	Continents and Oceans Lat. 50-600N and S
Tropical	T	Continents and oceans Lat. 20-350 N and S
Equatorial	L	Oceans close to equator

Trewartha has classified air masses on the basis of their geographical location into two broad categories, viz

Polar air masses (P)

(Which originate in polar areas. Arctic and Antarctic air masses are also included in this category)

Tropical air masses (T)

(Which originate in tropical areas. Equatorial air masses are also included in it)

Byers recognizes three major air masses, viz, Arctic, Polar and Tropical Air masses.

Classification of Air Masses on the Basis of the Nature of Underlying Surface

Air masses can be put into two categories on the basis of the nature of underlaying surface, these are:

Air Mass	Symbol	-Source Region Oceans
Maritime	m	
Continental	C	Continents

By combining the above mentioned two classification, A and B , a combined geographical classification (C) can be obtained which identifies six different types of air masses

6.4 GEOGRAPHICAL CLASSIFICATION OF AIR MASSES

Air Mass	Symbol	Source region	Properties	Temp (°C)	Specific Humidit (gm/Kg)
Maritime equatorial	mE	Warm oceans in the equatorial zone to 1505)_(15°N	Unstable, warm, very moist	27	19
Maritime tropical	mT	Warm ocean in the Tropical zone (150-350N&S)	Warm, moist	24	17
Continental tropical	cT	Sub-tropical deserts	Warm, dry	24	11
Maritime polar	mP	Mid-latitude Oceans	Cool, moist (winter)	4	4,4
Continental Polar	cP	Northern Continental interiors	Cold, dry (winter)	-11	1.4
Continental arctic (andcontinental antarctic	cA(cAA).	Regions near north and south poles	Very cold,Very Dry (winter)	-46	0.1

Air Mass (with Symbol)	Source Region	Usual Chracteristics at source	Accompanying weather
Tropical' Maritime (mT)	Tropical and Subtropical oceans	Subsiding air, failry stable, but some instability on western side of oceans; warm and humid	High Temperatures and humidity, cumulus clouds, covectional rain in summer, mild temperatures. Over cast skies, fog, drizzle and occasional snowfall in winter; heavy precipitation alone mT/cP fronts in all sessions
	Deserts and dry plateaus of latitudes	Subsiding air aloft; generally table, but some local instability at surface; hot mid very dry	High Temperatures, low humidity, clear skies, rare precipitation
\Polar Maritime (mP)	Oceans between 40º and 60º latitudes	Ascendingair and generally instability, especially in winter; mild and moist	Mild temperature, high humidity, overcast skies and frequent fogs and precipitation, especially during winter; clear skies and fair weather common in summer, heavy orographic
Polar Continental (cP)	Plains and plateaus of sub-polar	Subsiding and stable air, especially in winter, cold and dry.	Cool (summer) to very cold (winter) temperature, low humidity; clear skies except along fronts; heavy precipitation, including winter snow.

On the basis of location and nature of source region, the following six types of air masses are found.

For the sake of convenience , the above classification can be concised into the following four major types: -

Classification of Air Masses on the Basis of Thermodynamic and Mechanical Modifications

On the basis of thermodynamic and mechanical modifications air masses can be put into two categories:

Cold air Masses:

Cold air masses denoted by small letter k (for the German Kalt, meaning cold).

These air masses are colder than the underlying surfaces, and are heated from below on passing over a warmer surface. Their normal lapse rate increases and become unstable, resulting in convective process. If these move over warm oceans they pick up moisture there and cause precipitation on condensation.

Warm air masses :

A warm air mass is denoted by letter w (warm). It is warmer than the surface lying below it. Such an air mass is cooled from below and thus the lower layer becomes stable due to which vertical movements stop. These generally originate in the subtropical high pressure belts experiencing anticyclonic conditions.

Both the cold and warm air masses can be further divided into continental and maritime sub-groups on the basis of source region.

(F) Composite Classification Air masses

Based on thermodynamic and mechanical (dynamic) modifications and some other considerations air masses are divided into 16 following types:

(a) Continental Polar Air Masser (cP)

(1) Continental POlar cold stable Air Mass (cPks)

(2) Continental Polar Cold unstable Air Mass (cPku)

(3) Continental Polar Warm Stable Air Mass (cPws)

(4) Continental Polar Warm Unstable Air Mass

(cPwu) (b) Martitime Polar Air Masser (mP)

(5) Maritime Polar Cold Stable Air Mass (mPks)

(6) Maritime Polar Cold unstable Air Mass (mPku)

(7) Maritime Polar Warm stable Air Mass (mPws)

(8) Maritime Polar Warm Unstable Air Mass (mPwu)

(c) Continental Air Masses (cT)

(9) Continental Tropical cold stable Air Mass (cTks)

(10) Continental Tropical Cold unstable Air Mass (cTku)

(11) Continental Tropical warm stable Air Mass (cTws)

(12) Continental Tropical Warm unstable Airmass (cTwu)

(d) Maritime Tropical Air Masses (mT)

(13) Maritime Tropical Colil Stable Air Mass (mTks)

(14) Maritime Tropical Cold Unstable Air Mass (mTku)

(15) Maritime Tropical Warm Stable Air Mass (mTws)

(16) Maritime tropical warm unstableAir Mass (mTwu)

(G) T: Bergeron Classification of Air Masses

Basic Type	Geographical Subtypes	Thermodynamics Subtypes
Equitorial (E)	mE= Maritime equatoriall M= Monsoon air, over southeast Asia in summer6	mEk= mE colder than surface over which it is moving mEw = mE warmethan surface over which it is moving
Tropical (T)	mT= maritime tropical4 cT= Continental tropical3	mTk= mT colder than surface over which it is movingmTw=mT warmer than surface over which it is moving
Polar (P)	mP= Maritime polar 5cP= Continental polar 2'	mPk= mP colder than surface over which it is movingmPw= mP warmer than surface over which it is moving cPk = cP colder than surface over which it is moving.cPw = cP warmer than surface over which it is moving

mAk=mA colder than surface over which it is moving

mAw=mA warmer than surface over which it is moving

cAk= cA colder than surface over which it is moving

cAw= cA warmer than surface over which it is moving

Source regions:

Oceanic areas between subtropical anticyclones of northern and southern hemisphere.

Snow- covered continents under anticyclonic wind circulation.

Hot deserts of continents.

Oceanic areas on equatorial side of subtropical anticyclones.

Oceans in middle and high latitudes.

Equatorial areas of Indian Ocean.

6.5 FRONTS

When two air masses, that have originated in different source regions and therefore have differing temperature, pressure, density and humidity characteristics, are brought together by converging movements in the general atmospheric circulation, they do mot mix readily. Instead, they come in contact with one another along a sharply defined sloping boundary. Such a boundary , called a front, is a 'line of discontinuity' or a transition zone between the two contrasting air masses, thus, a front may be defined as an interface or transition zone or a line of discontinuity between two air masses of different physical characteristics. A front is a three dimensional surface with length, width and height. It is sometimes referred to as a surface of discontinuity.

The area where the surface of discontinuity between two contrasting air masses intersects the earth's surface is represented on weather maps by a line. On the earth's surface it is not actually a line but a zone that can cover an area of 1 or 2 miles wide to one as wide as 100 miles. Therefore, it is more appropriate to call it as a frontal zone than a front.

The sloping surface of a front is created as the warmer and lighter of the two contrasting air masses is lifted or rises above the cooler and denser air mass. Such rising is know as frontal lifting. It is a major agent of precipitation, especially in middle latitudes.

The steepness of the frontal surface depends upon the degree of difference between the two air masses, as when an mT air mass of high temperature and moisture content meets a cP air mass with its cold dry characteristics, the slope of the frontal surface will be steep. A steep slope and a greater frontal lifting will produce heavier precipitation than will a gentler slope.

The concept of fronts' was put forth by three eminent Norwegian meteorologists, namely V. Bjerknes, J. Bjerknes and H. Solberg to describe weather conditions,in middle latitudes (temperate regions).

Front genesis

The atmospheric process that leads to the formation or intensification of fronts is Galled frontogenesis. The term includes the creation of new fronts as well as the regeneration of the old and decaying fronts. This term was first used by Tor Bergeron. Frontogenesis is likely to occur when the wind blows in such a way that the isotherms become packed atong the leading edge of the intruding air mass. Convergence of the wind towards a point or contraction toward a line augments frontogenesis.

Frontolysis

Frontolysis refers to the atmospheric process that leads to destruction or dying of fronts. It is opposite of front genesis. Frontolysis takes place when either the two contrasting air masses move away or when they merge with each other in such a way that differences in their physical properties like temperature, pressure, velocity , moisture content, etc, remain no longer. In other words, the two air masses become uniform in terms of their physical characteristics. Divergence of the wind from a point, or dilation from a line is helpful to the process of frontolysis.

6.6 CLASSIFICATION OF FRONTS

Fronts can be differentiated by determining whether the colder air mass is moving on the warmer one or vice versa. The weather that occurs along a front is also dependant on which air mass is the aggressor. On the basis of their characteristic features, fronts are classified into the following four types:

Warm front,

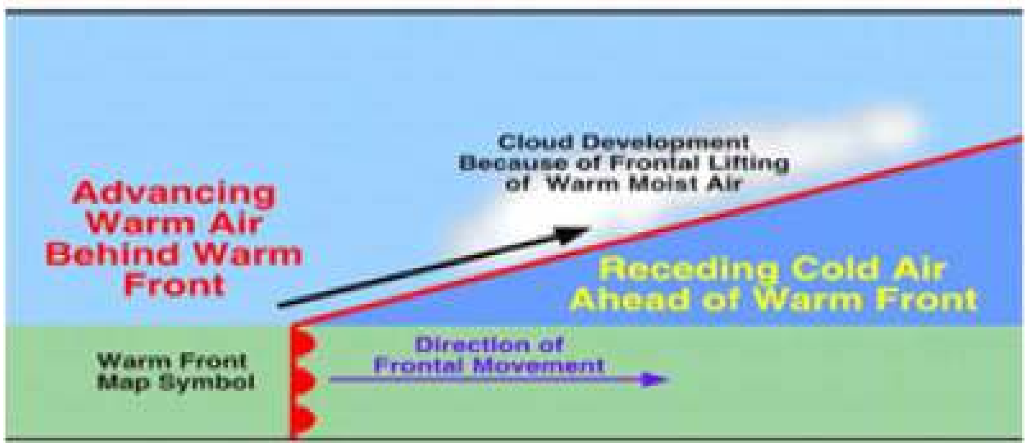
Cold front,

Occluded front, and

Stationary front.

Warm Front :

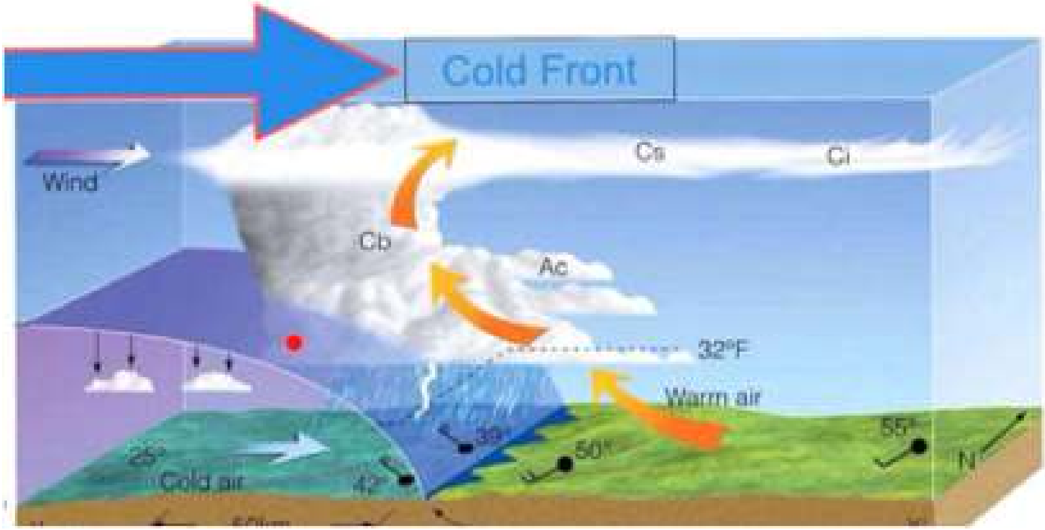
The frontal zone which is formed when a warmer air mass is the aggressor and invades a region occupied by a colder air mass. In a warm front, the warmer air rises over the colder, denser air mass which again stays in contact with the earth's surface. The resultant slope of the surface of discontinuity is usually very gentle. The warm air may rise 1 foot in 100 or even 200 feet of horizontal distance. Thus the frontal lifting that occurs is less than that caused by a cold front. As the warm air gradually ascends, it is cooled adiabatically and causes condensation and precipitation. Unlike the cold front, the weather associated with the passage of a warm front tends to be less • violent and the changes less abrupt.



Cold Front :

A cold front is that sloping frontal surface which occurs when a cold air mass is an aggressor and actively moves upon a warmer air mass and (forcibly) pushes it upward. The colder air, being denser and heavier than the warm air it is displacing, stays at the earth's surface while forcing the warmer air to rise. A cold front usually results in a relatively steep slope in which the warm air may rise 1 foot for every 40 to 80 feet or horizontal distance.

If the warm air mass is unstable and has a higher moisture content, heavy precipitation can occur, sometimes in the form of violent thunder stroms. In any case, cold fronts are usually associated with strong weather disturbances or sharp changes in temperature, air pressure and wind. A cold front is symbolized on the weather map by blue spikes printing in direction of travel.



Occluded Front :

An occluded front is formed during the process of cyclolgenesis when a cold front overtakes a warm front. When this occurs, the warm air is separated (occluded) from the cyclone center at the earth's surface. The point where the front and the occluded front meet is called triple point. There are two types of occlusion Warm and Cold. In a cold occlusion, the air mass overtaking the warm front is cooler than the cool air ahead of the warm front, and plows under both air masses. In a warm occlusion the air mass overtaking the warm front is not as cool as the cold air ahead of the warm front, and rides over the colder air mass while lifting the warm air.

A wide variety of weather tan be found along an occluded front, with thunderstorms possible, but usually their passage is associated with a drying of the air mass. Additionally, cold core funnel clouds are possible if shear is significant enough along the cold front. Occluded fronts are indicated on a weather map by a purple line with alternating semicircles and triangles pointing in.

Stationary Front :

A stationary front is a boundary between two different air masses, neither of which is strong enough to replace the other. They tend to remain essentially in the same area for extended periods of time, and waves sometimes propagate along the frontal boundary. A wide variety of weather is associated with a stationary front. Usually clouds, prolonged precipitation, and storm trains occur near a stationary front. Stationery fronts will either dissipate after several days or devolve into shear lines, but can change into a cold or warm front if conditions aloft change.

Stationary fronts are marked on weather maps with alternating -;:ed half circles and blue spikes pointing in opposite directions, indicating no significant movement.

6.7 GLOSSARY

1. Air mass - Homogeneous body of air with upward gradient if temperature and moisture uniform over extensive area.
2. Cold Airmass - Air mass with less temperture than underlyinh surface.
3. Warm Airmass - Air mass with greater temperature than the surface over which it moves.
4. North Eastern - The bad weather brought by winter maritime polar North Atlantic Air Mass in North-Eastern USA.

6.8 EXAMINATION ORIENTED QUESTIONS

A) Short Answer Type

Q1. Define Air mass.

Q2. What are the characteristics of Warm Air Mass?

Q3. Define Front.

Q4. Define Occluded Front.

B) Long Answer Type

Q1. Differentiate between Cold and Warm Air Mass.

Q2. Give in details the classification of Air Fronts.

Q3. Give the Geographical Classification of Air Masses.

Q4. What are the major differences in Occluded and Stationary Front.

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TROPICAL AND TEMPERATE CYCLONES-CAUSES AND DISTRIBUTION

Prof. Khalid Hussain

7.1 INTRODUCATION

CYCLONES:

Cyclone area centres of the low pressure surrounding by closed isobars having increasing pressure outward and closed air circulation from outside forwards the centre low pressure in such a way that air blows inward in anticlockwise in the northern hemisphere and close wise in the southern hemisphere. Cyclones are defined as an atmospheric system in which the barometric pressure diminishes progressively to a minimum at the centre and toward which the winds blow spirally inward from all sides, resulting in a lifting of the air and eventually in clouds and precipitation. Cyclones range in shape from circular, elliptical to V-shape.

ANTICYCLONES

Anticyclones: surrounding by circular isobars anticyclone is such wind system which has highest air pressure at the centre and lowest at the outer margin and winds blow from the centre outward in clockwise direction in the northern hemisphere and anticlockwise in the southern hemisphere. They are usually circular in shape but some time they also assume 'V' shape. There is maximum air pressure at the centre and it decrease outward. They are assumed much large in size and area than temperate cyclones as their diameter is 75 per cent large than that of the latter.

7.2 OBJECTIVE

Climate of a place plays a significant role for development; it is positive as well as negative impact. To study the climatic phenomena influence through cyclones in term of Tropical and Temperate Cyclone. The scientist divided the earth into different climatic zones on the basis of latitudes, the equatorial, tropical, temperate and frigid zones etc. in both the hemisphere. The global wind system and cyclonic activities change the climatic condition of a place or a region. The distribution of rainfall, destruction cause, and effect of cyclones are also studies under.

7.3 TROPICAL CYCLONES

Tropical cyclones are violent storms that originate over oceans in tropical areas and move over to the coastal areas bringing about large scale destruction due to violent winds (squalls), very heavy rainfall (torrential rainfall) and storm surge. They are irregular wind movements involving closed circulation of air around a low pressure center. This closed air circulation (whirling motion) is a result of rapid upward movement of hot air which is subjected to Coriolis force. The low pressure at the center is responsible for the wind speeds. The cyclonic wind movements are anti-clockwise in the northern hemisphere and clockwise in the southern hemisphere (This is due to Coriolis force). The cyclones are often characterized by existence of an anticyclone between two cyclones.

According to GA (2008) and BOM (1994), Tropical Cyclones (TC) are low pressure systems which develop in the tropics, in the southern hemisphere. They are sufficiently intense to produce sustained gale force winds of at least 63 km/h on average that rotates in clockwise circulations. The severe tropical cyclone is also known as a Hurricane or Typhoon. Australia experiences TC's regularly around the Northern coastline region due to its proximity to the tropics than the remainder of the country. As a result, many people are exposed to cyclones during the cyclone season between November and April, and a major precautionary system has to be working and reliable to ensure their safety. For six months of the year, approximately 20,000 km of Australia's coastline and 20 per cent of the population are vulnerable to the devastating winds, high seas and flood rains of a tropical cyclone Furthermore, the events of global warming and climate change have increased the possibility of cyclones to occur more often at a larger scale. In addition to this, El Nino and La Nina events that changed the currents and sea temperature also increase the numbers of cyclones occurring along the Australian Coast.

7.3.1 Type of Tropical Cyclone

It may be pointed out that tropical cyclones are so varied in size, weather condition and their general characteristics that no two cyclones are identical and therefore it become very difficult to classify them into certain categories. Generally, they are divided into four (4) major Types. (1)Tropical disturbances or easterly waves. (2) Tropical Depressions (3) Tropical storms (4) Hurricanes or typhoons

(1) Tropical disturbances are migratory wave like cyclones and are associated with easterly trade winds. They are also called easterly waves. Winds move towards centre with low speed. Though they move in westerly direction under the influence of trade winds with low velocity but they are most extensive and widespread and influence the weather condition of both tropical and subtropical areas.

(2) Tropical Depressions are centre of low pressure surrounding by more than one closed isobars and are very small in size. Wind velocity around low pressure centre range

between 40-50km per hour. Their direction and velocity are highly variable. Sometimes, they remain stationary at a place for several days. They usually develop in the vicinity of inter-tropical convergence (ITC) but seldom develop in the trade wind belt. Tropical depressions generally influence the weather conditions of India and north Australia during summers.

(3) Tropical storms are low pressure centre and are surrounding by closed isobars wherein winds move towards the centre with the velocity ranging between 40 ton 120km per hour. They frequently develop in the Bay of Bengal and Arabian Sea during summer season. They also develop in Caribbean Sea and in the vicinity of Philippines.

(4) Hurricanes or typhoons: The extensive tropical cyclones surrounding by serveral closed isobars are called hurricanes in the USA and Typhoons in China. They are also called willywilly in Australia, cyclones in Indian Ocean, baguio in Philippines, Taif in Japan etc. Hurricanes are in fact most violent, most awesome and most disastrous hazards of all the atmospheric disturbances. They move with average speed of more than 120km per hour.

7.3.2 Causes or Conditions favourable for Tropical Cyclone Formation

Origin and Development of Tropical Cyclones: The tropical cyclones have a thermal origin, and they develop over tropical seas during late summers (August to mid-November). At these locations, the strong local convectional currents acquire a whirling motion because of the Coriolis force. After developing, these cyclones advance till they find a weak spot in the trade wind belt. **Origin:** Under favorable conditions, multiple thunderstorms originate over the oceans. These thunderstorms merge and create an intense low pressure system (wind is warm and lighter). **Early Stage:** In the thunderstorm, air is uplifted as it is warm and light**.** At certain height, due to lapse rate and adiabatic lapse rate, the temperature of air falls and moisture in the air undergoes condensation**.** Condensation releases latent heat of condensation making the air warmer. It becomes much lighter and is further uplifted.The space is filled by fresh moisture laden air. Condensation occurs in this air and the cycle is repeated as long as the moisture is supplied.Due to excess moisture over oceans, the thunderstorm intensifies and sucks in air at much faster rate. The air from surroundings rushes in and undergoes deflection due to Coriolis force creating a cyclonic vortex (spiraling air column. Similarto tornado**).**Due to centripetal acceleration (centripetal force pulling towards the center is countered by an opposing force called centrifugal force), the air in the vortex is forced to form a region of calmness called an eye at the center of the cyclone. The inner surface of the vortex forms the eye wall, the most violent region of the cyclone. Conditions favourable for Tropical Cyclone Formation.

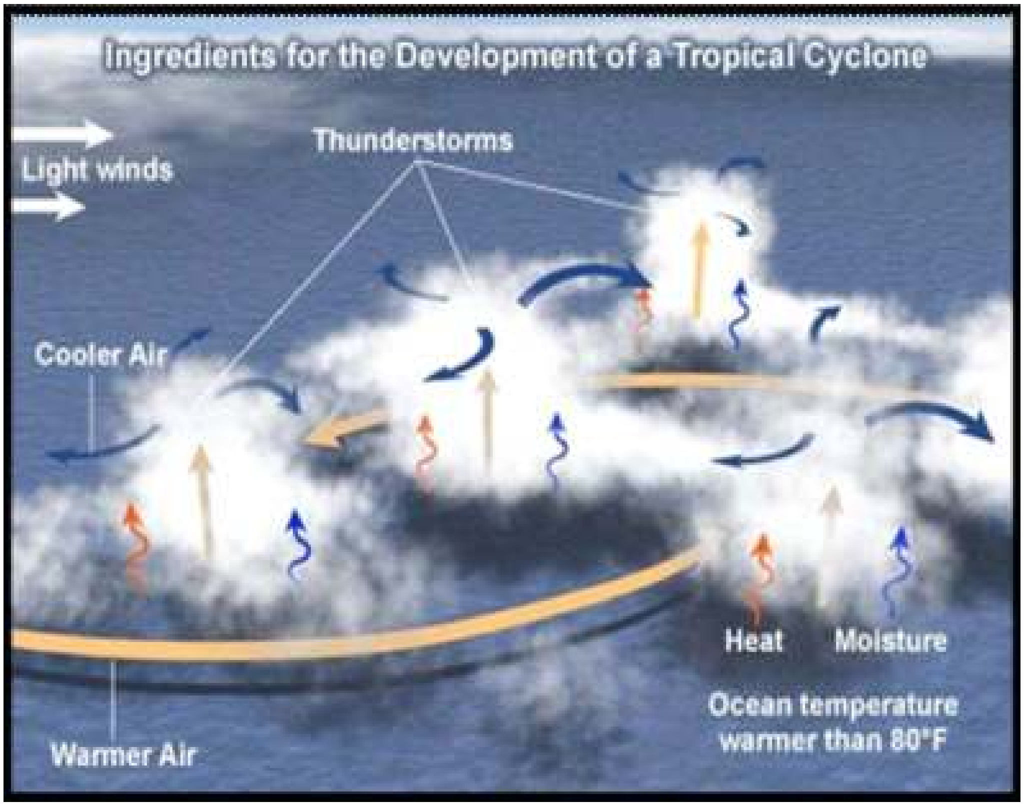
1. Large sea surface with temperature higher than 27° C
2. Presence of the Coriolis force enough to create a cyclonic vortex,
3. Small variations in the vertical wind speed,
4. A pre-existing weak low-pressure area or low-level-cyclonic circulation,
5. Upper divergence above the sea level system,

Good source of Latent Heat: Ocean waters having temperatures of 27° C or more is the source of moisture which feeds the storm. The condensation of moisture releases enough latent heat of condensation to drive the storm. The depth of warm water (26-27°C) should extend for 60-70 m from surface of the ocean/sea, so that deep convection currents within the water do not churn and mix the cooler water below with the warmer water near the surface.The above condition occurs only in western tropical oceans because of warm ocean currents (easterly trade winds pushes ocean waters towards west) that flow from east towards west forming a thick layer of water with temperatures greater than 27°C. This supplies enough moisture to the storm.The cold currents lower the surface temperatures of the eastern parts of the tropical oceans making them unfit for the breeding of cyclonic storms.

One Exception: During strong El Nino years, strong hurricanes occur in the eastern Pacific. This is due to the accumulation of warm waters in the eastern Pacific due to weak Walker Cell. Whirling motion is enhanced when the doldrums (region within ITCZ) over oceans are farthest from the equator. This happens during the autumnal equinox (August-September). At this time, there are two advantages the air is overheated and the sun is exactly over the equator. Due to high specific heat of water, and mixing, the ocean waters in northern hemisphere attain maximum temperatures in August. (Continents attain maximum temperatures in June-July)

Coriolis force: The Coriolis force is zero at the equator (no cyclones at equator because of zero Coriolis force) but it increases with latitude. Coriolis force at 5° latitude is significant enough to create a storm. About 65 per cent of cyclonic activity occurs between 10° and 20° latitude.

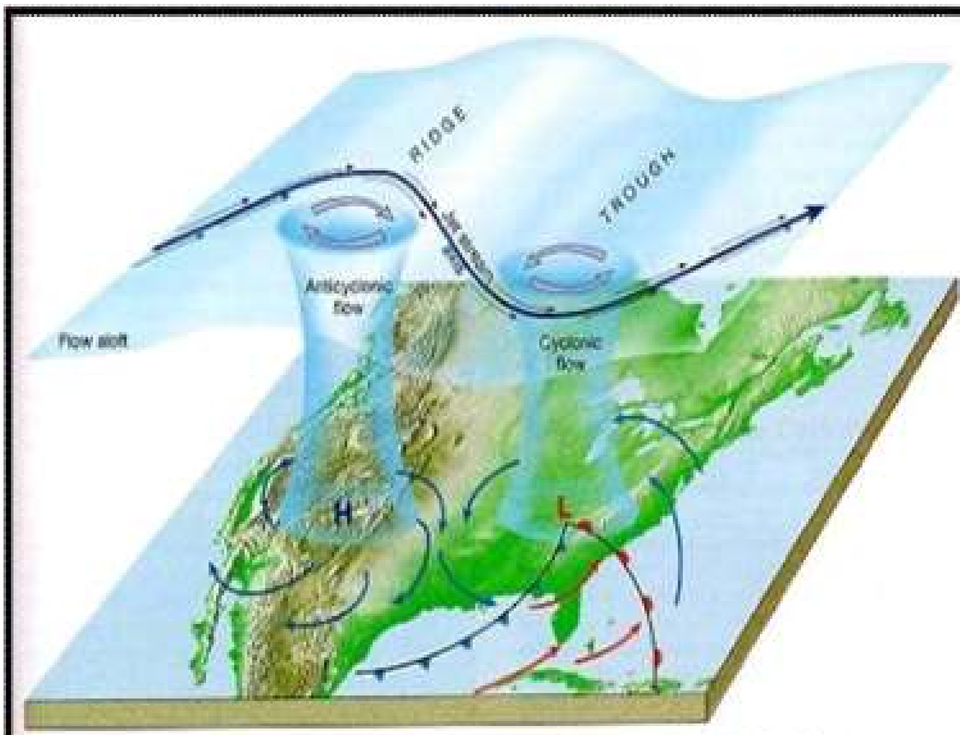
Low-level disturbance: Low-level disturbance (thunderstorms – they are the seeds of cyclones) in the form of easterly wave disturbances in the Inter-Tropical Convergence Zone (ITCZ) should pre--exist.



Small local differences in the temperature of water and of air produce various lowpressure centers of small size. A weak cyclonic circulation develops around these areas. Then, because of the rising warm humid air, a true cyclonic vortex may develop very rapidly. However, only a few of these disturbances develop into cyclones. (rising of humid air- adiabatic lapse rate-fall in temperature of air- condensation of moisture in air- latent heat of condensation released- air gets more hot and lighter- air is further uplifted- more air comes in to fill the gap - new moisture available for condensation - latent heat of condensation and the cycle repeats)

Temperature contrast between air masses: Trade winds from both the hemispheres meet along inter-tropical front. Temperature contrasts between these air masses must exist when the ITCZ is farthest, from the equator. Thus, the convergence of these air masses of different temperatures and the resulting instability are the prerequisites for the origin and growth of violent tropical storms.

Upper air disturbance: The remains of an upper tropospheric cyclone from the Westerlies move deep into the tropical latitude regions. As divergence prevails on the eastern side of the troughs, a rising motion occurs; this leads to the development of thunderstorms.Further, these old abandoned troughs (remnants of temperate cyclones) usually have cold cores, suggesting that the environmental lapse rate is steeper and unstable below these troughs. Such instability encourages thunderstorms (child cyclones).

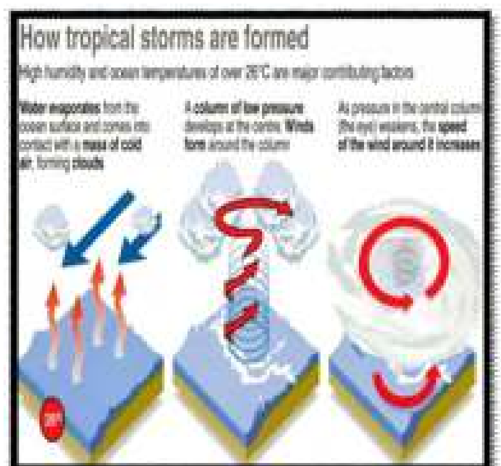


Vorticity provided by flow in the jet stream generates cyclonic flow near a trough and anticyclonic flow adjacent to a ridge.

Wind Shear: Wind Sheardifferences between wind speeds at different heights. Tropical cyclones develop when the wind is uniform. Because of weak vertical wind shear, cyclone formation processes are limited to latitude equator ward of the subtropical jet stream. [Jet streams] In the temperate regions, wind shear is high due to westerlies and this inhibits convective cyclone formation.

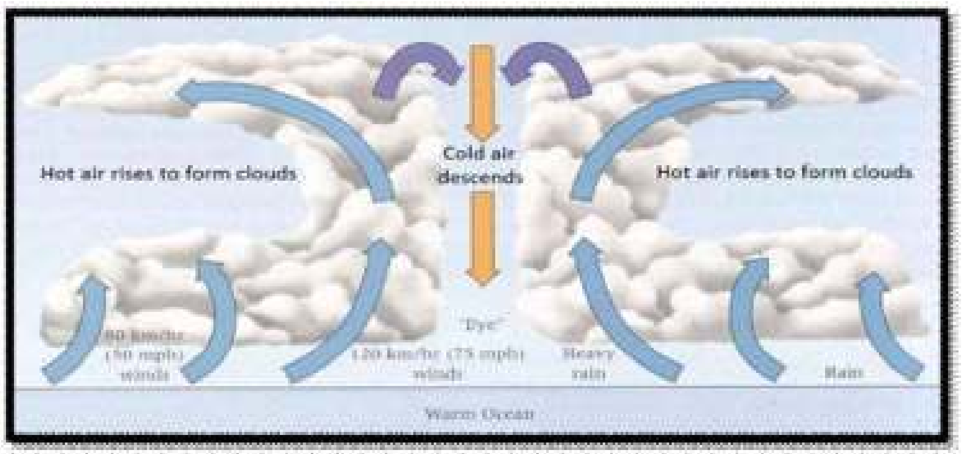
Upper Troposphere divergence: A well – developed divergence in the upper layers of the atmosphere is necessary so that the rising air currents within the cyclone continue to be pumped out and a low pressure maintained at the center.

Humidity: High humidity (around 50 to 60 per cent) is required in the mid-troposphere, since the presence of moist air leads to the formation of cumulonimbus cloud. Such conditions exist over the equatorial doldrums**,** especially in western margins of oceans (this is because of east to west movement of ocean currents), which have great moisture, carrying capacity because the trade winds continuously replace the saturated air.

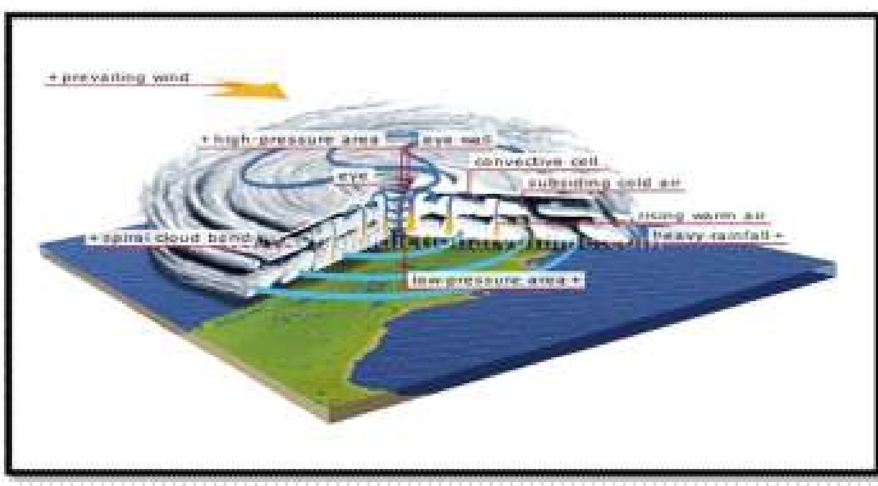


All the wind that is carried upwards loses its moisture and becomes cold and dense. It descends to the surface through the cylindrical eye region and at the edges of the cyclone. Continuous supply of moisture from the sea is the major driving force behind every cyclone. On reaching the land the moisture supply is cut off and the storm dissipates. If ocean can supply more moisture, the storm will reach a mature stage.

Mature Stage: At this stage, the spiraling winds create multiple convective cells with successive calm and violent regions. The regions with cumulonimbus cloud (rising limbs of convective cell) formation are called rain bands below which intense rainfall occurs. The ascending air will lose moisture at some point and descends (subsides) back to surface through the calm regions (descending limbs of convection cell – subsiding air) that exist between two rain bands. Cloud formation is dense at the center. The cloud size decreases from center to periphery. Rain bands are mostly made up of cumulonimbus clouds. The ones at the periphery are made up of nimbostratus and cumulus clouds. The dense overcast at the upper levels of troposphere is due to cirrus clouds which are mostly made up of hexagonal ice crystals. The dry air flowing along the central dense overcast descends at the periphery and the eye region.



Structure of a Tropical cyclone

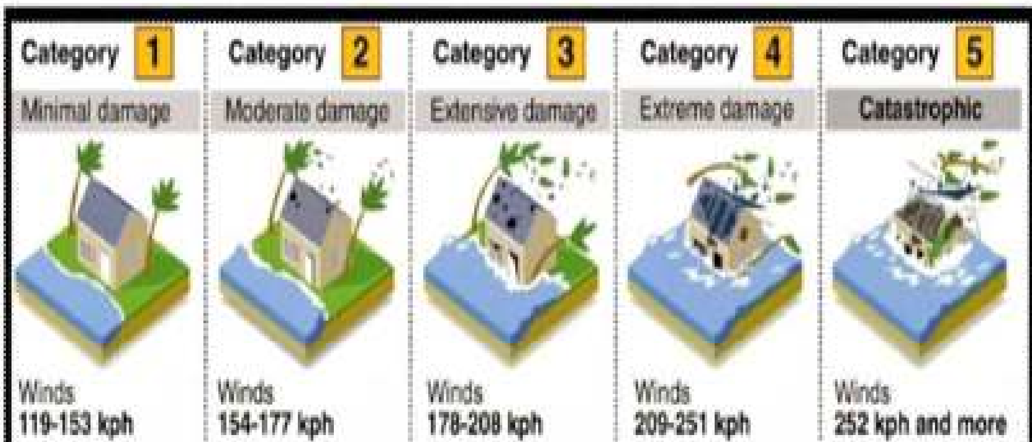


Eye: The "eye" is a roughly circular area of comparatively light winds and fair weather found at the center of a severe tropical cyclone. There is little or no precipitation and sometimes blue sky or stars can be seen. The eye is the region of lowest surface pressure and warmest temperatures aloft (in the upper levels) – the eye temperature may be 10°C warmer or more at an altitude of 12 km than the surrounding environment, but only 0-2°C warmer at the surface in the tropical cyclone. Eyes range in size from 8 km to over 200 km across, but most are approximately 30-60 km in diameter.

Eye wall: The eye is surrounded by the "eye wall", the roughly circular ring of deep convection, which is the area of highest surface winds in the tropical cyclone. Eye Wall region also sees the maximum sustained winds i.e. fastest winds in a cyclone occur along the eye wall region**.** The eye is composed of air that is slowly sinking and the eye wall has a net upward flow as a result of many moderate, occasionally strong, updrafts and downdrafts. The eye's warm temperatures are due to compressional warming (adiabatic) of the subsiding air. Most soundings taken within the eye show a low-level layer, which is relatively moist, with an inversion above – suggesting that the sinking in the eye typically does not reach the ocean surface, but instead only gets to around 1-3 km of the surface.

Spiral bands: Another feature of tropical cyclones that probably plays a role in forming andmaintaining the eye is the eye wall convection. Convection in tropical cyclones is organized into long, narrow rain bands which are oriented in the same direction as the horizontal wind. Because these bands seem to spiral into the center of a tropical cyclone, they are called "spiral bands". Along these bands, low-level convergence is a maximum, and therefore, upper-level divergence is most pronounced above.A direct circulation develops in which warm, moist air converges at the surface, ascends through these bands, diverges aloft, and descends on both sides of thebands.Subsidence is distributed over a wide area on the outside of the rain band but is concentrated in the small inside area.As the air subsides, adiabatic warming takes place, and the air dries.Because subsidence is concentrated on the inside of the band, the adiabatic warming is stronger inward from the band causing a sharp contrast in pressure falls across the band since warm air is lighter than cold air.Because of the pressure falls on the inside, the tangential winds around the tropical cyclone increase due to increased pressure gradient. Eventually, the band moves toward the center and encircles it and the eye and eye wall form.Thus, the cloud-free eye may be due to a combination of dynamically forced centrifuging of mass out of the eye into the eye wall and to a forced descent caused by the moist convection of the eye wall.

Vertical structure of a tropical cyclone: There are three divisions in the vertical structure of tropical cyclones. The lowest layer, extending up to 3 km and known as the inflow layer, is responsible for driving the storm. The middle layer, extending from 3 km to 7 km, is where the main cyclonic storm takes place. The outflow layer lies above 7 km. The maximum outflow is found at 12 km and above. The movement of air is anticyclonic in nature.



Cyclone Category	Wind Speed in Km/h	Damage Capacity
01	120-150	Minimal
02	150-180	Moderate
03	180-210	Extensive
04	210-250	Extreme
05	250 +	Catastrophic

Type of Disturbances	Wind Speed in Km/h
Low Pressure	Less than 31
Depression	31-49
Deep Depression	49-61
Cyclonic Storm	61-88
Severe Cyclonic Storm	88-117
Very Severe Cyclone	118-221
Super Cyclone	More than 221

7.3.3 Distribution of Tropical Cyclones

Category	Australian name	US*	NW Pacific	Arabian Sea /Bay of Bengal
-	Tropical low	Tropical depression	Tropical depression	Depression or severe depression
1	Tropical cyclone	Tropical storm	Tropical storm	Cyclonic storm
2	Tropical cyclone	Tropical storm	Severe tropical storm	Severe cyclonic storm
3	Severe tropical Cyclone	Hurricane	Typhoon	Very severe cyclonic storm
4	Severe tropical cyclone	Hurricane	Typhoon	Very severe cyclonic storm
5	Severe tropical cyclone	Hurricane	Typhoon	Super cyclonic storm

South-east Caribbean region where they are called hurricanes. Philippines islands, eastern China and Japan where they are called typhoons. Bay of Bengal and Arabian Sea where they are called cyclones. Around south-east African coast and Madagascar-Mauritius islands. North-west Australia

7.3.4 Regional Name of Tropical Cyclone

Regions	What they are called
Indian Ocean	Cyclones
Atlantic	Hurricanes
Western Pacific and South China Sea	Typhoons
Western Australia	Willy-willies

Characteristics of Tropical Cyclone: The main features of tropical cyclones are as follows.

Size and shape: Tropical cyclones have symmetrical elliptical shapes (2:3 ratio of length and breadth) with steep pressure gradients. They have a compact size—80 km near center, which may develop up to 300 km to 1500 km.Wind Velocity and StrengthWind velocity, in a tropical cyclone, is more in pole ward margins than at center and is more over oceans than over landmasses, which are scattered with physical barriers. The wind velocity may range from nil to 1200 km per hour.Path of tropical Cyclone**:** These cyclones start with a westward movement, but turn northwards around 20° latitude. They turn further north-eastwards around 25° latitude, and then eastwards around 30° latitude. They then lose energy and subside. Tropical cyclones follow **a parabolic path**, their axis being parallel to the isobars. Coriolis force or earth's rotation, easterly and westerly winds influence the path of a tropical cyclone. Tropical cyclones die at 30° latitude because of cool ocean waters and increasing wind shear due to westerly.

Warning of tropical cyclone: Detection of any unusual phenomena in the weather leading to cyclones has three main parameters**: fall in pressure, increase in wind velocity, and the direction and movement (track) of storm.** There are networks of weather stations monitoring pressure fall and wind velocities in all countries of the world, including the Arctic and Antarctic regions. The islands attain special significance in this as they facilitate monitoring of these developments. In India, there are detection radars along both the coasts. Monitoring is also done by aircraft which carry a number of instruments including weather radar. Cyclone monitoring by satellites is done through very high resolution radiometers, working in the visual and infra-red regions (for night view) of the spectrum to obtain an image of the cloud cover and its structure. Remote sensing by radars, aircraft and satellites helps predict where exactly the cyclone is going to strike. It helps in taking advance steps in the following areas:

1. Closing of ports and harbours,
2. Suspension of fishing activities,
3. Evacuation of population,
4. Stocking of food and drinking water, and
5. Provision of shelter with sanitation facilities (safety homes).
6. Today, it is possible to detect a cyclone right from its genesis in the high seas and follow its course, giving a warning at least 48 hours prior to a cyclone strike. However, the predictions of a storm course made only 12 hours in advance do not have a very high rate of precision.

7.4 TEMPRATE CYCLONS

Temperate cyclones, also called extra tropical cyclones or wave cyclones or simply depression are atmospheric disturbances having the low pressure in the centre and increasing pressure outward. They are in fact low pressure centre produced in the middle latitudes characterized by converging and rising air cloudiness and perception. The systems developing in the mid and high latitude (35° latitude and 65° latitude in both hemispheres), beyond the tropics are called the Temperate Cyclones or Extra Tropical Cyclones or Mid-Latitude Cyclones or Frontal Cyclones or Wave Cyclones.

7.4.1 Type of Temperate Cyclones

Though temperate cyclone are mainly originated due to convergence of two contrasting air masses in term of temperature, pressure and humidity but some local cyclones also from due to other reasons related to temperature variations and consequent pressure differences. The Temperate cyclone divided into three (3) types. (1)Dynamic Cyclones (2) Thermal Cyclones (3) Secondary cyclones.

(1) Dynamic Cyclones are in fact real temperate cyclones because they are formed due to convergence of cold polar air masses and warm and moist maritime tropical air masses. These cyclones affected the weather conditions of very large areas in middle latitudes .Different fronts are fully developed in dynamic cyclones.

(2) Thermal Cyclones: According to Brunt thermal cyclones are formed due to development of low pressure centre on the continents in summer in temperate region s and as such winds blow from all directions towards the low pressure centres. Such thermally induced temperate cyclones are stationary at their place of origin and different front are not developed.

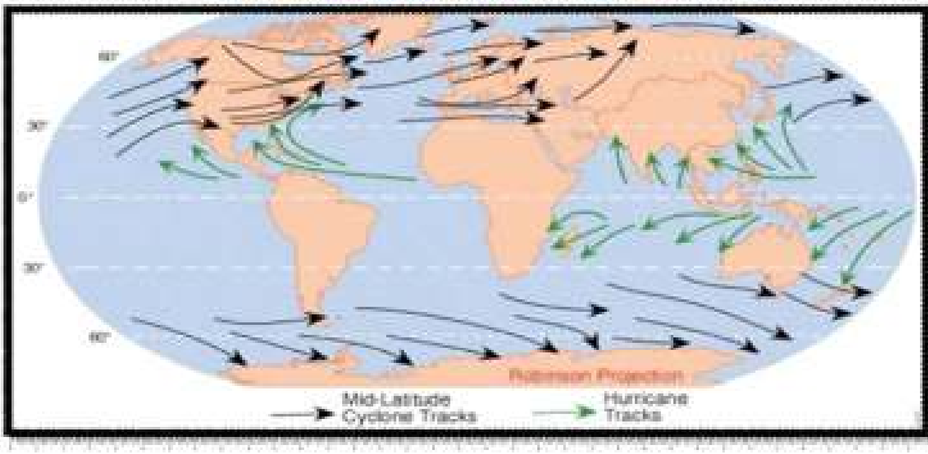
(3) Secondary cyclones are those which develop due to passage of cold winds over warm sea after the occlusion of main cyclone. They are short lived and very weak.

7.4.2 Cause of Temperate Cyclonesor Origin and development of temperate cyclone:

Polar Front Theory According to this theory, the warm-humid air masses from the tropics meets the dry-cold air masses from the poles and thus a polar front is formed as a surface of discontinuity.Such conditions occur over sub-tropical high, sub-polar low pressure belts and along the Tropopause.The cold air pushes the warm air upwards from underneath. Thus a void is created because of lessening of pressure. The surrounding air rushed in to occupy this void and coupled with the earth's rotation, a cyclone is formed which advances with the westerlies (Jet Streams).In the northern hemisphere, warm air blows from the south and cold air from the north of the front.When the pressure drops along the front, the warm air moves northwards and the cold air move towards south setting in motion an anticlockwise cyclonic circulation (northernhemisphere). This is due to Coriolis force.The cyclonic circulation leads to a well-developed extra tropical cyclone, with a warm front and a cold front.There are pockets of warm air or warm sector wedged between the forward and the rear cold air or cold sector. The warm air glides over the cold air and a sequence of clouds appear over the sky ahead of the warm front and cause precipitation.The cold front approaches the warm air from behind and pushes the warm air up. As a result, cumulus clouds develop along the cold front. The cold front moves faster than the warm front ultimately overtaking the warm front. The warm air is completely lifted up and the front is occluded (occluded front) and the cyclone dissipates.The processes of wind circulation both at the surface and aloft are closely interlinked.So temperate cyclone is intense frontogenesis involving mainly occlusion type front. (Occluded front explained in detail in previous posts).Normally, individual frontal cyclones exist for about 3 to 10 days moving in a generally west to east direction.Precise movement of this weather system is controlled by the orientation of the polar jet stream in the upper troposphere.

Seasonal occurrence of Temperate Cyclone: The temperate cyclones occur mostly in winter,late autumn and spring. They are generally associated with rainstorms and cloudy weather.During summer, all the paths of temperate cyclones shift northwards and there are only few temperate cyclones over sub-tropics and the warm temperate zone, although a high concentration of storms occurs over Bering Strait, USA and Russian Arctic and sub-Arctic zone.

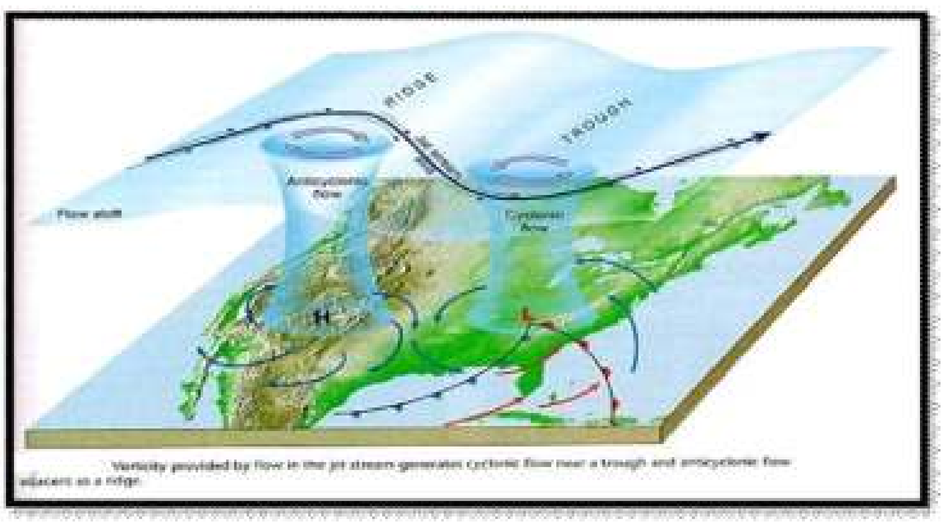
Distribution of temperate cyclone: USA and Canada – extend over Sierra Nevada, Colorado, Eastern Canadian Rockies and the Great Lakes region, the belt extending from Iceland to Barents Sea and continuing over Russia and Siberia, winter storms over Baltic Sea, Mediterranean basin extending up to Russia and even up to India in winters (called western disturbances) and the Antarctic frontal zone.



Characteristics of temperate cyclone: Size and shape: The temperate cyclones are asymmetrical and shaped like an inverted 'V'. They stretch over 500 to 600 km. They may spread over 2500 km over North America (**Polar Vortex**). They have a height of 8 to 11 km.

Wind velocity and strength: The wind strength is more in eastern and southern portions, more over North America compared to Europe.The wind velocity increases with the approach but decreases after the cyclone has passed.

Orientation and movement: Jet stream plays a major role in temperate cyclonogeneis.Jet streams also influence the path of temperate cyclones.



Since these cyclones move with the westerlies (Jet Streams), they are oriented east-west. If the storm front is east-west, the center moves swiftly eastwards. If the storm front is directed northwards, the center moves towards the north, but after two or three days, the pressure difference declines and the cyclone dissipates. In case the storm front is directed southwards, the center moves quite deep southwards-even up to the Mediterranean region [sometimes causing the Mediterranean cyclones or Western Disturbances (They are very important as they bring rains to North-West India – Punjab, Haryana)].

Structure: The north-western sector is the cold sector and the north-eastern sector is the warm sector (Because cold air masses in north and warm air masses in south push against each other and rotate anti-clockwise in northern hemisphere). Associated weather the approach of a temperate cyclone is marked by fall in temperature, fall in the mercury level, wind shifts and a halo around the sun and the moon, and a thin veil of cirrus clouds. A light drizzle follows which turns into a heavy downpour. These conditions change with the arrival of the warm front which halts the fall in mercury level and the rising temperature. Rainfall stops and clear weather prevails until the cold front of an anticyclonic character arrives which causes a fall in temperature, brings cloudiness and rainfall with thunder. After this, once again clear weather is established. The temperate cyclones experience more rainfall when there is slower movement and a marked difference in rainfall and temperature between the front and rear of the cyclone. These cyclones are generally accompanied by anticyclones.

7.5 SAMPLE PAPER CHAPTER

Short Answer Type Questions

Q.1 What is cyclone?

Q.2 What is Anticyclone?

Q.3 Define Eye Wall

Q.4 Define Hurricane

Q.5 What is difference between Tropical and Temperate cyclone?

Q.6 What is difference between Tropical and Temperate cyclone?

Long Answer Type Questions.

Q.1 Why tropical cyclones from mostly on the western margins of the oceans?

Q.2 Why tropical don't from in the eastern tropical oceans?

Q.3 Whatare main causes of origin and development of tropical cyclones?

Q.4 Give characteristics of tropical cyclones and also distribution pattern.

Q. 5 What are main causes of origin and development of temperate cyclones?

Q.6 Give characteristics of temperate cyclones and also distribution pattern.

Q.7 Explain in detail the origin, structure and stages in the development of Tropical cyclones.

7.6 GLOSSARY

1. Adiabatic: A process or condition in which heat does not enter or leave the system concerned.
2. Condensation: The process in which water vapour change into water is called condensation
3. Evaporation: The process in which water change into gases (Water vapour) is called evaporation.
4. Cumulus nimbus cloud: Cumulus nimbus clouds are thunder storm clouds. They show great vertical development and produce heavy rain.
5. Coriolis force: The force which deflects the direction of winds is called the Coriolis force. This force originated from rotation of the earth.
6. Hurricanes or typhoons: The extensive tropical cyclones surrounding by several closed isobars are called hurricanes in the USA and Typhoons in China.
7. Humidity: Humidity is referring to the content of water vapour present in the air in

gaseous form at a particular time and place.

8. Isobar: An imagery lines joining the places of equal pressure.

9. ITCZ: Inter tropical convergence zone.

10. Latent Heat: Energy in the form of heat is required for the conversion of water into gaseous from (water vapour).

11. Normal Lapse rate: The rate of decrease of temperature with increasing height is called normal lapse rate. (6.5C per 1000m.)

12. Squalls: A sudden violent gust of wind or localized storm, especially one bringing rain, snow, or sleet.

13. Torrents: A strong and fast-moving stream of water or other liquid.

7.7 SUGGESTED READING

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CLIMATIC CLASSIFICATION-BASIS AND TYPES OF KOPPENS's CLASSIFICATION

Prof. Khalid Hussain

8.1 INTRODUCTION

The world climate can be studied by organising information and data on climate and synthesising them in smaller units for easy understanding, description and analysis. Three broad approaches have been adopted for classifying climate. They are empirical, genetic and applied. Empirical classification is based on observed data, particularly on temperature and precipitation. Genetic classification attempts to organise climates according to their causes. Applied classification is for specific purpose. The German Botanist Climatologist Wladmir Koppen presented his descriptive scheme of the classification of world climate first in 1900 based on vegetation zones of French plant physiologist Candole presented in 1874. Koppen's original scheme was modified in 1953 by Geigger-Pohi.

8.2 OBJECTIVES

The planet earth has witnessed many variations in climate since the beginning. Geological records show alteration of glacial and inter-glacial periods. The climate of a place plays a significant role for economy as well as human development. The climate of world is very from one region to other region as well as from one nation to other nation. The Koeppen carefully study the climate of the world and describe the climate of the world into five major divisions and its many subtypes each and every type of climate their own nature and characteristics. The classification is based on mean annual and mean monthly temperature and precipitation data.

8.3 KOEPPEN 'S SCHEME OF CLASSIFICATION OF CLIMATE

Basis:The German Botanist and Climatologist Wladimir Koppen presented his descriptive scheme of the classification of the world climate first in 1900 century based on vegetation zones of French plant physiologist Candole presented in 1874. The most widely used classification of climate is the empirical climate classification scheme developed by V. Koeppen. Koeppen identified a close relationship between the distribution of vegetation and climate. He selected certain values of temperature and precipitation and related them to the distribution of vegetation and used these values for classifying the climates. It is an empirical classification based on mean annual and mean monthly temperature and precipitation data. He introduced the use of capital and small letters to designate climatic groups and types.

Although developed in 1918 and modified over a period of time, Koeppen's scheme is still popular and in use. Koeppen recognised five major climatic groups, four of them are based on temperature and one on precipitation. Table 1.1 lists the climatic groups and their characteristics according to Koeppen. The capital letters: A, C, D and E delineate humid climates and B dry climates. The climatic groups are subdivided into types, designated by small letters, based on seasonality of precipitation and temperature characteristics. The seasons of dryness are indicated by the small letters: f, m, w and s, where f corresponds to no dry season, m - monsoon climate, w- winter dry season and s - summer dry season.

8.3.1 Climatic Group According to Koppen

Table 1.1: Climatic Groups According to Koppen

Group	Characteristics
A- Tropical	Average temperature of the coldest month is 18° C or higher
B- Dry Climate	Potential evaporation exceeds precipitation
C- Warm Temperate	The average temperature of the coldest month of the (Mid-latitude) climates years is higher than minus 3°C but below 18°C
D-Cold Snow Forest Climate	The average temperature of the coldest month is minus 3° C or below
E-Cold Climate	Average temperature for all months is below 10° C
H-High Land	Cold due to elevation

The small letters a, b, c and d refer to the degree of severity of temperature. The B-Dry Climates are subdivided using the capital letters S for steppe or semi-arid and W for deserts. The climatic types are listed in Table 1.2. The distribution of climatic groups and types is shown in Table 1.2. Islands of East Indies. Significant amount of rainfall occurs in every month of the year as thunder showers in the afternoon. The temperature is uniformly high and the annual range of temperature is negligible. The maximum temperature on any day is around 30°C while the minimum temperature is around 20°C. Tropical evergreen forests with dense canopy cover and large biodiversity are found in this climate.

8.3.2 Climatic Types according to Koppen

Table 1.2: Climatic type According to Koppen

Group	Type	Letter Code	Characteristics
A-Tropical Humid Climate	Tropical wet Tropical monsoon Tropical wet and dry	Af Am Aw	No dry season Monsoonal, short dry season Winter dry season
B-Dry Climate	Subtropical steppe Subtropical desert Mid-latitude steppe Mid-latitude desert	BSh BWh BSk BWk	Low-latitude semi-arid or dry Low-latitude arid or dry Mid-latitude semi-arid or dryMid-latitude arid or dry
C-Warm temperate (Midlatitude) Climates	Humid subtropical Mediterranean Marine west coast	Cfa Cs Cfb	No dry season, warm summer Dry hot summer No dry season, warm and cool summer
D-Cold Snow forest Climates	Humid continental Subarctic	Df Dw	No dry season, severe winter Winter dry and very severe
E-Cold Climates	Tundra Polar ice cap	ET EF	No true summer Perennial ice
H-Highland	Highland	H	Highland with snow cover

Group A : Tropical Humid Climates :

Tropical humid climates exist between Tropic of Cancer and Tropic of Capricorn. The sun being overhead throughout the year and the presence of Inter Tropical Convergence Zone (INTCZ) make the climate hot and humid. Annual range of temperature is very low and annual rainfall is high. The tropical group is divided into three types, namely (i) Af-Tropical wet climate; (ii) Am - Tropical monsoon climate; (iii) Aw- Tropical wet and dry climate.

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Tropical Wet Climate (Af) Tropical wet climate is found near the equator. The major areas are the Amazon Basin in South America, western equatorial Africa and the islands of East Indies. Significant amount of rainfall occurs in every month of the year as thunder showers in the afternoon. The temperature is uniformly high and the annual range of temperature is negligible. The maximum temperature on any day is around 30°C while the minimum temperature is around 20°C. Tropical evergreen forests with dense canopy cover and large biodiversity are found in this climate.

Tropical Monsoon Climate (Am) Tropical monsoon climate (Am) is found over the Indian sub-continent, North Eastern part of South America and Northern Australia. Heavy rainfall occurs mostly in summer. Winter is dry. The detailed climatic account of this climatic type is given in the book on India: Physical Environment.

Tropical Wet and Dry Climate (Aw) Tropical wet and dry climate occurs north and south of Af type climate regions. It borders with dry climate on the western part of the continent and Cf or Cw on the eastern part. Extensive Aw climate is found to the north and south of the Amazon forest in Brazil and adjoining parts of Bolivia and Paraguay in South America, Sudan and south of Central Africa. The annual rainfall in this climate is considerably less than that in Af and Am climate types and is variable also. The wet season is shorter and the dry season is longer with the drought being more severe. Temperature is high throughout the year and diurnal ranges of temperature are the greatest in the dry season. Deciduous forest and tree-shredded grasslands occur in this climate.

Dry Climates : B

Dry climates are characterised by very low rainfall that is not adequate for the growth of plants. These climates cover a very large area of the planet extending over large latitudes from 15° - 60° north and south of the equator. At low latitudes, from 15° - 30°, they occur in the area of subtropical high where subsidence and inversion of temperature do not produce rainfall. On the western margin of the continents, adjoining the cold current, particularly over the west coast of South America, they extend more equator wards and occur on the coast land. In middle latitudes, from 35° - 60° north and south of equator, they are confined to the interior of continents where maritime-humid winds do not reach and to areas often surrounded by mountains. Dry climates are divided into steppe or semi-arid climate (BS) and desert climate (BW). They are further subdivided as subtropical steppe (BSh) and subtropical desert (BWh) at latitudes from 15° - 35° and mid-latitude steppe (BSk) and mid-latitude desert (BWk) at latitudes between 35° - 60°.

Subtropical Steppe (BSh) and Subtropical Desert (BWh) Climates

Subtropical steppe (BSh) and subtropical desert (BWh) have common precipitation and temperature characteristics. Located in the transition zone between humid and dry climates, subtropical steppe receives slightly more rainfall than the desert, adequate enough for the growth of sparse grasslands. The rainfall in both the climates is highly variable. The variability in the rainfall affects the life in the steppe much more than in the desert, more often causing famine. Rain occurs in short intense thundershowers in deserts and is ineffective in building soil moisture. Fog is common in coastal deserts bordering cold currents. Maximum temperature in the summer is very high. The highest shade temperature of 58° C was recorded at Al Aziziyah, Libya on 13 September 1922. The annual and diurnal ranges of temperature are also high.

Group C : Warm Temperate (Mid-Latitude) Climates-C

Warm temperate (mid-latitude) climates extend from 30° - 50° of latitude mainly on the eastern and western margins of continents. These climates generally have warm summers with mild winters. They are grouped into four types: (i) Humid subtropical, i.e. dry in winter and hot in summer (Cwa); (ii) Mediterranean (Cs); (iii) Humid subtropical, i.e. no dry season and mild winter (Cfa); (iv) Marine west coast climate (Cfb).

Humid Subtropical Climate (Cwa)

Humid subtropical climate occurs pole ward of Tropic of Cancer and Capricorn, mainly in North Indian plains and South China interior plains. The climate is similar to Aw climate except that the temperature in winter is warm.

Mediterranean Climate (Cs)

As the name suggests, Mediterranean climate occurs around Mediterranean sea, along the west coast of continents in subtropical latitudes between 30° - 40° latitudes e.g. — Central California, Central Chile, along the coast in south eastern and south western Australia. These areas come under the influence of sub-tropical high in summer and westerly wind in winter. Hence, the climate is characterised by hot, dry summer and mild, rainy winter. Monthly average temperature in summer is around 25° C and in winter below 10°C. The annual precipitation ranges between 35 - 90 cm.

Humid Subtropical (Cfa)

Climate Humid subtropical climate lies on the eastern parts of the continent in subtropical latitudes. In this region the air masses are generally unstable and cause rainfall throughout the year. They occur in eastern United States of America, southern and eastern China, southern Japan, northeastern Argentina, coastal South Africa and eastern coast of Australia. The annual averages of precipitation vary from 75-150 cm. Thunderstorms in summer and frontal precipitation in winter is common. Mean monthly temperature in summer is around 27°C, and in winter it varies from 5°-12° C. The daily range of temperature is small.

Marine West Coast Climate (Cfb)

Marine west coast climate is located pole ward from the Mediterranean climate on the west coast of the continents. The main areas are: Northwestern Europe, west coast of North America, north of California, southern Chile, southeastern Australia and New Zealand. Due to marine influence, the temperature is moderate and in winter, it is warmer than for its latitude. The mean temperature in summer months ranges from 15°-20°C and in winter 4°-10°C. The annual and daily ranges of temperature are small. Precipitation occurs throughout the year. Precipitation varies greatly from 50-250cm.

Group D : Cold Snow Forest Climates (D)

Cold snow forest climates occur in the large continental area in the northern hemisphere between 40°-70° north latitudes in Europe, Asia and North America. Cold snow forest climates are divided into two types: (i) Df- cold climate with humid winter; (ii) Dw- cold climate with dry winter. The severity of winter is more pronounced in higher latitudes.

Cold Climate with Humid Winters (Df)

Cold climate with humid winter occurs poleward of marine west coast climate and mid latitude steppe. The winters are cold and snowy. The frost free season is short. The annual ranges of temperature are large. The weather changes are abrupt and short. Poleward, the winters are more severe.

Cold Climate with Dry Winters (Dw)

Cold climate with dry winter occurs mainly over Northeastern Asia. The development of pronounced winter anti cyclone and its weakening in summer sets in monsoon like reversal of wind in this region. Pole ward summer temperatures are lower and winter temperatures are extremely low with many locations experiencing below freezing point temperatures for up to seven months in a year. Precipitation occurs in summer. The annual precipitation is low from 12-15 cm.

Group E: Polar Climates (E)

Polar climates exist pole ward beyond 70° latitude. Polar climates consist of two types: (i) Tundra (ET); (ii) Ice Cap (EF).

Tundra Climate (ET)

The tundra climate (ET) is so called after the types of vegetation, like low growing mosses, lichens and flowering plants. This is the region of permafrost where the sub soil is permanently frozen. The short growing season and water logging support only low growing plants. During summer, the tundra regions have very long duration of day light.

Ice Cap Climate (EF)

The ice cap climate (EF) occurs over interior Greenland and Antarctica. Even in summer, the temperature is below freezing point. This area receives very little precipitation. The snow and ice get accumulated and the mounting pressure causes the deformation of the ice sheets and they break. They move as icebergs that float in the Arctic and Antarctic waters. Plateau Station, Antarctica, 79°S, portray this climate.

Highland Climates (H)

Highland climates are governed by topography. In high mountains, large changes in mean temperature occur over short distances. Precipitation types and intensity also vary spatially across high lands. There is vertical zonation of layering of climatic types with elevation in the mountain environment.

8.4 SAMPLE PAPER CHAPTER 9th

Short Answer Type Questions

Q.1 Name the basis of Koppen climatic classification of the world.

Q.2 Define the Koppen classification of world climate **"A"** Type of Climate.

Q.3 Define the Koppen classification of world climate of Tropical Rainforest Type **(Af)**

Q.4 Define the Koppen classification of world climate of Mediterranean type **(Cs)**

Long Answer Type Questions

Q.1 Explain in detail the Koppen climatic classification of the world.

Q.2 Make a comparison of the climatic conditions between the "A" and "B" types of climate

Q.3 Disscuss in detail climatic classification of world given by Koppen.

8.5 GLOSSARY

1. Tropic of Cancer: An imagery line on the globe lies 23.5 degree in the northern hemisphere.
2. Tropic of Capricorn: An imagery line on the globe 23.5 degree in the southern hemisphere.
3. Monsoon: Monsoon is a seasonal is a prevailing wind in the region of South and South East Asia, blowing from the south-west between May and September and bringing rain (the wet monsoon), or from the north-east between October and April (the dry monsoon).
4. Mediterranean: The term applied for the Mediterranean Sea lies between North of Africa and South of Europe.

5. Subtropical: The zone lie between 23.5 degree to 35 degree in both Northern and Southern Hemisphere.

8.6 SUGGESTED READING

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3. Lal D.S "Climatology" ChitanyaPublication, Allhabad. 1986.
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CONFIGURATION OF OCEAN FLOOR: CONTINENTAL SHELF, CONTINENTAL SLOPE, DEEP SEA PLAINS AND OCEAN DEEP

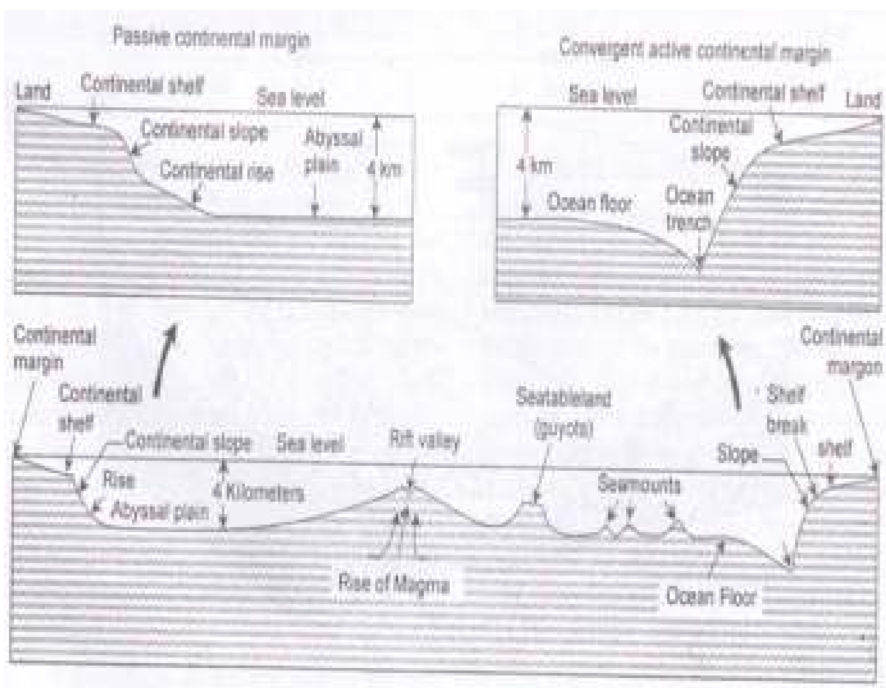
Dr. Tarsem Lal

9.1 INTRODUCTION

About three fourth of the globe is covered by hydrosphere. Out of the total surface area of the globe (509, 950,000km^2), the hydrosphere and lithosphere cover

361,060,000km^2 (about 71 % and 148,890,000km^2 (about 29 %) respectively. The hydrosphere is divided on the basis of size and location into oceans , inland seas, small enclosed seas, bays etc. the pacific ocean (165,000,000km^2) , the Atlantic ocean (82,000,000km^2) and Indian ocean (73,000,000km^2) are important among oceans. The significant seas are arctic sea, bearing sea, middle American sea, Mediterranean sea, Andaman sea, south china sea, yellow sea, Labrador sea, Arabian sea, Beauport sea, red sea etc. The hydrosphere is also characterized by various types of relief features like mid oceanic ridges, trenches, deep sea plains, sub marine canyons etc. The average depth of oceans is 3800 m against the 840 m average height of the lithosphere.

Ocean may be defined as the vast body of saline waters that occupies the depressions of the earth's surface. The relief features on the ocean floor tends to be more sharply defined than those on land. The active process of sub areal erosion and weathering are not present, and in the quiet waters below the limits of surface of wave action, constructional landforms resulting from crustal deformation of volcanic activities are preserved for millions of years.



Configuration of ocean floors ; modified from Thurman and Trujillo, 1999.

9.2 OBJECTIVES

(1) To study the different relief features below the water surface.

(2) To study the Importance of these features.

(3) To study the location of major relief features.

(4) To study the characteristics of these ocean floor features.

(5) To study the causes of their formation.

The surface beneath the water is characterized by a great diversity of relief features i.e. deep canyons, flat plains, oceanic ridges, trenches, island areas, seamounts. The submarine relief has, however been classified under the following major categories:

Continental shelves

Continental slopes

Deep sea plains

Ocean deeps

9.3 CONTINENTAL SHELVES

The continental marginal areas submerged under oceanic water. The continental shelves have developed along both the coasts of Atlantic ocean and the width ranges from 2- 4 km. to more than 80 km. In fact, the width of the continental shelves have been largely controlled by the reliefs of the coastal lands. These become significantly narrow where mountains and hill border the coast. The shelves become 200- 400 km wide along the north eastern coast of North America and the north west coast of Europe. Extensive shelves are found around New found land and British island. Similarly the continental shelves around Greenland and Iceland are quite wide. Very extensive continental shelves are found in the South Atlantic ocean.

The continental shelf was formed by either rise in the sea level or a fall in the sea level. Since the shelf is most continuous around the shores of the Atlantic the movement must have affected half of the globe, and it must have been remarkably uniform in amount. Unless there has been an increase in quantity of water in the ocean it is difficult to understand how a change of level is so wide and regular.

A shelf may also be formed by deposition. The surface of the land is born by rain and rivers and its edge by the wave and the sea. The broken material thus produced is laid down beneath the water, but always near the land. Off the mouth of the Amazon that the sea is sometimes discoloured by mud at a distance of 300 miles. But even the largest rivers must deposit most of their burden near the shore. Waves and currents may bear it a little further, but their action is slight except in shallow water. Consequently the material derived from the land accumulate as a sub marine terrace is the limit beyond which the waves and currents cease to be effective., and within that limit the material collects and is disturbed along the shore. Thus limit, however, is not permanent, for as the terrace is built up and the water becomes shallower, the transporting action of the currents becomes more affective and they are able to carry the material farther than before. The terraces therefore gradually outward by addition of its edge in the same fashion as a railway embankment or the tip-heaps of a quarry.

According to above explanation the continental shelf are formed by the deposits brought from the land. The shelf is the surface of the deposit, smoothed and redistributed by waves and currents; the slope is the edge of the deposits, too deep to be thus effected

According to THURMAN and TRUJILLO, 1999," The continental shelf is defined as a shelf like zone extending from the shore beneath the ocean surface to a point at which marked increase in slope angle occurs. This point is referred to as shelf break is known as continental slope, In fact continental marginal areas submerged under oceanic water with average depth of 100 fathoms(1fathom=6 feet or 1.8 meters) and gently sloping(1-3 degree) towards the oceans are called continental shelves".

P.R PINET, 2000," defines it as nearly flat plains, or terraces, at the top of the sedimentary wedge beneath the drowned edges of the continents are called continental shelves".

The continental shelf lying next to the land, and sloping very gently from the shore. It extends to a depth of about 100 fathoms. The continental shelf is the gently sloping as a part of the floor which forms a ledge around the continents. The continental shelf usually extends from a sea level to a depth of 100 fathoms. Its width varies greatly. The depth of continental shelf varies between 20 to 550 mt. at its outer edge.

The widest shelf, 1280 km. across, lies north of Siberia in the tectonically quiet arctic sea. Shelf width not only depends on tectonic , but also on marine processes. Fast moving ocean currents can sometimes prevents sediments from accumulation. For Example the east coast of Florida has a very narrow shelf because there is no off shore currents and because the swift current of near by Gulf stream erodes sediment away.

Continental shelf having gentle slope, are greatly influenced by change in sea level. About 120 millions years ago, high rates of sea floor spreading were associated with the expansion in volume of mid oceanic ridges. The enlarged ridges displaced sea water and caused sea level to rise. During that time, the sea level may have been about 300mts. higher than it is at present, flooding about 35% of the continents and resulting in proportionally greater shelf areas. In contrast, around 18000 years ago, at the height of the last ice age, or major period of glaciations, the ridges had become less active, massive icecaps covered huge regions of the continent. The water that formed the thick ice sheets was derived from the ocean, and sea level fell nearly 100 meters below its present position. The continental shelves were almost complexly exposed, and the surface area of the continents was about 18% greater than it is today. Sea level began to rise when the ice caps melted.

The continental shelves have become increasingly important because of exploration for natural resources.

The width of continental shelves largely depends on the nature of local and regional reliefs of the coastal land as follows:-

- The shelves are narrow where high mountains are very close and parallel to the coast.
- The shelves are wide where the coastal lands are wide plains.
- The continental shelves are generally wider in front of the river mouths but the shelf of Mississippi river mouth is exceptionally narrow.

On an average, the width of continental shelves is about 48 kms. Though Sheppard has taken 67 km as average width. The Pacific continental shelf of south America represents the example of narrow shelf (16km), the Atlantic continental shelf off the coast of North America represents the example of medium size shelves(96-120 km) and extensive shelves having width of a few 100kms are found of the coast of East Indies, in the Arctic sea, China sea, Adriatic sea, Arafura sea etc. Continental shelves represent 8.6% of the total area of the ocean basin. Regionally these cover 13.3%, 5.7% and 4.2% of areal coverage of the Atlantic Ocean, the Pacific Ocean and the Indian ocean respectively.

9.3.1 Continental shelves of India

The maximum seaward limit of the continental shelves of the Indian coasts is demarcated by 100 fathoms contour. The continental shelves along the eastern and the western coast of India are 50km. and 150 km wide respectively. The shelves are narrow (30-35) kms. Off the mouths of the Ganga, Mahanadi, Godavari. The average slope of the continental shelves off the eastern Indian coast is about 21^0 where as it is 10degree near cape comorin and only 1^0 near the gulf of combay.

9.3.2 Origin of continental shelf

The nature, composition, extension and depth of continental shelves are so varied that it becomes difficult to explain their exact mode of origin through a single mechanism and process the following different views have been expressed by several authorities to explain the complex origin of continental shelves.

a. Continental shelves are the result of marine erosion and fluvial deposits.

b. Continental shelves are the result of subsidence of continental margin.

c. Continental shelves are formed due to terrigenous fluvial deposits.

d. Continental shelves are formed due to faulting and consequent subsidence of continental margins.

e. Continental shelves are formed due to glacial control and marine erosion.

f. Continental shelves are formed due to cliff erosion and sub emergence of wave cut platforms.

g. Continental shelves are formed due to titling.

The continental shelves is equivalent to 18% of the earth's dry land area, and they occupy about 7.6% of the ocean floor. Sediments at the outer edge of a shelf can be upto 9 km. thick and 150 millions year old. water depth over shelves average only about 75 meters. Continental shelves may be very wide, 1280 km. off Siberia or virtually non existence off chile.

Continental shelves have become increasingly important because of the natural resources. Numerous deposits of oil and natural gas are found in continental shelves which are being prospected and extracted. Moreover the waters of continental shelves contain many of the important fishing's grounds of the world. They are thus significant source of food. The continental shelf is even more important as geopolitically and economically as the fast growing population of the developing countries will look towards the sea for its food, minerals and raw material requirements. Having an average depth of 75 mts. The continental shelves are accessible to mining and drilling activities.

9.4 CONTINENTAL SLOPES

The zone of steep slopes extending from the continental shelf to the deep sea plains is called continental slope. In other words continental slopes may be defined as the continuously sloping portion of the continental margin, seaward of the continental shelf and extending down to the deep sea floor of the abyssal plain, is known as continental slope. It is characterized by the gradients of $2\text{-}5^0$ also varies from 5 degree to 60 degree at different places **e.g.:** 40^0 near St. Helena, 30^0 off Spanish coast, 62 degree near St. Paul, 5^0 to 15^0 near Calicut coast (India). The depth of water over the continental slope varies from 200 m to 2000 meteres. Continental slope occupies only 8.5% of the total area of the ocean basins but it varies from one ocean to the other **e.g.:** 12.4% in Atlantic Ocean, 7% in Pacific Ocean, 6.5% in Indian Ocean.

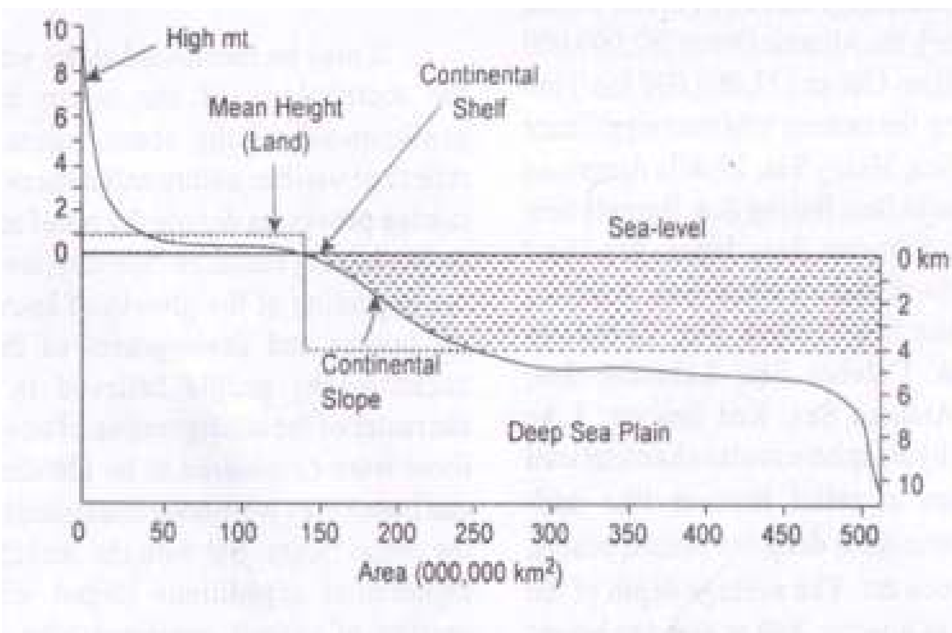
The continental slope makes the boundary between 20^0 N and 50^0 N latitudes and on 80^0 N and 70^0 S latitudes. Generally the steep gradients of the continental slopes do not allow any marine deposits because the materials coming from the continental shelves are immediately removed downward but in some cases a thin veneer of deposits does exist.

The continental slope having gentle slope. The angle of continental slope varies from more than that of shelf. Off Ireland, it is only about 5 degree; but off the coast of Spain it is much steeper and near cape torifiana it is in one place as much as 36 degree a steep angle even for a mountain side.

9.4.1 Origin of continental slope

The origin of continental slope has been related by various authorities to the erosion, tectonic and a gradational process. The erosion theory of the origin of continental slope is based on the presence of sub marine canyons, which is the most significant relief feature of continental slope. According to the theory slopes are formed due to erosion by marine processes mainly sea wave. According to the tectonic theory faulting is held responsible for the origin of the continental slopes.

Some exponents believe that continental slope are formed due to bending and warping of continental shelves followed by the sedimentation having long narrow and deep trenches located on the continental shelves and slopes with vertical walls resembling the continental canyons are called sub marine canyons, because of their location under oceanic water.



Hypsometric (hypsographic) and bythemetric curves of the earth.

9.5 DEEP SEA PLAINS

The deep ocean basins are the most significant relief feature of the ocean floor also known as **deep ocean basins.** Away from the margin of continents, the structure of the ocean floor in quiet different. Here the sea floor is blanket of sediments overlying basaltic rocks up to 5 km. thick. Deep ocean basins comprise more than half of the earth's surface. The deep ocean floor consists mainly of oceanic ridge systems and the adjacent sediment covered plains. Deep basins may be trimmed by the trenches or by the masses of sediments. Flat expenses are interrupted by island hills, active and extinct volcanoes and active zones of sea floor spreading. The sediments on the deep sea floor reflect the history of surrounding continents, the biological productivity of the over lying water and the areas of the basins themselves.

The deep ocean basins are characterized by the following significant relief features of elevation (like abyssal hills) and depressions (like ocean trenches and ocean deeps). The most extensive features are deep sea plains, very often called as Abyssal plains but these are physiographical monotonous because of their fattish character of vast terrain.

Abyssal plains known as deep sea plains are the most extensive but flattest terrain units to be found on the earth's surface including continents. The average slope gradient is about 0.5^0

Deep sea plains are characterized by the flat and rolling sub marine plain is the most extensive relief zone of the ocean basins. These deep seated plans having the depth from 3000 to 6000m. Covers 75.9% of the total area of the ocean basins but this areal coverage varies from one ocean to another 80.3% in Pacific Ocean, 80.1% in Indian ocean, 54.9% in Atlantic ocean.

Important deep sea plains are:

a. Somali Abyssal plains

b. Ceylone(Srilanka) Abyssal plains

c. Indian Abyssal plains

9.6 OCEAN DEEPS

Ocean deeps representing depressions and trenches on the ocean floors are the deepest zones of the ocean basins. These are of generally located parallel to the coasts facing mountains and along the islands.The no. of deeps in the atlantic oceans is less than in the pacific ocean because of the effects of teritiary orogenic movements along the altlantic coasts.

MURRAY has identitified 29 deeps upto the depth of 3000 fathoms in the Atlantic ocean. Some of the important are as Nares deep, Pureto rico deep ,Hatteras deep, Columbia deep, Valdivia deep, Tizard deep.,Buchanan deep, Veema deep etc.

Ocean deeps are grouped into two categories according to size: Very deep but less extensive depressions are called deeps and Long & narrow linear depressions are called trenches.

These deeps and trenches are characterized by very steep slopes. Sometimes these rise almost to vertically. The few important ocean trenches have been presented in below:

Table no. 1 MAJOR OCEANIC TRENCHES WITH DEPTH (mts.)

S.NO.	Name of oceanic trench	Location	Depth(mts.)
1.	Mariana/Challenger trench	North pacific	11,022mts.
2.	Aldrich trench	Central s. Pacific	10,882
3.	Philippine trench	N.W.Pacific	10,475
4.	Rico trench	Off west Indian island	8,385
5.	Kurile trench	Off Sakhalin Kamchatka	10,498
6.	Tizard trench	S. Atlantic	7,631
7.	Java trench	E. Indian ocean	7,450

There are few deeps and trenches in the Indian ocean. About 60% of the Indian ocean consists of deep sea plains with depth ranging from 3600- 5487 m. Important trenches are as under: Java Or Sunda trench, Ob trench, Mauritius trench, Amirante trench.

9.7 CONCLUSION

The ocean floor is highly uneven. The ocean basin has similar topography as that of earth's land, many plains of the ocean floor are larger and flatter than any found on the earth's surface. Underwater mountains and mountain ranges are found throughout the ocean. The main features of ocean floor are continental shelf lying next to the land and sloping gently from the shore. Continental slope lies immediately outside the continental shelf and sloping more steeply. Deep sea plains, a broad nearly level area forming the greater part of the ocean floor. Deeps are the deepest part of the ocean, forming depression, in the floor, relatively small in the area and with comparatively steep sides.

9.8 EXAMINATION ORIENTED QUESTIONS

Q1. Write a short note on following

(i) Continental shelf (ii) Continental slope

(iii) Deep sea plain (iv) Ocean deeps

Q2. Discuss the relief features of ocean flour in details.

Q3. What is continental shelf? Discuss it i details.

Q4. Differentiate between continental shelf and continental slope.

Q5. Describe in details the Deep sea plains and name the major Oceanic Trenches.

9.9 GLOSSARY

1. Oceanic Ridge – Features of elevation in Ocean basic.
2. Trenches – The depression in oceans.
3. Continental shelf – zone extended from shore.
4. Marine Erosion – Erosion caused in water.
5. Fluvial deposits – The deposits brought by rivers.

9.10 SUGGESTED READING

Physical Geography by Savindera Singh, Prayag Pustak Publication, 20-A, Univ. Road, Allahabad

Oceanography, by Savindera Singh, Prayag Pustak Bhawan Allahabad

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TEMPERATURE OF OCEANS: HORIZONTAL AND VERTICAL DISTRIBUTION OF THE TEMPERATURE

Dr. Tarsem Lal

10.1 INTRODUCTION

The temperature may be defined as degree of hotness and coldness. The major source of temperature of the oceanic water is the sun. The temperature of sea water is important for marine organism and indirectly important for all the biota on this planet earth. The temperature of the ocean is not uniform. It differs from latitude to latitude and from surface to bottom. In other words temperature variations in the oceans occur from equator towards pole and from surface to the oceanic bed.

The temperature is an important physical property of ocean water. It is the factor in controlling the movement of large masses of ocean water and their characteristics. The type and distribution of marine floura and fauna also largely depend on the temperature of the water. In the ocean, temperature decreases according to the increasing depth.

10.2 OBJECTIVES

To study the importance of oceanic temperature.

To study the factors affecting the distribution of oceanic temperature.

To study the characteristics of horizontal and vertical distribution of temperature of oceans.

10.3 DIFFERENT RANGES OF SEA TEMPERATURE

The temperature of the oceans is recorded under two main range i.e. the temperature should be recorded daily or day by day within 24 hours called daily range of temperature and the temperature recorded in the months of August and February called annual range of temperature.

(i) DAILY RANGE OF TEMPERATURE

(ii) ANNUAL RANGE OF TEMPERATURE

(i) DAILY RANGE OF TEMPERATURE:-

The difference of maximum and minimum temperature of day is known as daily range of temperature. The daily range of temperature of surface water of oceans is almost insignificant as it is around only 1^0c. On an average the maximum and minimum temperature of ocean water recorded at 2pm and 5am respectively. The daily range of temperature usually 0.3^0 c in low latitude and $0.2-0.3^0$ c higher latitude.

The diurnal range of temperature depends on the conditions of sky, stability or instability of air. Under overcast sky and strong air circulation in diurnal range of temperature becomes a bit higher and due to high density of water below surface water causes very little transfer of heat through conduction and hence the diurnal range of temperature becomes low.

(ii) ANNUAL RANGE OF TEMPERATURE:

The temperature records annually are annual range of temperature. The average temperature is about -12^0c. but there is a lot of regional variation due to water of seas, prevailing winds. The annual range of temperature is higher in enclosed sea than in open sea. Atlantic Ocean records about higher temperature than the Pacific Ocean.

10.4 IMPORTANCE OF OCEAN TEMPERATURE

The temperature of sea water is directly very important for marine organisms and is indirectly important for all the biota on this planet earth including both lithosphere and oceanic environments because of the following facts:

a. Oceans are great storehouse for heat energy because they receive and store solar energy and thereafter release heat energy in various forms.

b. The solar energy received at the water surfaces of the oceans help in the process of photosynthesis by phytoplankton of marine environments. Thus, sea temperature becomes very important also for zooplanktons as they drive their food from phytoplanktons.

c. The sea temperature plays vital role in influencing global radiation balance and heat budget.

d. The temperature of seawater affects the weather and climate of coastal areas through diurnal rhythm of land and sea breezes ,evaporation and moisture conditions of coastal areas and gives birth to marine climate

e. Since the sea water has higher specific heat than land areas and hence its heating and cooling process of much slower than these processes on lands, and hence oceans have high storage capacity of heat.

f. The sea temperature plays vital role in making the global hydrological cycle functional.

g. The sea temperature determines evaporation process and precipitation.

h. The salinity and density of ocean water are closely related to sea temperature.

10.5 FACTORS AFFECTING DISTRIBUTION OF OCEAN TEMPERATURE :

The factors affecting distributional pattern of temperature of ocean are as follows:

10.5.1 Latitudes

The temperature of surface water decreases from equator towards poles because the sun's rays become more and more slanting and thus the amount of isolation decreases pole wards accordingly. The temperature of surface water between 40^0N and 40^0S is lower than air temperature but it becomes higher than the air temperature between 40^{th} latitude and the poles in both the hemispheres.

10.5.2 Unequal distribution of land and water

The temperature of ocean water varies in the northern and southern hemisphere because of the dominance of land in the former and water in the latter. The oceans in the northern hemisphere receive more heat due to their contact with larger extent of land than their counter parts in the southern hemisphere and thus the temperature of surface water is comparatively higher in the former than the latter. The isotherms are not regular and donot follow latitudes in the northern hemisphere because of the existence of the both warm and cold land masses whereas isotherms are regular and follow latitudes in the southern hemisphere because of the dominance of the water. The temperature in enclosed seas in low latitude becomes higher because of the influence of the surrounding land area than the open seas. **e.g.** The average annual temperature of surface water at the equator is 26.70C where as it is 37.80 C in the Red sea and 34.40C in the Persian gulf.

10.5.3 Nature of land and water

The contrasting nature of land and water surfaces in relation to the income shortwave solar radiation largely affects the spatial and temporal distribution of temperature. It may be pointed out that land becomes warm and cold more quickly than the water body. This is why even after receiving equal amount of insolation the temperature of land becomes more than the temperature of the water body.

10.5.4 Prevailing winds

Wind direction largely affects the distribution of the temperature of ocean water. The winds blowing from the land towards the oceans and seas drive warm surface waterway from the coast resulting into upwelling of cold bottom water from below. Thus, the replacement of cold water introduces longitudinal variation in temperature. Contrary to this the onshore winds pile up warm water near the coast and thus raise the temperature. For e.g. Trade wind cause low temperature (in the tropics) along the eastern margin of the oceans are the western coastal regions of the continents because they blow from land towards the oceans whereas these trade winds raise the temperature in the western margins of the oceans or the eastern coastal areas of the continents because of their onshore position.

10.5.5 Ocean Currents

Surface temperature of the oceans is controlled by warm and cold currents. Warm currents raise the temperature of the affected areas whereas cool currents lower down the temperature. For e.g. the Gulf Stream raises the temperature near the eastern coast of the northern coast of America and western coast of Europe. Kuro shio derives warm water away from the eastern coast of Asia and raises the temperature near Alaska.

10.5.6 Minor factors

It includes:

i). Submarine ridges

ii). Local weather conditions like storms, cyclones, hurricanes, fogs, cloudiness, evaporation, and condensation, and

iii). Location and shape of the sea.

Longitudinally more expensive seas in the low latitudes have higher temperatures than the latitudinally more expensive seas as the Mediterranean seas records higher temperature than the gulf of California. The enclosed seas in the low latitudes record relatively higher temperatures than the open seas.

10.6 DISTRIBUTION OF TEMPERATURE

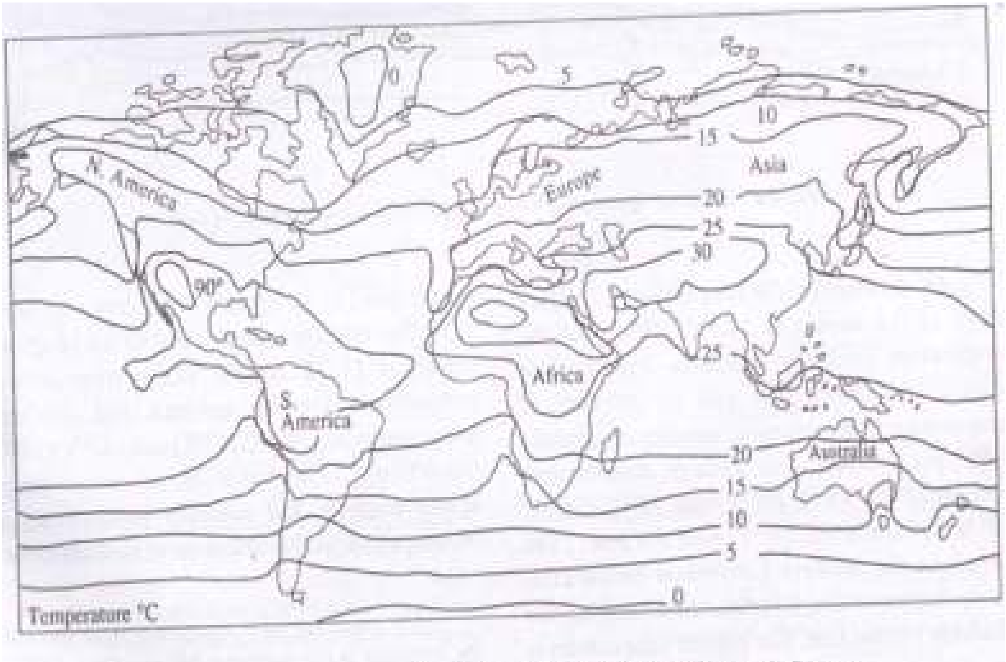
The distribution pattern of temperature of oceanic water is studied in two ways:

10.6.1 Horizontal distribution of temperature

The distribution of surface water temperature in the ocean is a complex matter. The horizontal distribution of temperature i.e. from equator towards pole ward is closely influenced by solar energy that enters the ocean from the sun. The oceans absorb solar energy and act as a major storage of reservoir of the heat. In general, there is an increase in surface water temperature as one move from poles to the equator, resulting from the latitudinal variations in solar energy inputs. There is gradual decrease in the annual average temperature of waters of Open Ocean from 26^0 Celsius at the equator to 23^0 Celsius at 20^0 latitude, 14^0Celsius at 40^0 latitude and only 1^0 Celsius at 60^0 latitude.

The seasonal temperature of the earth's surface including both land and ocean surfaces are shown through isotherms of January for winter season and July for summer season.

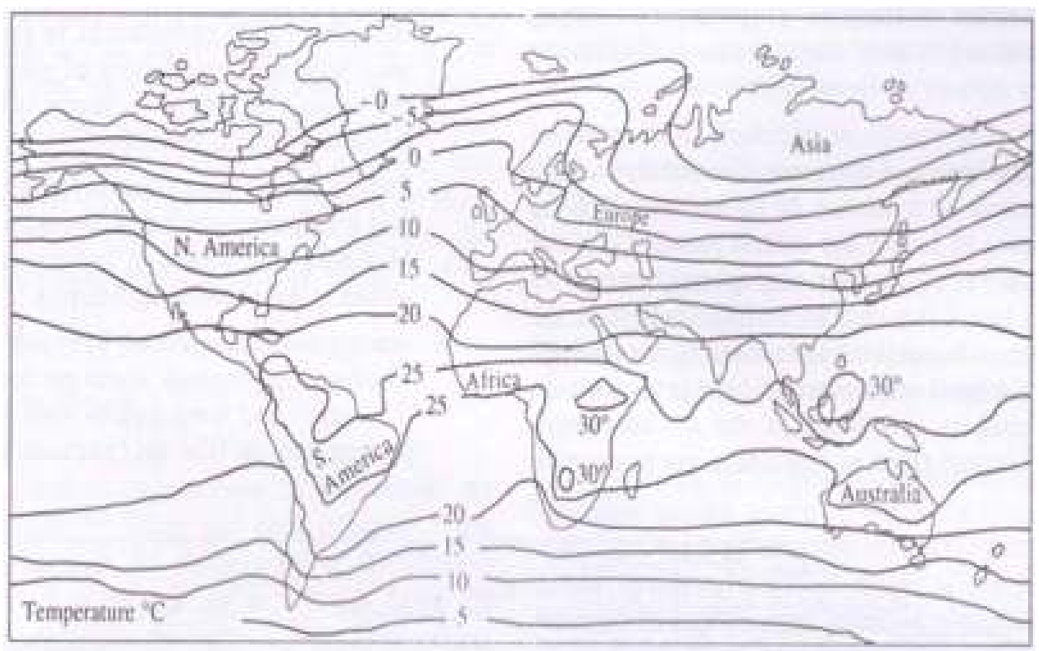
The seasonal change in temperature is much less than in the case of land masses. The seasonal change in temperature is greater in the Atlantic Ocean than that in the Pacific Ocean because of its small size and greater in the oceans of the northern hemisphere than those in the southern hemisphere because of the effect of the cool air masses moving over the oceans from the northern landmass in winter. The range of seasonal temperature is however about 6^0 Celsius between 20^0 and 20^0S latitude and again south of 50^0S.



Isotherms representing horizontal distribution of temperature in January.

The maximum water temperature is recorded in the enclosed tropical sea or semi enclosed tropical seas **e.g.** In Red sea temperature over 30^0 Celsius is occasionally recoded. The average summer temperature of the Red sea reads 29^0 c**.**

In the horizontal distribution of oceanic temperature, influence the ocean current is also quiet significant. Isotherms are the imaginary lines drawn on the map joining places of equal temperature reduced to sea level. It is necessary to reduce the actual temperature of all places at sea level before drawing isotherms. It is thus obvious that isotherms do not represent real temperatures of a place. That is why this isotherm map is not useful for farmers because they need real temperatures of a particular place for growing crops. Normally isotherms run east west and are generally parallel to latitudes. This trend shows that strong control of latitudes on horizontal distribution of temperature. Isotherms are generally straight but they bend at the junction of continents and oceans due to differential heating and cooling of land and water. isotherms lines are more irregular in the northern hemisphere because of large extent of continents but they are more regular in the southern hemisphere due to over dominance of oceans. Isotherms are closely spaced in the northern hemisphere but they are widely spaced in the southern hemisphere. The closely spaced isotherms denote the rapid rate of change for temperature and steep temperature gradient. On the other hand widely spaced isotherms indicate slow rate of change and low temperature gradient. On an average the isotherms trending from land towards ocean bend equator ward during summer and Pole ward during winter. The isotherms during the months of January and July are taken as representative for the study of horizontal distribution of temperatures during winter and summer season respectively because they represent seasonal extremes.



Isotherms representing horizontal distribution of temperature in July.

The months of maximum and minimum insolation do not coincide with the month of hottest and coldest respectively.

On an average the temperature of surface water of the ocean is 26.7^{0}c and the temperature gradually decreases from the equator towards pole. The rate of decrease of temperature with increasing latitude is generally 0.5^{0}F per latitude. The average temperature becomes 22^{0}c at 20^0 latitude 140 C at 40^0 latitude and 0^0 C near poles. The oceans in the northern hemisphere record relatively higher temperatures than in the southern hemisphere. The highest temperature is not recorded at the equator rather it is a bit north of it. The average annual temperature of all the oceans is 17.2^{0}C (63^0)F. The average annual temperature for northern and southern hemisphere are 19.4^{0}C (67^0) F and 16.1^{0}C (61^0) F. The decrease of temperature with increasing latitude in the northern Atlantic Ocean is very low because of warm ocean currents. The average temperature between 50^0- 70^{0}N latitude is recorded as 5^0 C. The temperature of the surface water of the ocean is higher than the air temperature above the ocean surface which means ocean surface gives off heat to the atmosphere. It has been observed that the air temperature at the height of 8m from the sea surface between 20^0 N and 55^0 S latitudes in the Atlantic Ocean is cooler by 0.80^{0}C than the sea surface. There is a lot of variation in the heat emitted from the oceans to the atmosphere during winter and summer and this phenomenon causes differences of air temperature over the oceans and continents mainly during winter season. The temperature for January is 22.2^{0}C higher over the oceans between 20^0 and 80^0 N, while in July it is 4.8^{0}C lower .The mean annual temperature is 7^{0}C higher over the water meridian.

10.6.2 Vertical distribution of temperature

It may be pointed out that maximum temperature of the oceans is always at their surface because it directly receives that insolation and the heat is transmitted to the lower sections of the oceans through the mechanism of conduction.

In the vertical distribution of temperature, the temperature falls very rapidly up to the depth of 200m and thereafter the temp. Decrease is slow down. From this the oceans are vertically divided into two zones: photic zone and aphotic zone **. PHOTIC ZONE:** This zone represents the upper surface up to the depth of 200m and is heated directly through solar radiation. **APHOTIC ZONE:** This zone extends from 200m depth to the bottom of the oceans where solar radiation is unable to penetrate.

The photic zone is biologically very important because marine plants, and called as marine prototroph's or phytoplankton's produce their food energy through the process of photosynthesis. This phytoplankton's become rich marine pasture for marine animals of the category of zooplanktons.

The following are the characteristic features of vertical distribution of temperature of ocean water:

a) Though the sea temperature decreases with increasing depth but the rate of decrease of temperature is not uniform. The change in sea temperature below the depth of 2000m is negligible. The trend of decrease in temperature with increasing depth has been noticed by Murray in his challenger expedition.

Table1 Comparison of temperature at sea surface at different depths

Latitudes (N)	0-10	10-20	20-30	30-40	40-50	50-60	60-70
Surface Temperature (^{o}C)	26.88	25.60	23.90	20.30	1 2.94	8.94	4.26
Depth at 7.30^{o} N (meters)	0	100	200	400	800	1000	_
Temperature(^{o}C)	26.86	18.57	10.71	7.70	5.13	4.81	_

b) Diurnal and annual ranges of temperature cease after the depth of 5 fathoms(30 feet) and 100 fathoms (600 feet) respectively.

c) The rate of decreasing temperature with increasing depth from equator towards pole is not uniform.

d) The areas from where sea surface water is driven away by off shore winds resulting into upwelling of water from below record low temperature at sea surface and thus the rate of decrease of temperature with increasing depth becomes low. On the contrary, the areas where there is pilling of water because of onshore winds , record relatively high temperature at the sea surface and thus rate of decrease of temperature with increasing depth is rapid

e) In some areas high temperature is recorded at greater depth, e.g. Sargasso sea, red sea, Mediterranean sea, sulu sea etc. The Mediterranean Sea records 24.40 C at the depth of 1829m whereas Indian ocean has about 1.10 C temperature at the same depth.

f) The enclosed seas of high latitudes register inversion of temperature.

g) The enclosed shallow seas have different vertical distribution of temperature. The temperature of red sea remains uniform at 21^{0}C. right down to bottom while in

Indian ocean the temperature at 2100mts. Is about 2^{0}C similarly the temperature of water near the bottom of Mediterranean sea is about 13^{0}C, the coldest water that can pass over the still at a strait of Gibraltar which is only 350mts. Deep

Table 2. Vertical Distribution of Temperature in the Oceans

Depth in fathoms	Depth in mts.	Temperature ^{0}F	Temperature ^{0}C
100	183	60.7	16
200	366	50.1	10
500	915	45.1	7.3
1000	1830	36.5	2.3
1500	2745	35.5	2.0
2200	4026	35.2	1.7

h) Vertically the oceans are divided into 3 layers from the stand point of thermal conditions of sea water, in the lower and middle latitude as follows:

i) The **Upper layer** represents the top layer of warm water mass with a thickness of 500 meters with average temperature ranging between 20 to 25^{0}C. These lighter ocean water mass floats over the thickest heavy water mass of the oceans extending up to the ocean bottoms. This layer is present within the tropics throughout the year but it develops in middle latitudes only during summer season.

ii) The **Lower layer** extends beyond 1000m depth up to the ocean bottoms. This layer is very cold and represents denser ocean water mass.

iii) The **upper and lower** ocean water masses are separated by the transitional zone of rapid change of temperature with increasing depth. This zone of ocean water mass is called thermoclines which extend between 300m-1000m depth. Besides, there are seasonal thermoclines between the depth of 40m and 100m.

These seasonal thermoclines are formed due to heating of water surface through solar radiation during summer season. There are also diurnal thermoclines which form in shallow water depth usually less than 10-15 m. The polar seas have only one layer of cold water mass from the ocean surface (sea level) to the deep ocean floor.

10.7 CONCLUSION

The ocean water gets heated when it receives heat from the sun and its temperature rises. The temperature of the sea water is fixed at the sea surface by heat exchange with the atmosphere. The average incoming sun's energy at the surface is about four times higher at the equator than the poles. This heat is transferred from low to higher latitudes by winds in the atmosphere and waves in the oceans. The geothermal heat flux from the interior is insignificant. Water is transparent, so radiation penetrates some distance below the surface, heat is also carried to deeper levels by mixing. Most of the sun's energy is absorbed within few metres of the ocean surface. Directly heating the surface water and providing the energy for photosynthesis by marine plants and algae. The main mechanism of the transfer heat deeper is turbulent mixing by winds and waves.

10.8 EXAMINATION ORIENTATED QUESTIONS

Q1. Discuss the distribution of oceanic temperatures.

Q2. Write a detailed note on horizontal distribution of temperature of oceans.

Q3. Discuss the vertical distribution of temperature of oceans in details.

Q4. Differentiate between Daily and Annual Range of temperature.

10.9 GLOSSARY

1. Range – Difference between high and low.
2. Warm Currents – Water channel with higher temperature than surrounding water.
3. Isotherm – Imaginary lines joining the places of equal temperature.
4. Diurnal – Heating and cooling of ocean water under clear sky.

10.10 SUGGESTED READING

Physical Geography by Savindera Singh, Prayag Pustak Publication, 20-A, Univ. Road, Allahabad

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SALINITY CAUSES AND DISTRIBUTION

Dr. Shivani Walia

11.1 INTRODUCTION

This chapter explains the salinity of seawater. We know that oceans have a great amount of water but it is not suitable for drinking. The main cause for it to be unsuitable for drinking purpose it the presence of salts in the ocean water. It is more appropriate to call ocean water a dilute solution of salts. The presence of salts in ocean water causes salinity which is known as the salinity of ocean water. Salinity is defines as the ratio between the weight of the dissolved solid material and the weight if the sample seawater. Generally salinity is expressed as part per thousand (‰). If suppose the salinity of sea water is 30‰, it means 30 grams of salt in 1000 grams of seawater. It is also important to mention here that the river and sea water are much different from each other from the point of view of mineral substances river water has a lot of calcium and bicarbonates but has very low quality of sodium, magnesium and chloride. The case is just the reverse in sea water one thousand tones of sea water contains, on an average , 34.75 tonnes of salts. According to Jolly, 50,000 million tonnes of salt are present in the oceanic water. This salt, is dried will cover the entire globe with a layer of 50 metres thick. If this salt is spread over land areas, the thickness will be more than 150 metres. The sea level will fall by about 30 metres if the salt is entirely withdrawn from the ocean. Gases are also dissolves in sea water. The main gases are nitrogen, oxygen and carbon dioxide. According to T. Schloesing, the quantity of carbon dioxide in oceans is 18 to 27 times that of in atmosphere.

11.2 OBJECTIVES

The main objective is to explain the students that what is salinity and what is the importance of salinity in various oceanic processes. It also helps to make the students aware of the source and distribution of oceanic salinity.

11.3 SOURCES OF OCEAN SALINITY

It is importance to mention here that chloride ion (cl) is the most dominant constituent of salinity and is easily measured and thus, chloride ion (cl) is measured to derive chlorinity, which is the weight of chloride ion in a sample of seawater. The measurement of chloride ions in all the oceans has reveled that it accounts for 55.5 percent of the total amount off dissolve solids in the ocean of seawater whereas average chlorinity is 19.2% (in one kilogram of seawater). Salinometer is the instrument used to measure sea water salinity very accurately even upto the accuracy of 0.003% or even more.

Table: Dissolved materials in sample seawater having 35‰ salinity.

Constituents	**Concentration ‰ (parts per thousand)**	**Ratio of total Constituents (Salts) in percent**
Chloride (cl)	19.3	56.04
Sodium (Na^+)	10.7	30.61
Sulphate ($S0^2_4$)	2.7	7.68
Magnesium (mg^{2+})	1.3	3.69
Calcium (ca^{2+})	0.41	1.16
Potassium (K+)	0.38	1.10
Total	**34.79%**	**99.28%**

Ocean salinity is derived from the following three source and process:

1) Chemical weathering of continental rocks and their transport by the rivers to the oceans.
2) Degassing by the earth i.e undersea volcanic eruption.
3) Atmosphere and biological interactions.

River runoff is the most significant contributor of sea water salinity. The continental rocks are subjected to chemical weathering through different processes like carbonation, oxidation, solution, hydration, hydrolysis, chellation etc. The weathered material, which containing different dissolved substance are carried by surface runoff and overland flow and are brought to the rivers which finally dump these dissolved material into the oceans.

The second source of seawater salinity is vulcanicity in the oceans. We know that there is frequent volcanic activity along the divergent plate boundaries representing divergence zone of sea floor spreading and convergent plate boundaries representing subduction zone. These undersea volcanic eruption spew chloride and sulphate which are added to the ocean water.

The other insignificant sources of seawater salinity include atmosphere and biological sources. Certain gases from the atmosphere are dissolved in ocean water and contribute to the increase in the ocean salinity certain biological interactions also add some sort of salt in the oceans. The addition salt in seawater from various sources is called source or input. The outputs of salts from the oceans are called sinks of ocean salinity, which include evaporation, salt spray by tidal surges from the oceans, new basalts which are extracted along the mid-oceanic ridges due to divergent movements of plates and rultant sea floor spreading, adsorption etc.

11.4 CONTROLLING FACTORS IF SALINITY

The factors affecting the amount of salt in different oceans and seas are called as controlling factors of oceanic salinity. Evaporation, precipitation influx of river water, prevailing winds, ocean currents and sea waves, melting of ice etc. are the significant controlling factors. In general, evaporation and formation of ice increase ocean salinity, where as precipitation runoff, melting of ice decrease ocean salinity.

Temperature:-Evaporation of water is accelerated when the temperature of the area is high. The salts are, however, left in the seas. The water condensed from the water vapour in the clouds reaches the earth in the form of rainfall. This water dissolves salts from the soil as it flow through it. When this water reaches the seas, the salts are thrown into them. This process increases the amount of salt in the ocean.

Evaporation:- There is direct positive relationship between the rate of evaporation and salinity e.g greater the evaporation higher the salinity and viceversa. In fact, salt concentration increases with rapid rate of evaporation. Evaporation due to high temperature with low humidity causes more concentration of salt and overall salinity becomes higher e.g subtropical high pressure belts and trade wind belts records rapid rate of evaporation which increases salinity but cloudy sky with high humidity and influx of rainwater lower down salinity in the equatorial belt. It may be pointed out that salinity also controls evaporation.

Ice Formation:- Formation of ice in the high latitude areas of the oceans increase seawater salinity. It may be noted that the formation of ice in the oceans requires extraction of seawater and thereafter freezing of such water. Whenever temperature of seawater becomes at or below freezing point, water molecules are removes from seawater and are frozen to form sea ice. Thus sea ice contains fresh water and only less than 30 percent of seawater salinity where water freezes to form sea ice. For example, if the salinity of seawater of part of an ocean is 33‰ and if the seawater freezes and is changed to sea ice, it contains only 30 percent of seawater salinity of 33‰, i.e about 10 percent only. If appears that the sea ice contains mostly fresh water. This results in the reduction of volume of fresh water in the oceans. This situation causes increase in sea water salinity

Precipitation:- Precipitation is inversely related to salinity, i.e higher the precipitation, lower the salinity and vice versa. This is why the regions of high rainfall (equatorial regions) record comparatively lower salinity than the regions of low rainfall (subtropical high pressure belts).

Influx of River water:- Big and voluminous rivers add immense volume of water into the oceans and seas and thus salinity is reduced at their mouth. For example, comparatively low salinity is found near the mouths of the Ganga, the Congo, the Nizer, the Amazon, the St. Lawrence etc. The effect of influx of river water is more pronounced in the enclosed seas e.g the Danube, the Dneister, the Dneiper etc. reduce the salinity in the black Sea.

Atmosphere Pressure and wind Direction

Anticyclonic conditions with stable air and high temperature increase salinity of the surface water of the oceans. Subtropical high pressure belts represent such conditions to cause high salinity. Winds also helps in the redistribution of salt in the oceans and the seas as winds drive away more saline water to less saline areas resulting into decrease of salinity in the former and increase in the latter.

Circulation of Ocean Water:- Ocean currents affect the spatial distribution of salinity by mixing seawaters. Equatorial warm current drive away salts. From the western coastal areas of the continents and accumulate them along the eastern coastal areas. The high salinity of the Mexican Gulf is partly due to this factor, the North Atlantic Drift, the extension of the Gulf Stream increase salinity, along the north western coasts of Europe. Similarly, salinity is reduced along the north eastern Coasts of North Amrica due to cold Labrador current. Oceans currents have least influence on salinity in the enclosed seas but those marginal seas through wide opening are certainly affected by currents in term of salinity.

11.5 DISTRIBUTION OF SALINITY

The spatial distribution of salinity is studied in two ways:-

Horizontal Distribution of Seawater Salinity

Horizontal distribution of surface salinity of seawater at world level is studied in relation to the latitudes. On an average, salinity decreases from equator towards the poles. It may be mentioned that the highest salinity is seldom recorded near the equator though this zone records high temperature and evaporation but high rainfall reduces the relative proportion of salt. Thus, the equator accounts for only 35‰ salinity. The highest salinity is observed between 20º-40º N (36‰) because this zone is characterized by high temperature, high evaporation but significantly low rainfall. The average salinity of 35‰ is recorded between 10º-30º latitudes in the southern hemisphere. The zone between 40º-60º latitudes in both the hemisphere records low salinity where it is 31‰ and 33‰ in the northern and the southern hemisphere respectively. Salinity further decreases in the polar zones because of influx of melt water.

Following four zones of ocean salinity are identified on the basis of latitudinal distribution:-

i) **Equatorial Zone:-** (10º to 20º latitude on either side of the equator) It is a zone of low salinity due to excessive rainfall.

ii) **Tropical Zone:-** (20º-30º N and S latitudes) it is a zone of maximum salinity due to low rainfall, high evaporation and high atmospheric pressure caused by subsidence of air.

iii) **Temperate Zone:-** It is a zone of low salinity.

iv) **Sub Polar and Polar Zone:-** It is a zone of maximum salinity due to negligible evaporation more melt water etc.

Following is the regional distribution of surface salinity of different seas:-

i) **Seas having salinity above normal:-** Red sea (34-41‰), Persian Gulf (37-38‰), Mediterranean Sea (37-39‰)

ii) **Seas having normal Salinity:-** Caribbean Sea and Gulf of Mexico (35-36‰), Bass Strait (35‰) and Gulf of California (25-35.5‰)

iii) **Seas having salinity below normal:-** Arctic ocean (20-35‰), North Australian Sea (33-34‰) Bering Sea (25-33‰) Okhotsk Sea (30-32‰), Japan Sea (30-34‰) China Sea (25-35‰).

iv) **Seas having Salinity much below:-** Baltic sea (15-32‰) and Hudson Bay (3-15‰).

Vertical Distribution of Salinity:-

There is no definite trend of distribution of salinity with depth, because both the trends of increase and decreases of salinity with increasing depths have been observed. For example, salinity at the southern boundary of the atlantic is 33‰ at the surface but it increase to 34.5‰ at the depth of 200 fathoms. It further increases to 34.75‰ at the depth of 600 fathoms. On the other hand, surface salinity is 37‰ at 20º S latitude but it decreases to 35‰ at greather depth. The following characteristics of vertical distribution of salinity may be stated as:

i) Salinity increase with increasing depth from 300 metres to 1000 metres in high latitudes but salinity becomes more or less constant beyond 1000m depth.

ii) Salinity decreases between the depth zone of 300 metres to 1000 metres in the low latitudes, but it becomes more or less constant beyond 1000m depth.

iii) It appears from the above mentioned trends of vertical distribution of salinity that there is rapid rate of change of salinity in the depth zone of 300 m-1000 m. This zone of steep gradient of salinity is called halocline.

iv) Salinity is low at the surface at the equator due to high rainfall and transfer of water through equatorial current but higher salinity is noted below the water surface. It again becomes low at the bottom.

v) Maximum salinity is found in the upper layer of the oceanic water, salinity decreases with increasing depth. Thus, the upper zone of maximum salinity and the lower zone of minimum salinity is separated by a transition zone which is called as halocline.

11.6 SUMMARY

In the concluding lines it is important to mention here that salinity has the great significance is modifying the various processes and phenomena of the oceanic water. For example, the freezing and boiling points are greatly affected and controlled by the addition or subtraction of salts in seawaters. Similarly salinity and density of seawater are positively corrected. All this information helps the students to understand the concept and the importance of salinity.

11.7 GLOSSARY

Chlorinity:- Chlorinity is the weight of chloride ion in a sample seawater usually in one kilogram of seawater.

Halocline:- Halocline denotes zone of sharp salinity change in the vertical section of the oceans between 300 m- 1000 m depth.

Pycnocline:- Pycnocline is a layer of seawater mass between the depth of 300 m- 1000 m wherein there is sharp change of density in the vertical section of seawater.

Salinometer:- It is an instrument which is used to measure salinity of seawater very accurately i.e upto the accuracy of 0.003‰ or even more.

Thermocline:- Thermocline is the layer of ocean water between the depth zone of 300 m – 1000 m characterized by sharp change of temperature in the vertical section a seawater.

11.8 SHORT ANSWER TYPE QUESTIONS

Q1. What is Salinity?

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Q2. Name the variour sources of salinity?

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Q3. Write a short note on the horizontal distribution of salinity?

Q4. Name the seas of world having highest salinity?

11.9 EXAMINATION ORIENTED QUESTIONS

Define Salinity

Q1. What is salinity. What are controlling factors of salinity

Q2. Write a detail note on the horizontal and vertical distribution of salinity

Q3. Tropical areas record high salinity than the equatorial and the polar areas why?

11.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker

2) Physical Geography, By Savindra Singh

11.11 REFERENCES

1) Oceanography: An Invitation to Marine Science, By Tom S. Garrison

2) Oceanography, By Sharma and Wattal

3) Oceanography, By D.S. Lal

4) The Ocean, By Ellen Prager

11.12 MODEL TEST PAPER

Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

Section-A

Short question type (compulsory) (8x2=16)

Q1. Define weather and climate.

Q2. What is the significance of inversion of temperature?

Q3. Write a short on the equatorial low pressure belt.

Q4. What do you mean by orographic rainfall?

Q5. Write a note on frigid zone.

Q6. What do mean by Radiolarian ooze?

Q7. What is the difference between spring tides and neap tides?

Q8. What is the significance of Gulf stream?

Section-B

Long question type

(Attempt four questions in all, selecting one question from each unit)

Unit-I

Q1. What is Atmosphere. Write a note on the structure at atmosphere.

Or

Q2. Explain diagrammatically Global Heat Budget.

Unit-II

Q3. Give the climatic classification of the world given by Koppen.

Or

Q4. What are the main factors responsible for the origin of cyclones. Also give the distribution of tropical cyclones?

Unit-III

Q5. What is salinity? What are the factors affecting the salinity of an ocean?

Or

Q6. Write a note on the types of currents of Atlantic ocean.

Unit-IV

Q7. What are coral reefs. Explain Subsidence Theory given by Darwin regarding the origin of coral reefs?

Or

Q8. What are tides. Explain the various types of tides?

OCEAN WATER CIRCULATION:- CAUSES AND TYPES OF OCEAN CURRENTS: INDIAN OCEAN CURRENT AND ATLANTIC OCEAN CURRENTS

Dr. Shivani Walia

12.1 INTRODUCTION

Ocean current is defined as the general movement of a mass of ocean water in a definite direction over great distance. Ocean Current are most powerful of all the dynamics of oceanic waters because these drive oceanic waters for thousands of kilometers away.

Ocean currents are divided on the basis of temperature into warm currents and cold current. And on the basis of velocity, dimension and direction, ocean currents are divided into drifts, currents and streams. Drifts are defined as the movement of surface water of the ocean under the influence of prevailing winds, whereas the ocean currents are the movement of oceanic water in a definite direction with greater velocity. Ocean streams involved movement of larger mass of ocean water like big rivers of the continent in a definite direction with greater velocity than the drifts and current, e.g Gulf stream.

12.2 OBJECTIVES

— to familiarize the students with the origin of the currents.

— to provide the knowledge to the students regarding the types of the Atlantic ocean and the Indian ocean.

12.3 FACTOR AFFECTING THE ORIGIN AND MOVEMENTS OF CURRENTS

The currents in the oceans are originated due to combined effects of several factors acting internally as well as externally. Besides, there are some factors also which modify ocean currents. All these factor are discussed below one by one.

1. **Rotation of the Earth:-** The rotation of the earth on its axis from west to east results in the genesis of deflective force or coriolis force, which deflects the general direction of ocean currents. For example, the current flowing from equator towards the north pole and from north pole towards the equator are deflected to their right, while the currents flowing north south and south-north in the southern hemisphere are deflected towards their left.

2. **Temperature difference:-** Due to high temperature in the equatorial regions the water density decreases because of greater expansion of water particles whereas the density of sea water becomes comparatively greater in the polar areas. Consequents, water moves due to expansion of volume from equatorial region to polar areas of relatively very low temperature. These is movement of ocean water below the water surface in the form of subsurface current from colder polar areas to warmer equatorial areas in order to balance the loss of water in the equatorial areas.

3. **Salinity Difference**:-Oceanic salinity affects the density of ocean water, and density variation causes ocean current. Salinity increases the density of ocean water. If two areas having equal temperature are characterized by varying salinity, the area of high salinity will have greater density than the area of low salinity. The denser water sinks and moves as surfaces current whereas less saline water moves towards greater water as surface current.

4. **Density Difference:-** In facts, difference in the density of oceanic water is the main cause for the movement of oceanic water as ocean current. Density is the function of temperature, air pressure and salinity. As a rule, water moves from the areas of lower density to the areas of higher density. The density variation caused by temperature and salinity and resultant movement of oceanic water as ocean current has been explained just above.

5. **Air Pressure:-** Air pressure on the oceanic water causes ocean current through density variations. The areas of high atmospheric pressure are characterized by low volume of water and thus lowering of water level. Contrary to this, the areas of low atmospheric pressure record higher volume of water and higher water level. Thus, water moves as surface current from the areas of higher water level (low pressure areas) to low water level areas (high pressure areas).

Winds:- Prevailing winds play major role in the origin of ocean currents. The winds blowing on the water surface also moves water in the direction due to its friction with the water. Most of the ocean currents of the world follow the direction of prevailing winds. For example, equatorial current flow westward under the influence of NE and SE trade winds. The Gulf stream in the Atlantic and the Kuroshio in the Pacific move in the north-eastern direction under the influence of the westerlies.

Rainfall and Evaporation:- High rainfall with low evaporation lowers the amount of salinity and thus reduces water density. This mechanism result in the rise of sea level. On the other hand, high evaporation and low rainfall increases salinity and water density and thus lowers the sea level. Thus, surface ocean current are generated from the area of high level to the area of low water level. Thus, ocean currents originated in low latitude move towards high latitudes. Ocean currents are also generated in polar areas due to exceptionally low temperature and abundance of water due to melting of ice mass. Thus polar cold current move towards low latitudes.

Bottom relief:-The irregularities of the bottom reliefs of the oceans modify the ocean currents at the surface as well as at the bottom. According to Erman, the ocean currents tend to follow the bottom contours in the middle and high latitude, but they are independent of bottom reliefs in the low latitudes. The sub marine ridges usually deflect the course of the currents. Generally the ocean current while crossing over a sub marine ridge are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

Seasonal variation:- There is seasonal change in the directions of currents in some areas in response to seasonal change in weather conditions. e.g in the regions of monsoon climate as the current of the Indian ocean show seasonal changes in their flow directing. The monsoon drifts (current) move east to west along the coast during north east monsoon in winter season while these flow in north-eastern direction under the influence of south-west monsoon in summar season.

12.4 CURRENTS OF ATLANTIC OCEAN

North and South Equatorial Current:- North and South equatorial current are lying to the north and south of the equator. Both the currents flow westward. North equatorial current is formed between equator and 10º N, and South Equatorial current is formed between equator and 20º S latitude. These currents drive their energy mainly from trade wind deflection, created by the rotation of the earth. The north equatorial current after reaching West Indies gets divided into two parts. One part of this current move to the south of Cuba, which is know as Caribbean current. The other part moves to the east to West Indies, which is known as the Antilles Current. The south equatorial current flows between the coats of Africa and South America. It is stronger than northern current.

Gulf Stream:- The Gulf stream is the largest of the Western boundary current of North Atlantic ocean. It originates at 20ºN in the Gulf of Mexico. It carries warm water into colder latitude once taken off Cape Hatteras. It bonds with the coastal line upto 40º parallel. After this the direction is almost to the east due to the force and direction of the westerly.

North Atlantic Drift:- Eastward of the Grand banks the Gulf steam breaks into various branches demonstration itself only as a slow moving easterly current. This current is known as the north Atlantic Drift, driven by westerly wind. It is warm, saline and is divided into two parts. The northern branch moves eastward. It is mixed by the Labrador current on west. The other branch of the drift is warm due to lesser mixing of cold current and moves eastward.

The Canaries Cold Current:- It flows along the west coast of North Africa between Madeira and Cape Verde. The velocity of the current varies from 8 to 30 miles/day. The origin of the current is attributed to the trade width.

The Labrador Cold Current:- In north Atlantic, a cold current flows from Baffin Bay and Davis Strait towards the south. It flows down along the East Coast of Greenland. It merges with Gulf stream of 50ºW. It brings the ice bergs along with its from Baffin Bay. These ice bergs present effective hindrance in oceanic navigation. Dense fog is also produced due to the convergence with Gulf stream near Newfoundland.

South Atlantic Current

The Brazilian Current:- The south equatorial current flow westward is diverted to the south along the South American coast as the Brazilian current. The Brazil current is characterized by high temperature and high salinity. It deflected eastward due to deflective force in easterly directly under the influence of westerly. The Falkland cold current coming from south merges with the Brazil current near 40ºS latitude.

Falkland Cold Current:- The cold water of the Antarctica sea flows in the form of Falkland cold current from the south to north along the eastern coast of South America upto Argentina.

South Atlantic Drift (part of west Drift):- Under the influence of strong westerly the ocean water between 40-60ºS moves from west to east. It is a continuation of the easterly-deflected Brazilian current but less much of its original characteristics. It is comparatively shallower due to presence of well developed Antarctica intermediate water. The velocity of the current is between 6-33 miles/day.

Benguela Cold Current:- The benguela cold current flows from south to north along the western coast of south to north. In fact, the south Atlantic drift turns northward due to obstruction caused by the southern tip of Africa. Further north this current merge with south equatorial current.

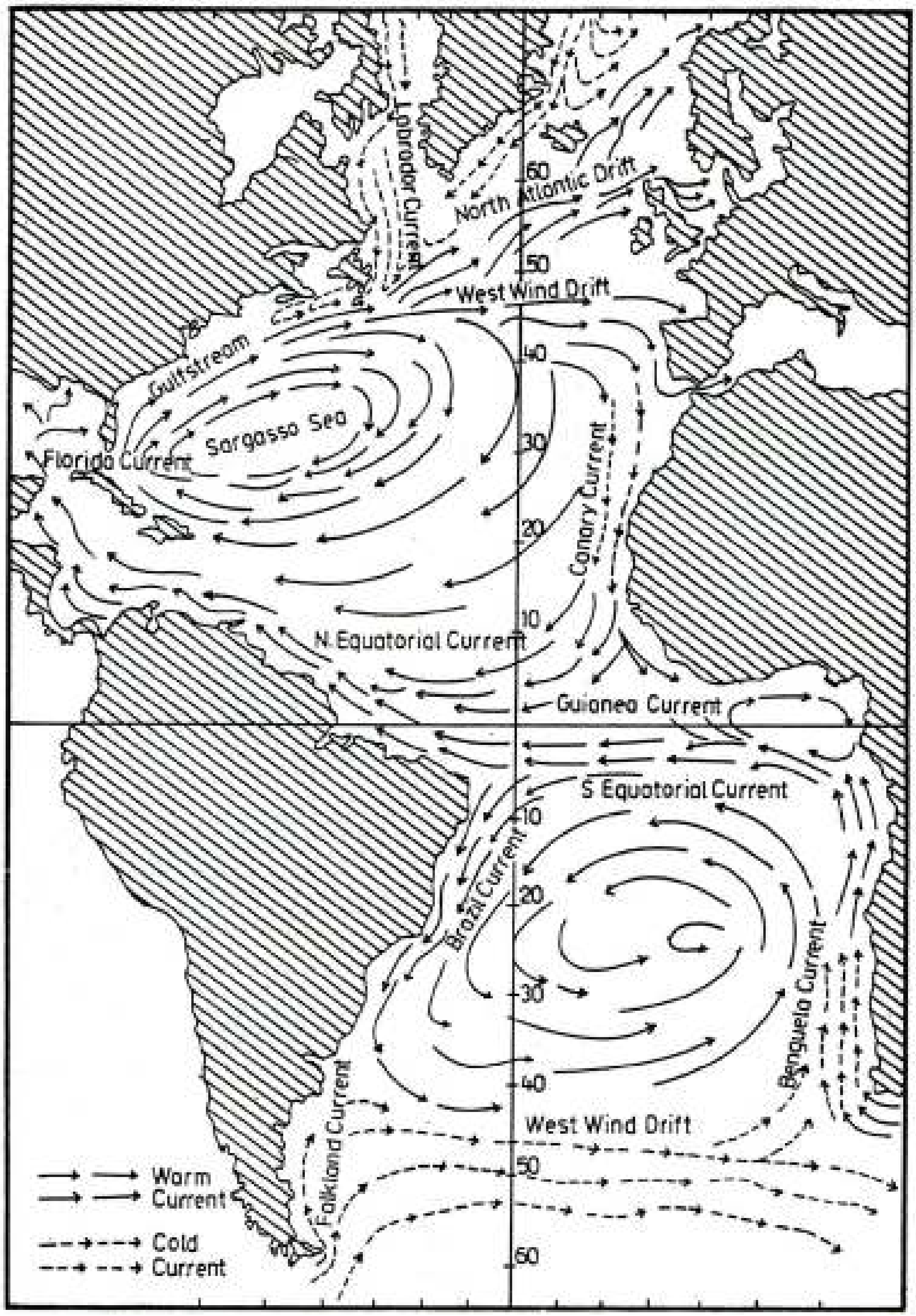

Fig. 12. A Major Currents of the Atlantic Ocean

12.5 CURRENTS OF THE INDIAN OCEAN

The current system of the Indian ocean are largely controlled and modified by land masses and monsoon wind. Indian ocean being surrounded by the Indian sub continent, Africa and Australia do not present most favourable conditions for the development of permanent and consistent system of ocean currents. The currents in the northern Indian Ocean change their flow direction twice a year due to northeast and southwest monsoon winds.

1. **Northeast Monsoon Current (warm):-** Northeast monsoon wind blow from land to ocean during winter season in the northern hemisphere and thus westward blowing northeast monsoon currents are produced between Andaman and Somali. This current flow to the south of 5ºN latitude. The current moves in an anticlockwise direction in Bay of Bengal and the Arabian Sea.

2. **Indian Counter Current (warm):-** Indian counter current is originated during winter season (Northern Hemisphere). This current flow in easterly direction between 2ºS to 8ºS latitude from Zanzibar to Sumatra.

3. **Southwest Monsoon Current (warm):-** This is complete reversal in the direction of monsoon wind during summer season. In other words, the north easterly direction of winter monsoon wind becomes south westerly during summer season in the northern hemisphere. This reversal of direction of monsoon wind also reverse the direction of ocean current of Indian ocean during summer season. Northeast Monsoon ocean current disappear and southwest ocean current develops. The general direction of monsoon current is from southwest to northeast but several minor branches emerges from the main branch and move in Bay of Bengal and Arabian Sea. The Indian counter current develop during winter season disappear due to this current.

4. **Indian Equatorial Current (warm):-** The current of the southern Indian ocean is least affected by seasonal change in the direction of monsoon. The Indian equatorial current flow from east to west between 10-15º S latitude from Australian coast to African coast. After bring obstructed by Madagascar, this current is divided into many branches. One major branch flows southward in the name of Agulhas current (warm), while the other branches are directed towards the north.

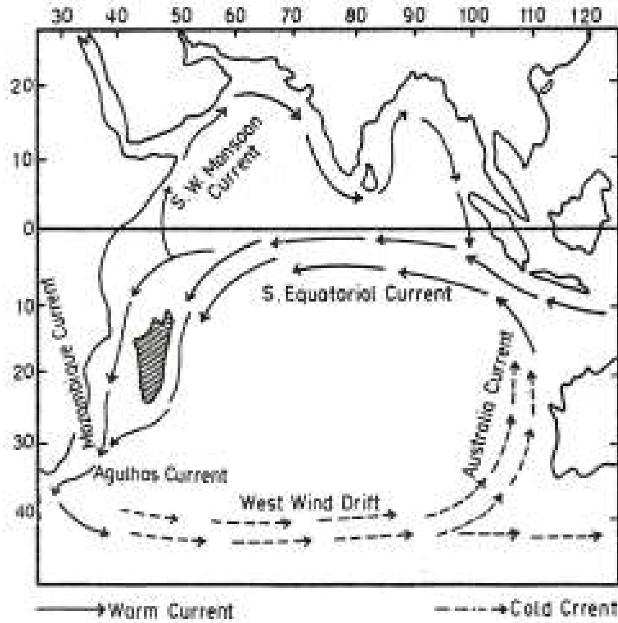

Fig 12.B Currents of Indian Ocean during Summer

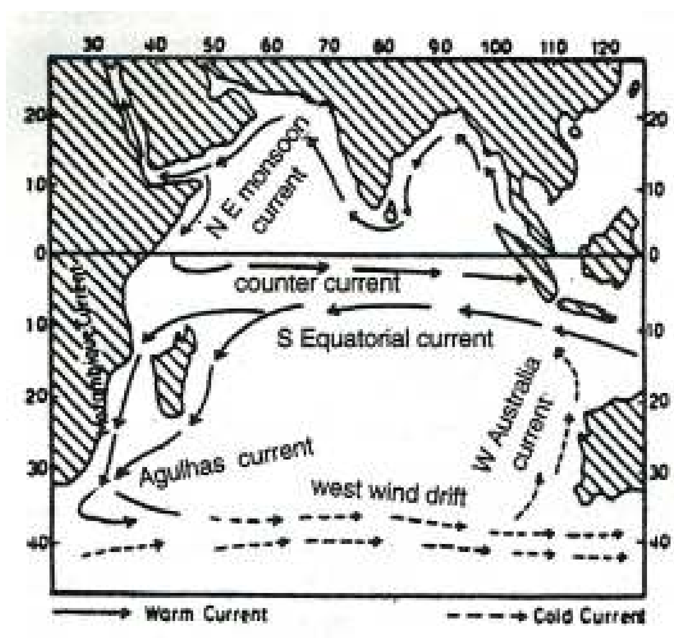

Fig 12.C Currents of Indian Ocean during Winter

12.6 SUMMARY

In the concluding lines, it is important to mention here that the currents play and important role in modifying the climatic conditions of an area. Various factors like rotation of the earth, temperature, salinity, air pressure, winds, rainfall and evaporation play major role on the origin, movement and drifting of the ocean currents.

12.7 GLOSSARY

Coriolis Deflective Force:- It is the force which deflect the direction of surface winds. Coriolis force or effect is not a force in itself in real sense rather it is an effect of the rotational movement of the earth.

Currents:- The movement or circulation of ocean water in definite direction with greater velocity.

Drift:- The surface ocean current moving forward under the influence of prevailing winds.

Streams:- It involves movement of enormous volume of ocean water like big river of the continents, in definite direction with greater velocity.

12.8 SHORT ANSWER TYPE QUESTIONS

Q1. What is the difference between current and drift?

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Q2. Write a short note on "The canaries cold current.

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Q3. What do you means by Thermolaline current?

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Q4. What is the importance of current?

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12.9 EXAMINATION ORIENTED QUESTION

Q1. What are currents? What are the factors affecting the origin of the currents?

Q2. Explain in details the currents of Atlantic Ocean.

Q3. Explain in details the current of the Indian Ocean.

12.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker
2) Physical Geography, By Savindra Singh

12.11 REFERENCES

1) Oceanography: An Invitation to Marine Science, By Tom S. Garrison
2) Oceanography, By Sharma and Wattal
3) Oceanography, By D.S. Lal
4) The Ocean, By Ellen Prager

12.12 MODEL TEST PAPER

Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

SECTION-A

(8x2=16)

Q1. Define Sirocco and Blizzard.

Q2. Write a note a troposphere.

Q3. What are orographic rainfalls?

Q4. What is difference between the red mud and the blue mud?

Q5. Write a short note on the periodic winds.

Q6. What are constructive waves?

Q7. Name the factors affecting the salinity.

Q8. What do you mean by sub-tropical high pressure belts?

Section B

Unit-I

Q1. Define Atmosphere. Explain in details the composition of atmosphere.

Q2. Give the vertical and horizontal distribution of temperature.

Unit-II

Q3. Give the climatic classification of Thornwaits.

Or

Q4. What do you mean by Humidity? Explain the types of Humidity.

Unit-III

Q5. Write a detailed note on the vertical and horizontal distribution of temperature of oceanic water.

Or

Q6. What are the important factors affecting the distribution of salinity?

Unit-IV

Q7. What are waves? Write a note on the types of waves.

Or

Q8. What are ocean deposits? Explain the various types of ocean deposits

WAVES DEFINITION, ORIGIN, TYPES

Dr. Shivani Walia

13.1 INTRODUCTION

Sea waves are defined as undulation of seawater characterized by well developed crests and troughs. The upper part of a wave is called the crest, and the lower part is the trough. Besides geomorphic importance, sea waves are now also considered as a source of non-conventional energy. Thus sea waves have great energy potential for future generations. This is why H.V Thurman and A.P. Trujillo (1999) have defined sea waves in terms of energy levels as "Waves are moving energy traveling along the interface between ocean and atmosphere, often transferring energy from a storm far out at sea over distance of several thousand kilometers."

13.2 OBJECTIVES

- To make the students aware of basic concept of waves, and the factors responsible for the generation of waves.
- To explain the various types of waves.
- To familiarize the students with the chief characteristics of the waves.

13.3 CHARACTERTIC COMPONENTS OF WAVES

The mechanism of the origin of sea waves is not precisely known but it is commonly believed that waves are generated due to friction on ocean water surface caused by blowing winds. The undulations of sea water at the place of their origin are called swells which are low, broad, regular and rounded ridges and troughs of water. In other words the regular pattern of smooth, rounded waves that characterize the surface of the ocean during fair weather is called swell (A Bloom 1978).

The sea waves are characterized by the following components:

Waves Crests:- The successive higher parts of the progressive sea waves are called waves crests, which are the highest parts of the waves (fig 13.1).

Wave troughs:- These are the successive lowest parts of progressive sea waves which are alternated by waves crests such as wave crest – Wave trough – wave crest-wave trough and so on. Thus it is clear that a wave trough is located between two successive wave crests, or a wave crest between two successive wave troughs.

Wave height:- It is the vertical distance between crest and horizontal straight distance between the two successive troughs of progressive sea waves or between the trough and horizontal straight distance between two successive wave crest (fig 13.1).

Wave length:- It is the straight horizontal distance between two successive wave crests or wave troughs, which is expressed in terms of length unit of meters in case of sea waves (fig 13.1).

Wave period:- The time taken by a progressive sea wave to cover the distance of one wave length or one wave cycle is called wave period which is usually expressed in the time unit of seconds.

Wave Frequency:- The number of sea waves (one wave is equal to one wave length) passing through a certain point per unit time (usually one second or one minutes) is called wave frequency, which varies according to the wavelength of waves. There is universe relationship between the wavelength and wave frequency, i.e shorter the wavelength, higher the wave frequency, and longer the wavelength, lower the wave frequency (fig 13.1).

Fetch:- It is the distance or length of sea surface over which the wind blows in one direction for longer duration. It is the fetch that determines the nature of sea waves.

Seiches:- These are harbour waves wherein water moves back and forth.

Wave trains:-Wave trains include numerous sets of waves having varying wavelength. These wave trains originate in different generating areas and move outward from wave generation areas. When these wave trains approach a shore, they combine together and produce successions of high and low waves.

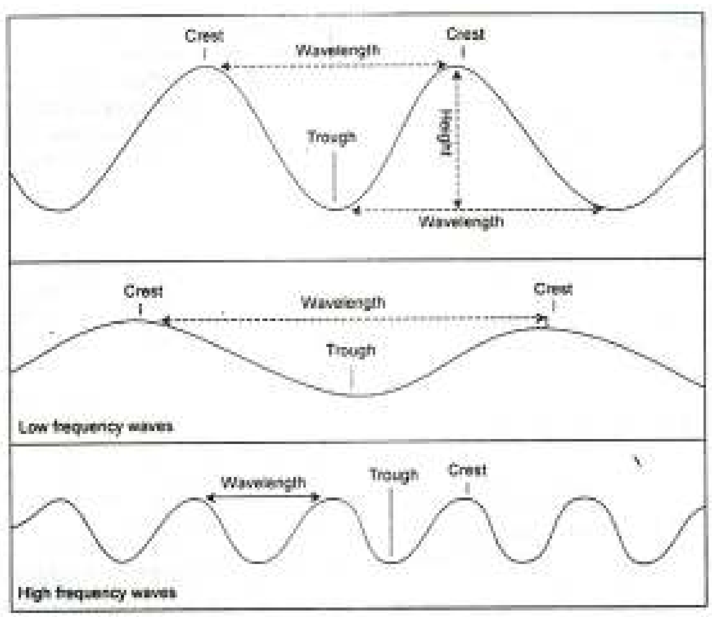

Fig 13.A Patterns and components of Sea Waves.

13.4 Factors responsible for the generation of sea waves

The following are the probable causes of generation of waves in the ocean and seas:-

- Atmosphere circulation and winds.
- Movement of fluids of two contrasting densities (air and seawater) along the interfaces of two masses of fluids of varying densities.
- Mass movement into the ocean such as lands in coastal areas.
- Occurrence of undersea earthquake, undersea volcanic eruptions.
- Gravitational forces of the sun and the moon (tidal waves).
- Atmosphere storms such as tropical cyclones.
- Anthropogenic activities, namely plying of large commercial ships, undersea nuclear tests and explosions etc.

13.5 TYPES OF WAVES

Deep water waves:- The deep water zone of the oceans is that part of the ocean where the depth of the ocean water exceeds the depth of the wave base, which is one half of the wavelength. So the waves generated in deep ocean water by winds are called deep ocean water waves and do not have any interaction with ocean bottom. These waves are called oscillatory waves. In these waves, the water particles move in orbital circle and their original position after the passage of waves while wave form or wave energy moves forward.

Shallow water waves:- The sea waves travelling in shallow water zone, where the depth of ocean water or wave base is less than $1/20^{th}$ of the wavelength, are called shallow water waves or long waves. Thus, shallow water waves travel in the shallow near shore zone of oceans and touch the bottom of the oceans. The water particles in such wave follow flattened orbits and hence there is forward movement of water mass also. Such movement of waves is called translatory motion and the concerned waves are called translatory waves. Such waves include the waves of near-shore zone, tsunami waves and tidal waves.

Transitional Waves:- The sea waves between the deep water waves and shallow water waves, are called transitional waves or intermediate waves. In such waves the depth of water is greater than $1/20^{th}$ part of wavelength of shallow water waves but less that ½ of the wavelength of deep water waves as given below.

Rogue waves:- Rogue waves are the occasional or non-regular sea waves with enormous wave length. These waves are also called monstrous waves or super waves only because of the fact that such waves occur very rarely and assume very great height and thus become very severe and destructive. The exact mode of origin of rogue wave is actually not yet known but the theoretical models have shown that the overlapping of numerous waves can produce one single monstrous waves.

Other types:-

From geomorphological point of view, sea waves are divided into two major types:

(i) Constructive Waves

(ii) Destructive Waves

The low frequency waves with longer wavelength approaching the shore and beaches are constructive in character because they lose volume and energy rapidly while moving up the beaches because water percolates in the shingles and other beach materials and thus the backwash is weakened which hinders the removal of material seaward. It is thus, obvious that low frequency waves help in the building of beaches. On the other land, high frequency waves with shorter wavelength and high wave heights approaching a more steeply slopping shore are destructive in nature because instead of spilling they plunge and generate powerful breakers traveling towards the shore and strong backwash towards the sea which combs down the beaches i.e removes the beach materials and transports them towards the sea. Such destructive waves also report to cliff erosion which leads to retrogradation of coastland and sea.

13.6 SUMMARY

In the concluding lines, it is important to mention here that waves play a very important role in modifying the coasts. Also the waves are considered to be the powerful source of energy. They have great potential for further energy generation. Earthquakes, volcanic eruptions, winds etc. play and important role in the generation of waves. Different types of waves play major role in the modification of beaches and coasts, e.g. constructive waves help in the building of beaches, whereas as destructive waves leads to erosional activities on the coast.

13.7 GLOSSARY

Cliff:- Steep rocky coast rising almost vertical above seawater is called cliff, which very precipitous and overlapping with over hanging cliff.

Fetch:- The distance or length of sea surface over which wind blows in on direction for longer duration is called fetch.

Oscillatory Waves:- The waves generated in deep ocean water by gusty winds are called oscillatory or deep ocean water waves which do not have any interactions with ocean bottoms.

Plunge line:- The distance from the sea shore where the waves break due to shallow water depth and enormous wave height is called plunge line.

Rouge Waves:-The occasional and non-regular sea waves of enormous wave height are called rouge waves or monstrous waves. Such waves occur very rarely and assume very great height. These waves are very destructive and also called super waves.

Seiches:- These are harbour waves wherein water moves back and forth. Also known as stationary or standing waves in herboures and bays.

Swells:-The undulations of seawater at the place of their origin are called swells, which are low broad regular and rounded ridges and troughs of seawater.

Tidal Waves:- The sea waves caused by the ocean tides due to gravitational pull of the moon and the such on the sea surface are called tidal waves. They occur twice a month.

Transitional Waves:- Sea wave between the categories of deep water ways and shallow water waves are called transitional or intermediate waves.

13.8 SHORT ANSWER TYPE QUESTIONS

Q1. What do you mean by waves?

Q2. What are destructive waves?

Q3. How the waves are considered to be source of energy?

Q4. What is the difference between the oscillatory waves and the transitional waves?

13.9 Examination oriented Question

Q1. What do we mean by waves. What are the factors responsible for the generation of sea waves.

Q2. Write a detail note on the various types of sea waves.

13.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker

2) Physical Geography, By Savindra Singh

13.11 REFERENCES

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Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

Section-A

Short question type (compulsory) (8x2=16)

Q1. Define weather and climate.

Q2. What is the significance of inversion of temperature?

Q3. Write a short on the equatorial low pressure belt.

Q4. What do you mean by orographic rainfall?

Q5. Write a note on frigid zone.

Q6. What do mean by Radiolarian ooze?

Q7. What is the difference between spring tides and neap tides?

Q8. What is the significance of Gulf stream?

Section-B

Long question type

(Attempt four questions in all, selecting one question from each unit)

Unit-I

Q1. What is Atmosphere. Write a note on the structure at atmosphere.

Or

Q2. Explain diagrammatically Global Heat Budget.

Unit-II

Q3. Give the climatic classification of the world given by Koppen.

Or

Q4. What are the main factors responsible for the origin of cyclones. Also give the distribution of tropical cyclones?

Unit-III

Q5. What is salinity? What are the factors affecting the salinity of an ocean?

Or

Q6. Write a note on the types of currents of Atlantic ocean.

Unit-IV

Q7. What are coral reefs. Explain Subsidence Theory given by Darwin regarding the origin of coral reefs?

Or

Q8. What are tides. Explain the various types of tides?

TIDES DEFINITION ORIGIN AND TYPES

Dr. Shivani Walia

14.1 INTRODUCTION

Tides are the most important of all the ocean movements because tidal current affect the whole water mass from sea surface to the bottom. The rise and fall of seawater due to gravitational forces of the sun and moon are called tides. P.R. Pinet (2000) has defined the tide as : Tides are waves with very long wavelength much longer than ordinary wind waves that cause sea level to rise and fall with extraordinary regularity. In fact tides are the most uniformly varying phenomenon in the ocean.

14.2 OBJECTIVES

- The main objective behind the present chapter is to make students familiar with —

  — the characteristic features of tides

  — the tide generated forces and time of tides

  — types of tides

  — theories regarding the origin of types

14.3 CHARACTERISTIC FEATURES

1. Tides are single wave phenomenon which covers the entire ocean basin, where as sea waves are succession of waves approaching the sea shore one after another.
2. Tides are shallow water waves but with very long wavelength even in the deep ocean basin.
3. Tides are differentiated from wind driven sea waves with respect to wavelength mode of origin etc. Tides are originated due to interactions of the sun and the moon with ocean surfaces while sea waves are generated by wind drag. Sea waves are also originated by other factors such as atmosphere pressure, temperature variations salinity variations etc.
4. Tides are low waves but with high energy while sea waves are high waves with low energy
5. Sea waves such as rouge waves and storm breakers have very high crest but are localized phenomena but tides are widespread phenomenon they stretch across the entire ocean basin.
6. The vertical difference between high tide water and low tide water is called the

tidal wave height or tidal range which generally varies between less than 2 meters. To more than 4 meters. The basis of height tidal range is divided into the following three categories:-

i) Microtidal range:- height (wave height) less than 2 meters.

ii) Mesotidal range:- height between 2 to 4 meters

iii) Macrotidal range:- wave height more than 4 meters

7. The rise of seawater and its movement towards the coast is called tide and the resultant high water level is known as high tide water (H.T.W) while the fall of the seawater and its movement towards the sea is called ebb and the resultant low water level is known as low tide water (L.T.W)

8. There is much variation in the height of high and low tides at different places in different oceans because of varying characteristics of the depth of ocean water, configuration of sea coasts and coastlines and openness or closeness of the seas.

9. Gravitational pull of ocean water is called tidal bulge which occurs at two places. One bulge is towards the moon and the other is away from the moon on the opposite side of the earth, i.e. opposite to the first bulge. The tidal bulge which is created on the earth's water surface by the gravitational force of the moon are called lunar tidal bulges. Thus each place on the earth experience bulges twice each day, i.e. they occur at the interval of 12 hours 25 minutes each day. The total period of two bulges each day is called lunar day.

10. Like moon, sun also produces bulges on opposite sides of the earth by its gravitational force. The bulges created by the sun on the earth's water surface are called solar bulges. One bulge is oriented towards the side of the sun while the other bulge is oriented towards the opposite side of the earth. The size of the solar bulge is 46 percent small than the lunar bulge because the gravitational pull of the moon far exceeds the gravitational pull of the sun.

11. The coastward transgression of seawater under the influence of tidal waves is called flood tide while seaward regression of water of tidal bulge is called ebb tide.

12. Any place on the earth facing oceans or seas will experience two flood tides and two ebb tides each lunar day,

13. The heights of high and low tides are never identical rather these greatly vary.

14. There are two high tides and two neep tides in every month.

15. There are exception of the occurrences of two high tides and two low tides each lunar day in some localities due to complex factors. Thus, the tidal patterns of a lunar day are divided into the following 3 patterns:-

    i) **Diurnal tidal pattern:-** It refers to the occurrence of only one high tide and one low tide each lunar day in shallow seawater.

    ii) **Semidiurnal tidal pattern:-** Two high tides and two low tides each lunar day having almost identical tidal height of successive high and low tides. Such tidal patterns occurs along the western parts of the Atlantic ocean facing east coast of USA.

    iii) **Mixed tidal Pattern:-** It is characterized by occurrence of diurnal as well as semidiurnal tidal patterns but the heights of successive high or low tides are never identical rather they frequently charge. This tidal pattern is the most common pattern of the occurrences of tides almost in all the oceans. The variations in the height of successive high and low tides of mixed tidal pattern are called diurnal inequalities.

16. The steep wall of water created in the narrow estuaries of rivers that debouch in the oceans or in the bays having narrow and constricted mouths due to incoming tide is called tidal bore. Tidal bore is formed due to friction of seaward water flowing rivers and incoming tidal waves.

14.4 GENERATING FORCE, TIME & TYPES OF TIDES

14.4.1 Tide Generating Force

The origin of tides in the oceans is primarily concerned with the gravitational forces of the sun and the moon. As we know that earth rotates from west to east and revolves around the sun following an elliptical orbit. Similarly, the moon rotates from west to east and revolves around the earth along and elliptical orbit so that the distance between the moon and the earth changes during different times in every month (fig 14.A).

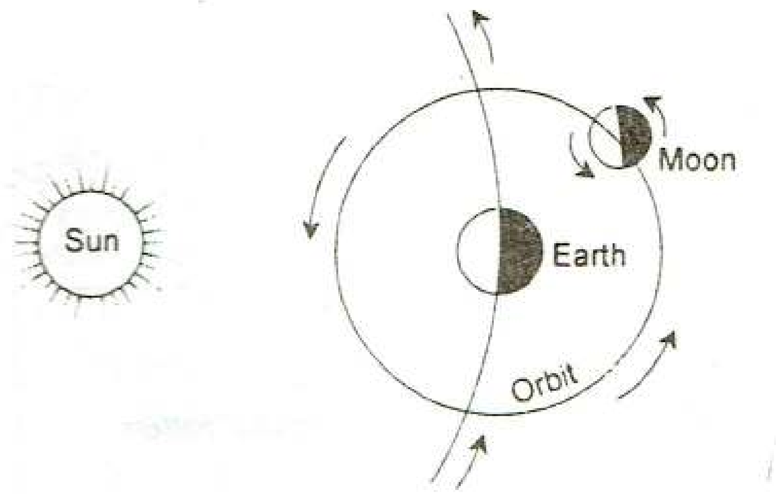
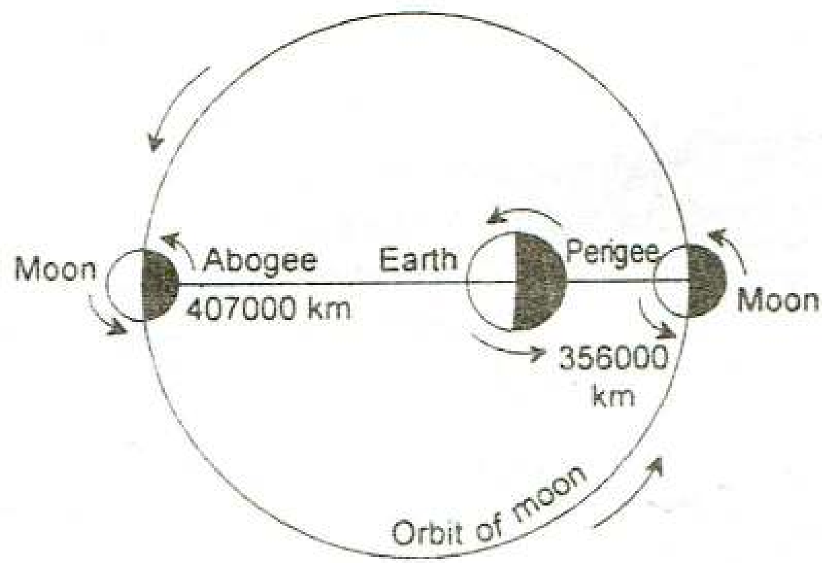


Fig 14.A Similar direction of rotation and revolution of the earth and the moon.



14.B Varying distance between the earth and the moon.
Situations of apogee and perigee.

The period of the fartherest distance between the moon and the earth (407,000 km) is called apogee while the period of the nearest distance (356,000 km) is called perigee

The surface of the earth with its diameter of 12,800 km is 64,000 km nearer to the moon than its centre. The centre of the moon is 3,84,800 km away from the centre of the earth. The earth's outer surface is 3,77,000 km away from the outer surface of the moon. It is evident that the earth's outer surface which is opposite to that surface of the earth which faces the moon is 3,90,400 km away from the moon surface. The gravitational force of the moon will be maximum at the earth's surface facing the moon (at T in fig 14-C) while it will be minimum at the opposite side of the earth (at A in fig 14.C). Consequently the water of the earth's surface facing the moon is attracted and pulled and high tide occurs (Fig 14.C) High tide is also formed at the opposite side of the earth (A in fig 14.C) simultaneously because of the centrifugal force of the gravitational (centripetal) force of the moon causing outward bulge of the water.

There are two principal that govern the strength of gravitational attraction between the two celestial bodies. The first is that "the gravitation attraction is proportional to the mass of the body, i.e the greater the mass of the body, the greater the gravitational attraction and vice versa" The second principal is that the gravitational attraction also depends on the distance between two interacting bodies. The greater the distance between two interacting bodies the lesser the gravitational force and vice versa.

This is remember that though the mass of the sun is 10 million times greater than the mass of the moon but the strength of gravitational attraction of the moon is 2 times more than the sun because the moon is 390 times closer to the earth than the sun. this is why the moon has twice the tide generating force on the earth, and thus, the moon is more potent sources of tide generation on the earth's surface than the sun.

The tide generating force of the moon causes two lunar tidal bulges on the earth's surface at the same time. One bulge of ocean water, located at T in fig 14.C. This side of bulge is called zenith. The other lunar tidal bulge located at A in fig 14.C, this side of lunar bulge is called nadir. The Zenith lunar bulge (at T in Fig 14.C) is caused by the gravitational attraction of the moon, while the nadir lunar bulge (at A in Fig.14.C) is generated by the centrifugal force due to the rotation of the earth and the moon.

It is clear that, two tides and ebbs are experienced twice at every place on the earth's water surface within 24 hours. When the sun, the earth of full moon are in the same line (at the time of full moon and new moon) their gravitational forces work together and high tides are formed. On the other hand, when the sun and the moon are at the position of right angle with reference to the earth, the gravitational forces of the sun and the moon work against each other and hence low tides are formed. This situation occurs during the 8^{th} day of each fortnight of a month.

14.4.2 Time of Tides :-

On an average, every place experienced tides twice a day. Since the earth completes its rotation in roughly 24 hours, every place should experience tide after 12 hours but this never happens. Each day tide is delayed by 26 minutes because the moon also rotates on its axis while revolving around the earth. When the tide centre completes one round the moon's position is ahead of the tide centre by that time because the moon also revolves around the earth, with the result the tide centre takes 24 hours 52 minutes to come under the moon but by that the time there is another tide at the opposite side of the referred tide centre and this happens after 12 hours 26 minutes.

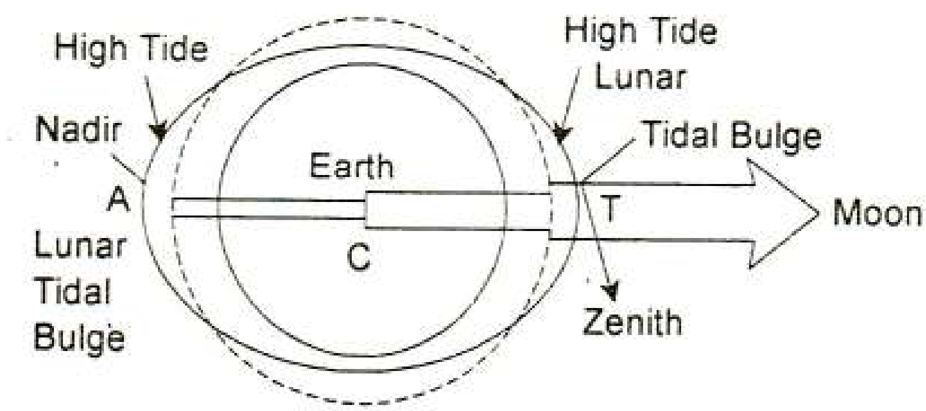


Fig 14.C: Effects of gravitational forces of moon on earth's water surface and occurrence of high tides. Simultaneously there are two lunar bulges on the earth's surface at place T, facing the moon (zenith) and at place A, on opposite side of the earth (nadir).

14.4.3 Types of Tides

The oceanic tides are caused due to tide producing forces of the sun and the moon. There is a lot of temporal and spatial variations in the tide producing forces because of different positions of the sun and the moon with the earth. Because of these variations in the forces, several types of tides are caused.

1) **Spring Tides:-** These are very high tides. These tides occurs when the sun, the moon and the earth are almost in the same time. The position of the sun, the moon and the earth in a straight line is called syzygy. When the sun and the moon are in one side of the earth the position is called conjunction. This situation occurs at the time of solar eclipse. When the position of the earth is in between the sun and moon, this is called opposition. On the other hand, when the sun the earth and the moon are in a position of a right angle (Fig 14.D) this position is called quadrature. The positions of conjunctions and opposition take place during new moon and full moon respectively. In these situations, the gravitational forces of the sun and the moon work together, and thus high tides are occurred. The height of such tides is 20 percent more than the normal tides. Such sides occur twice every month and their timing is fixed.

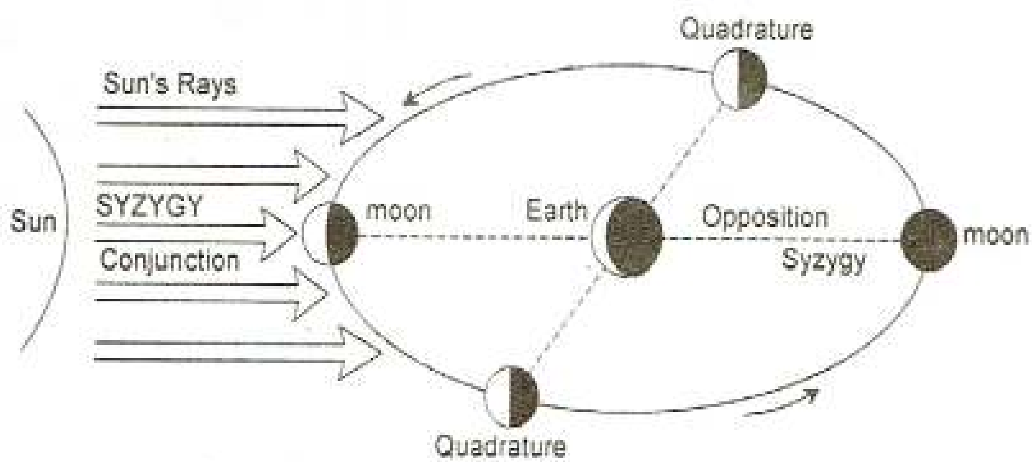


Fig 14.D Position of the sun, earth and moon and the situation of conjunction, opposition and quadrature.

Neep Tides

Neap tides occur on seventh and eighth day of every fortnight of a month, when the sun the earth and the moon come in the position of qudrature (i.e form right angle) Thus the tide producing forces of the sun and the moon work in opposite direction, with the result low tide is caused. The height of neap tides is generally 20 percent lower than the normal tides.

Tropical and Equatorial Tides

Like the sun, there is also northward and southward position of the moon in relation to the equator of the earth. If the sun completes its northward and southward positions in one year, the completes it in 27.5 days, which is known as one synodic month, when there is maximum declination of the moon to the north of the 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 height than the normal tides and ebbs respectively. Such tides recur twice every month when the moon's rays fall vertically on the tropics of cancer and capricorn. 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 height of two neap tides and two spring tides because the moon is vertical on the equator every month. Such tides are called equatorial tides.

Apogean and Perigean Tides

The nearest position of the moon with the earth is called perigee, when the distance between them is 3,56,000 km. the tidal force of the moon is most powerful during this position and hence high tides are caused. Such tides are called perigean tides, which are 15 to 20 percent higher than the normal tides. On the other hand, tidal force of the moon is minimum during the position of apogee when the moon is at the farthest distance (4,07,000 km) from the earth, and hence low tides are caused. Such low tides are called apogean tides, which are 20 percent lower than the normal tides.

Daily and Semi Diurnal Tides

The tides recurring at the interval of 24 hours 52 minutes daily are called diurnal or daily tides, while the tides recurring at the interval of 12 hour 26 minutes are called semi-diurnal tides.

Equinoctorial Spring Tides

The tides recurring at an interval of 6 months due to revolution of the earth around the sun and sun's revolution of the earth around the sun and sun's varying declination are called equinoctical tides.

Zenith and Nadir Tides

The strength of gravitational attraction of the moon is greatest at the earth's water surface that faces the moon (T in fig 14.C) at Zenith with the result high tidal bulge is created at the zenith. This is called zenith tide or direct tide. Simultaneously high tide is also created at the opposite side (A in fig 14.C) of the earth at nadir. This nadir lunar tidal bulge is called nadir tide or indirect tide because it is not generated by the centrifugal force resulting from the rotation of the earth and the moon.

14.5 THEORIES OF THE ORIGIN OF THE TIDES

Numerous theories have been given by different scholars from time to time to explain the origin of tides in oceans. Among them, the two important theories are given as under:-

i) Progressive Wave Theory by William Whewell (1833)

ii) Stationary Wave Theory by R.S Harris

i) Progressive Wave Theory:-

W. Whewell propounded his "progressive wave theory" in the year 1883, and G.B Airy postulated "the canal theory" in the year 1942 to explain the origin of the ocean tides. These two theories are based on the following facts:-

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

ii) Tides occurs at different times at different places on the 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 the form of tidal wave which travels from east to west. The crests and toughs of such tidal waves become tides and ebbs respectively. These waves are originated in the ocean under the influence of tidal waves depend 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 ocean 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 forces waves. These waves are obstructed by the continents and are consequently refracted northward. Secondary waves are generated when the westward movements 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 progressively move northward though there is gradual decrease in their magnitude and amplitude but these waves generate tides everywhere. It may be pointed out that the primary waves are influenced by the moon but the minor wave after being originated in the southern ocean progressively move northward with continuous lag of time and dissipation of wave energy. In other wards, 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 at different places on the same longitude. These progressive waves become ineffective after reaching north pole. These crests and trough of these waves after reaching the coasts cause tides and ebbs respectively. Fig 14.E depicts the co tidal lines (the lines joining the point of high waters occurring at the same hour are called co-tidal line) of the Atlantic ocean.

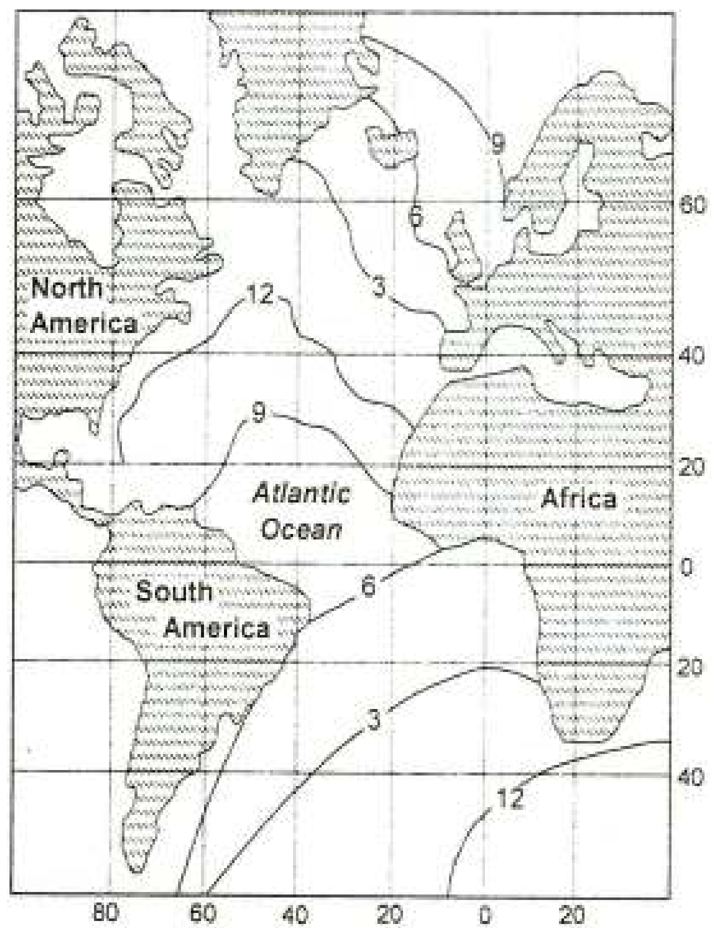


Fig 14.E Co-tidal lines of the Atlantic Ocean, based on progressive wave theory.

Evaluation of the Theory:-

According to the progressive wave theory, the age of tides increases northward. In other wards, if tide is generated in the south on a particulars longitude, it reaches quite late at the points located further north on the same longitude. On the other hand, the data available so far about the time of tides denote that the time of spring tides is almost the same from Cape Horn to Greenland in the Atlantic ocean. Normally, the tides are local or regional phenomena rather than phenomena originating in the southern ocean and moving progressively north ward. At some latitudes daily and semi-diurnal both types of tides are observed. Further there is spatial variation in the irregularity of tides in different ocean. These variations can not be explained on the basis of progressive wave theory.

ii) Stationary Wave Theory:-

This theory was propounded by R.S Harris of the U.S Coast and Geodetic Survey. This theory is considered as opposed to the progressive waves because it offers almost satisfactory explanation for local differences in tides, their types and their age. Accordingly to Harris, tide phenomena are not due to progressive waves which originate in the southern oceans as claimed by William, 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 a developing tray containing water is rocked from one side to the other or is simply titled, the water level rises along one side of the tray but fall along the other side. This generates oscillations, 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 in 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 the other end along a line which is called nodal line. The period of oscillation of water in the tray depends on the length and depths of the tray and the force of shocks applied to the tray. The aforesaid example is the case of uninodal system but there may also be binodal oscillation system (fig. 14.F)

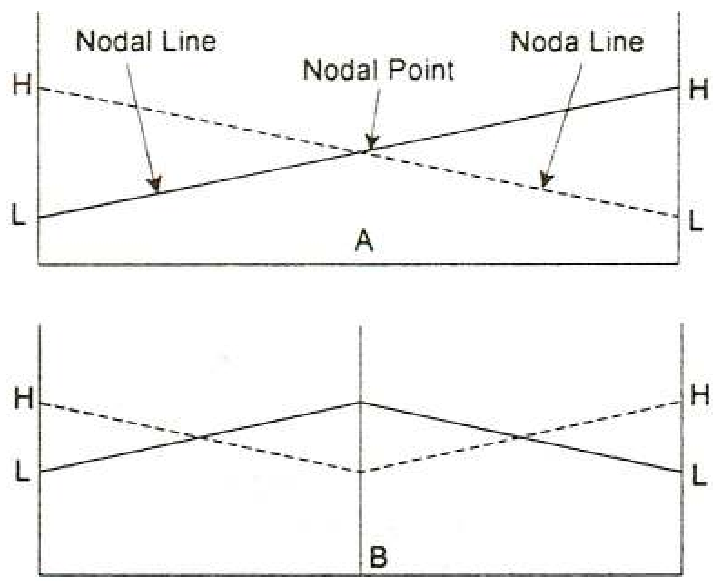


Fig 14.F Uninodal (A) and bimodal (B) oscillation systems.

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 not occur along straight lines 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 changes around them. This mechanism result 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 stationary waves after being originated from the amphidromic centres moves towards the coasts. The forward movement of these waves is hampered by the continental peninsulas, island, bays etc. When these waves reach the coasts, their crests and troughs cause tides and ebbs respectively. There is positive correction between the depth of the oceans and the height of tides. In other words, if the depth of the ocean becomes greater, high stationary waves are generated and high waves generate high tides. Low tides are caused in shallow seas because of lower height of stationary waves.

14.6 SUMMARY

In the concluding lines, it is important to mention here that tides have a great impact on the morphology and evolution of the coasts. An ocean tide is the cyclic rise and fall of seawater, and these are caused by the gravitational attraction between the earth and the Moon and the Sun. Individuals who live and work on the seas and ocean study the tides and learn to predict their movements and effects.

14.7 GLOSSARY

Apogean Tides:- The low tides caused at the time when the moon is at the farthest distance from the earth, are called apogean tides, which are 20 percent lower than normal tides

Centrifugal Force:- it is the force that works outward on a body rotating about an axis.

Centripetal Force:- It is the force that works toward the centre of a rorating body.

Conjuction:- The situation or position of the sun and the moon in straight line on one side of the earth.

Ebb:- The fall of sea water and its movement away from the coast, i.e toward the sea.

Nadir Lunar Bulge:- The lunar bulge causes by the centrifugal effect associated with the rotation of the earth and the moon, on the apposite side of the earth which faces the moon.

Nodal Point:- The point in the water body where there is no change in water level characterized by stationary waves.

Perigean Tide:- The tide generated at the nearest position of the moon with the earth is called perigean tide, which is 15 to 20 percent higher than the normal tides.

Quadrature:- The position of the sun, the earth and the moon in right angle.

Solar Bulge:- The bulges created by the gravitation pull of the sun on the earth's water surface.

Syzygy:- The position of the sun the moon and the earth in a straight line.

Zenith Lunar Bulge:- The tidal bulge facing the moon and caused by the gravitational attraction of the moon.

14.8 Short Answer Type Questions

Q1. What are tidal generating forces?

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Q2. What are Apogean and Perigean tides?

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Q3. Define:- Conjuction, Syzygy, Opposition.

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Q4. What are Neap tides?

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14.9 EXAMINATION ORIENTED QUESTION

Q1. What are tides? Explain in detail the various types of tides.

Q2. Compare and contrast the views of progressive wave Theory and Stationary wave theory regarding the origin of tides.

Q3. What are the Characteristics of waves? Also explain the tidal generating forces in detail.

14.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker

2) Physical Geography, By Savindra Singh

14.11 REFERENCES

1) Oceanography: An Invitation to Marine Science, By Tom S. Garrison.
2) Oceanography, By Sharma and Wattal
3) Oceanography, By D.S. Lal
4) The Ocean, By Ellen Prager

14.12 MODEL TEST PAPER

Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

SECTION-A

(8x2=16)

Q1. Define Sirocco and Blizzard.

Q2. Write a note a troposphere.

Q3. What are orographic rainfalls?

Q4. What is difference between the red mud and the blue mud?

Q5. Write a short note on the periodic winds.

Q6. What are constructive waves?

Q7. Name the factors affecting the salinity.

Q8. What do you mean by sub-tropical high pressure belts?

Section B

Unit-I

Q1. Define Atmosphere. Explain in details the composition of atmosphere.

Q2. Give the vertical and horizontal distribution of temperature.

Unit-II

Q3. Give the climatic classification of Thornwaits.

Or

Q4. What do you mean by Humidity? Explain the types of Humidity.

Unit-III

Q5. Write a detailed note on the vertical and horizontal distribution of temperature of oceanic water.

Or

Q6. What are the important factors affecting the distribution of salinity?

Unit-IV

Q7. What are waves? Write a note on the types of waves.

Or

Q8. What are ocean deposits? Explain the various types of ocean deposits

Course No. GO-301	Unit-IV
Semester III	Lesson-15

CORAL REEFS ORIGIN AND TYPES

Dr. Shivani Walia

15.1 INTRODUCTION

In this chapter, we will study the whole concept of the coral reefs. Firstly, I would like to give you an introduction about the coral reefs. In general, coral reefs are the significant sub marine features, and these are formed due to accumulation and compaction of skeletons of time secreting organisms known as coral polyps. Coral polyps are sea organisms belonging to the Phylum Cnidaria. A deep study reveals that the outer layer of the flesh of the animal consists of unicellular photosynthetic plants, called zooxanthellae, which comprise more than 75% of the tissue weight of coral animals. These plants help in providing nutrient to coral animals and also assist them in secreting carbonates. There are also many tentacles at the mouth of polyps, which help them to catch preys. Polyps are cup shaped animals of the size of average ants. Coral polyps thrive in the tropical oceans confined between 25º N-25º S latitude and live on lime. Numerous coral polyps live in groups in the form of colony at one place and form calcareous shells around them Coral reefs are formed due to formation of one shell upon another shell along submarine platforms at suitable depths. Coral reefs are called as rainforests of the oceans, because coral reefs are more diverse than the tropical rainforests Coral reefs have about 1,000,000 species, of which only 10 percent have been studied.

15.2 OBJECTIVES

- To explain the meaning of coral reefs and also the condition required for the growth of coral reefs.
- To familiarize the students with the concept of fringing reef, barrier reefs and atolls, with examples and also the detailed explanation of the distribution of coral the reefs.

15.3 CONDITIONS FOR THE GROWTH OF CORAL POLYPS

Now, I would like to explain here the important conditions which are required for the growth of coral polyps. Following are the required conditions for the growth of coral polyps.

1. Temperature of Sea Water:-

Coral Polyps are found mainly in the tropical oceans and seas (between 25º N-25º S), because they require mean annual temperature ranging between 20º C- 21º C for their survival. We can say that the mean monthly temperature remain more than 18º C but less than 30º C throughout the year. Coral polyps cannot survive in either very high or very low temperature conditions.

2. Depth of Sea Water:-

Coral animals cannot survive in deeper water, because sufficient sunlight is required for the growth of the coral polyps. Since the sunlight decrease with increasing depth of sea water, the depth becomes a limiting factor for the growth of coral polyps. Most of the corals die of starvation as the zooxanthellae algae cannot perform photosynthesis due to lack of proper sunlight and hence coral cannot get food from internal sources and thus they die. The oxygen is another factor that limits the growth of coral polyps. Oxygen is required by corals to thrive and as oxygen also decrease with increasing depth, corals cannot survive in water deeper that 80 meters. According to M.S land and J.E Hoffmeister (1936), the maximum depth for ideal growth of the coral polyps is 61 to 91 metres below sea level, while Gardiner observed some corals thriving at the depth of 274-310 metres below sea level.

3. Turbidity of Sea water:-

Turbidity of seawater means cloudiness of water caused by the presence of suspended material of organic and inorganic origin. The higher the density of suspended material, the greater is the turbidity of seawater and vice versa. The coral polyps require clean sediment free water for their growth because muddy water clogs the mouths of coral animal, as a result, they die because they cannot get food though filter feeding. Because if this factor, corals are, generally, not found in the vicinity of the mouth of major river because the turbidity of seawater increase enormously at the sea mouth because big rivers dump here huge quantity of eroded sediments.

4. Flux of Fresh Water:-

Like muddy water, fresh water is also injurious for the survive and growth of coral polyps. This the reason that corals avoid coastal land and build their colonies away from the areas of river mouths. Sea Island are surrounded by coral reefs, because there are total absence of sea Island.

5. Ocean Salinity:-

The oceanic salinity ranging between 27% and 30% is most ideal for the growth of polyps. Sea water with high salinity contains very less amount of calcium carbonates, whereas lime is important food of coral polyps.

6. Ocean Current and Waves:-

Ocean current and waves bring necessary food supply to the symbiotic zooxanthellae algae. These symbiotic algae manufacture food through photosynthesis and provide 60% of food requirement of coral animals. Since ocean current and sea waves brings nutrients with them, the symbiotic zooxanthellae algae use these nutrients and supply then to the coral polyps. It is also important to mention here that corals grow in open seas and oceans where there is ample wave energy, but they die in lagoons and small enclosed seas.

7. Submarine Foundations:-

The coral polyps require a firm base of hard rocks, or say, an extensive platform for the formation of colonies. Such platforms should not be more than 50 fathoms (300 feet or 91 m) below sea level. The polyps start their colonies from a firm base of hard rocks and grow upward until they reach the sea level.

8. Human Factor:-

Human economic activities like deforestation and industrialization, causing global warming, put an adverse affect on the growth of polyps. It is believed that about 10% of the corals have dies because of global warming. The increase in temperature causes bleaching in the corals wherein the corals lose their embedded algae and become white in colour. This process is called coral bleaching, which causes death to corals. The studies have shown that coral bleaching being when the temperature rises 1º C above normal temperature. According to Clive Wilkinson of the Global Coral Reef Monitoring Network (GC RMN), coral bleaching has occurred at large scale off the coats of West Asia, East Africa, South Asia, South East Asia and East Asia in the Indian ocean, East pacific, the Caribbean sea and the Atlantic ocean (1998).

9. Pollution of ocean water:-

Human activities like pollution of oceanic water through excess flux of sediments, industrial and urban wastes, sewage, over fishing, mining of Coral rocks, clearance of maritime forests cause fatal disease to corals. Recent studies have shown that 58% of the world’s coral reefs are threatened by human activities (Down to Earth, 1999).

10. **Distribution of Coral reefs:-**

Under this heading, we will study the areas of the world where do we find the coral reefs. In general, corals are mostly found in the tropical ocean and seas. They are abundantly confined in the tropical Indo-pacific oceans between 20º N and 30º S latitudes. The largest concentration of coral reefs is found in the tropical western pacific ocean. It important to mention here that pacific oceans accounts for 55 percent of worlds coral, whereas there are more than 30 percent of world corals in the Indian ocean. Following description shows the major concentration of coral reefs in different oceans.

11. Indian Ocean:-

Eastern coasts of Kenya, around Madagascar, eastern coasts of South Africa, western coasts of Australia, Red Sea, Maldives, Lakshadweep Andaman and Nicobar etc.

12. Pacific Ocean:-

Around Philippines, off the Southern coasts of Japan, Polynesia and Micronesia, off the coasts of the Northern Territory of Australia, East coasts of Queensland of Australia etc.

13. Atlantic Ocean:-

Continental coasts bordering the Caribean Sea, around islands of the Caribbean Sea, East coast of Brazil etc.

15.4 TYPES OF CORAL REEFS:-

Fringing Reefs:- Coral reefs developed along the continental margins or along the island are called fringing reefs. The seaward slope is steep and vertical while the landward slope is gentle. It is usually attached to the coastal land but sometimes separated from the shore by a shallow lagoon e.g along Southern Florida.

Fig 15.A Example of fringing reef.

Barrier Reefs:- This is the most extensive of all types. A barrier reef is separated from the coast by much wider and deeper channel or lagoon. Barrier reefs, generally parallel to the coasted platforms have narrow gaps at several places providing the lagoons contact with the open sea and ocean, these gaps are very useful for shipping purposes. Great Barrier Reef located parallel to the east-coast of Australia, is the largest of all the barrier reefs in the world.

Fig 15.B Example of Barrier reef

Atolls:- Atoll is a narrow ring of growing corals, having horseshoe shape. It is generally found around an island in an elliptical form on a submarine platform. There is a lagoon in the middle of coral ring. The encircling ring is usually broken in a few place to allow the free flow of water. On the inside of the reefs, limestone debris may collect and palm tree like coconuts may grow. Atolls are divided into 3 types i.e 'True Atoll' characterized by circular reef enclosing a shallow lagoon but without island, second one is 'Island Atoll' having an island in the central part of the lagoon enclosed by circular reef, and the last one is 'Coral Island, having no island in the beginning but later on island may be formed due to deposition by marine waves. Atolls are found in Antilles Sea. Funfub Atoll of Ellica Island is a famous atoll.

Fig 15.C Example of an atoll.

15.5 ORIGIN OF CORAL REEF

The problem of the origin of coral reef's in general, and atoll in particular, is highly complex. Several contrasting theories have been proposed to explain the origin of coral reefs. Among them, the Subsidence Theory given by Darwin and the Glacial Control Theory given by Daly are most important. These theories are explained one by one.

1. Subsidence Theory (Darwin)

It is a widely accepted theory. According to Darwin, the land or island involved in the origin and growth of coral reefs is seldom stationary rather it undergoes gradual subsidence. Darwin believed that fringing reefs, barrier reefs and atolls are successive stages in the development of coral reefs.

First of all, individual coral polyps form a block together along a suitable submarine platform and row upward and ultimately reach sea level and a fringing reef is formed. Thus fringing reef is formed in stable condition of the land. After this, the land is subjected to subsidence because of tectonic forces. Coral polyps also reach greater depth due to subsidence of land. Consequently they grow upward and outward seeking food for their survival. The growth of polyps is retarded near the shore of the island but it is very vigorous at the outer edge of the island because of more favourable conditions Gradually, a lagoon is formed between the coast and fringing reef, and a barrier reef is formed There is further subsidence of the land and the island is completely submerged under water and a ring of coral reef in the form of an atoll is formed.

Following evidences support Darwin's contention:-

(i) the shallowness of lagoons indicates gradual subsidence land

(ii) absence of cliffs along the coral islands.

(iii) coasts and the islands of the pacific ocean having raised beaches are indicative if emergence / barrier devoid of former and atoll reefs,

(iv) island having atolls are characterized by very steep slopes.

(v) thickness of coral reefs increases downward.

But there are problems too. If fringing reefs, barrier reefs and atoll reefs are only three stages of the evolutionary growth of a reef, then fringing reef and barrier reef should not be found on either side of the same island at the same level. However, there is evidence of such a phenomenon. Again, if subsidence theory is accepted then most of the islands of the Pacific Ocean would be submerged. There are also same evidences of the existence of coral reefs associated with the emerging islands.

2. Glacial Control Theory (Daly)

According to the Daly, sea-level fell by 44 to 38 fathoms (198 feet to 228 feet) due to glaciation during Ice age. The existing corals died. Wave cut platform were formed along contiental coasts, and islands due to abrasion. After the end of the Ice Age, the sea-level again rose, wave cut platform got submerged up to the depth of 33 to 38 fathoms. The corals which could survive during the glacial period and new coral polyps began to grow and established their colonies on the seaward edges of submerged platforms. Thus fringing reefs were formed on narrow wave-cut-platform. Atolls are formed around isolated wave-eroded island peaks. Lagoons of uniforms depth were formed between the reefs and the land because of uniform lowering of sea level.

There are some limitations of this theory like, (i) the depth of different lagoons varies considerably, even the depth at different parts of the same lagoons ranges between 120 to 300 feet. (ii) If all marine islands were eroded up to 33 to 38 fathoms then there should not be islands between the coasts and coral reefs but numerous such island are found.

15.6 SUMMARY

In the concluding lines, it is important to mention here that coral reefs, which are also called as the rain forests of the ocean, are extremely valuable to the citizen of all nations. The distribution and growth of corals depend on many factors. Corals are considered to be an important part of marine ecosystem with biological diversity. It helps us to get a vast knowledge about the fringing reefs, barrier reefs and atolls and their distribution in the world.

15.7 GLOSSARY

Atoll:- A ring of narrow growing coral animals of horseshoe shape and crowned with palm trees.

Barrier Reef:- The largest coral reefs off the coastal platforms of the continents, but parallel to them.

Boat Channel:- The lagoon formed between the fringing reef and the land is called boat channel which is long but narrow in width.

Corals:- The living organisms of the category of marine animals and related to jellyfish, which are responsible for building of coral reefs.

Coral bleaching:- It is a process which causes loss of vivid colour from coral organisms and turns them white due to expulsion of symbiotic zooxathellae algae which are embedded in the tissue of outer bodies of living corals.

Coral Reefs:- The reefs of cemented and compacted rigid massive structure of numberless skeletons of dead coral animals.

Fringing reef:- Coral reefs develop along the continental margins or along the islands.

15.8 SHORT ANSWER TYPE QUESTIONS

Q1. What do not mean by boat channel

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Q2. Write a note on coral bleaching.

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Q3. What is the difference between the fringing reefs and barrier reefs?

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Q4. What can we do to save coral reefs?

Q5. Why are coral reefs so important?

15.9 EXAMINATION ORIENTED QUESTIONS

Q1. What are coral reefs? What are the conditions required for the growth of coral reefs?

Q2. What are coral reefs? Write a note on the various types of coral reefs. Give atleast one example of each type.

Q3. What are coral reefs? Explain in detail the subsidence theory regarding the origin of the corals reefs.

15.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker

2) Physical Geography, By Savindra Singh

15.11 REFERENCES

1) Oceanography: An Invitation to Marine Science, By Tom S. Garrison

2) Oceanography, By Sharma and Wattal

3) Oceanography, By D.S. Lal

4) The Ocean, By Ellen Prager

15.12 MODEL TEST PAPER

Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

SECTION-A

(8x2=16)

Q1. Define Sirocco and Blizzard.

Q2. Write a note a troposphere.

Q3. What are orographic rainfalls?

Q4. What is difference between the red mud and the blue mud?

Q5. Write a short note on the periodic winds.

Q6. What are constructive waves?

Q7. Name the factors affecting the salinity.

Q8. What do you mean by sub-tropical high pressure belts?

Section B

Unit-I

Q1. Define Atmosphere. Explain in details the composition of atmosphere.

Q2. Give the vertical and horizontal distribution of temperature.

Unit-II

Q3. Give the climatic classification of Thornwaits.

Or

Q4. What do you mean by Humidity? Explain the types of Humidity.

Unit-III

Q5. Write a detailed note on the vertical and horizontal distribution of temperature of oceanic water.

Or

Q6. What are the important factors affecting the distribution of salinity?

Unit-IV

Q7. What are waves? Write a note on the types of waves.

Or

Q8. What are ocean deposits? Explain the various types of ocean deposits

OCEAN DEPOSITS ORIGIN AND TYPES

Dr. Shivani Walia

16.1 INTRODUCTION

Ocean deposits are the unconsolidated material, derived from various sources and deposited at the ocean floors. These marine sediments are the weathered and eroded material of rocks, volcanic ashes, dust, remains of marine organisms, fragments of meteorites etc. It also includes the broken parts of sunken ships and boats through ages. Thus, ocean floors are called as the "library of the earth's geological history", because they are the repository of sediments of various sorts and different time periods. The unconsolidated marine sediments are lithified due to tectonic activities makes the deep ocean floor into a consolidated and layered floor. Such consolidated marine sediments are called ocean deposits.

16.2 OBJECTIVES

— The main objective behind the present chapter is to make students familiar with

- the production, transportation and deposition of marine sediments.
- sources and types of marine sediments.
- classification of ocean sediments

16.3 PRODUCTION, TRANSPORTATION AND DEPOSITION OF MARINE SEDIMENTS

The marine sediments are formed due to three main processes, i.e weathering, erosion and decay of shells. The transportation of the eroded material to the seas and oceans is done by different agents like, rivers, glaciers, winds, waves, currents and by human activities also. This mechanism is discussed under one by one.

1. The continental rocks are weathered through the process of disintegration and decomposition of small pieces. The eroded sediments are brought to oceans and seas by rivers.
2. The glaciers in the high latitudes also bring glacially eroded sediments in the oceans.
3. Similarly, wind blown sands and dusts from the coastal land and hinterlands are deposited in the oceans.
4. The skeletons of dead marine organisms decay and decompose on the ocean floor, and provide biogenous sediments to ocean repository.
5. Sea waves erode the coastal rocks produce substantial quantity of sediments to the ocean floor. Not only waves, but tides and storms also do the same.
6. Human economic activities to some extent also provide the sediments to the continental margins and continental shelves. These activities are like dredging of

ports and harboors, devegetation and extensive cultivation constructions of dams and reservoirs, quarrying of beaches etc.

16.4 SOURCES AND TYPES OF MARINE SEDIMENTS

On the basis of sources and mode of formation marine sediment are classified into the following categories:-

1. **Terrigenous (Lithogenic) sediments:-**The lithogenic sediments are derived from the weathering and erosion of rocks, whether on land or in the ocean, whereas terrigenouos sediments include only those sediments of various sizes which are produced by weathering and erosion of only continental rocks. Since there is much variation in the size and shape of terrigenous materials, there is marked gradation of these materials when they are deposited in the oceans, i.e coarser and larger sediments (boulders cobbles and pebbles) are deposits near the coast and the size of the sediments becomes smaller and finer away from the coast. Very fine sediments are kept in suspension in the offshore region. On the basis of size, composition and chemical characteristics, terrigenous sediments are divided into gravels, sands and silt, clay and muds.

   Gravels:- The diameter of gravels ranges from 2mm to 256mm. There is marked gradation in the size of gravels like boulders (256mm), cobbles (64mm), pebbles (4mm), granules (2mm). Since these sediments are very large in size, these are deposited neat the coast on the continental shelves. These sediments are further reduced is size due to further disintegration caused by sea waves. Gravels are brought to the oceans by the rivers.

   Sands:-These sediments varying in diameter from 1mm to 1/16mm are termed as sands. On the basis of size of grains, sands are classified in five types as, very coarse sands (1mm), coarse sands (0.5mm), medium sands (0.25mm), fine sands (0.125mm) and very fine sands (0.0625). Sands are produced due to disintegration of continental rock fragments into fine sediments, which are deposited in the oceans by divers and winds. Also the coarser sands are deposited close to the coast while fine sands are deposited away from the coast.

   Silt, Clay and Mud:- The finer sediments ranging in diameter from 1/32mm to 1/8192mm are grouped under the category of slit, clay and mud. Mud is still finer than clay. Clay is significant cementing element. These material are brought from the continents by the rivers. Clay and mud are deposited in calm seawater. Generally these deposits are found at the depth of 100 to 1000 fathoms (600 to 6000 feet). Murray has divided mud into three types on the basis of colour.

(i) Blue mud:- It includes the materials derived through the disintegration of rocks rich in iron sulphide and organic elements. These are generally found at greater depth of the continental shelves. The original colour of blue mud is bluish black and it contains 35 percent of calcium carbonate. Blue mud predominate in the Atlantic ocean, Mediterranean sea, Arctic sea and enclosed seas.

(ii) Red Mud:- The sediments derived through the communition of rocks rich in iron oxides form red mud. The reddish colour is mainly due to dominance of iron content. It contain 32 percent of calcium carbonate. The deposit of red mud is confined mostly to the Yellow sea, Brazilian coast and the floors of the Atlantic ocean.

iii) Green Mud:- Green mud is formed due to chemical weathering wherein the colour of blue mud is changed to green mud due to reaction of seawater. It contain green silicates of potassium and glauconite which constitutes 7-8 percent of total mineral composition whereas, calcium carbonate range from 0 to 5 percents. The deposits of green mud are found along the Atlantic and Pacific coasts of North America, off the coast of Japan, Australia and Africa. These are generally found at the depth of 100 to 900 fathoms.

2. **Volcanic material:-** Volcanic material deposits in the marine environment are derived from eruptions in the sea. In case of the volcanic eruptions in the oceans and seas, volcanic material are directly deposited. While in case of volcanic eruptions on the land, the material are deposited either by the wind or by the rivers. Volcanic materials resemble blue mud and are grey to black in colour.

3. **Organic Material:-** Organic material include skeletons of marine organisms and plant remains. The source of organic materials is sea itself. These material are further grouped into two categories, i.e neretic matter and pelagic matter. The neretic matter includes skeletons of marine organisms and plants. The skeletons of animals and dead plants

are subjected to decomposition and chemical changes. They deposited mostly on the continental shelves. These include shells of moluscs and their fragments, skeletons of radiolarian, and spicules of sponges, calcareous and siliceous plant remains. On the other hand, pelagic matter consists of remains of different types of algae and are mostly in the form of liquid mud, generally known as ooze. These oozes are divided into two groups on the basis of lime and silica content.

i) **Calcareous Oozes:-** Such type of oozes contain lime content in abundance and are found at greater depth because of their high degree of solubility. They are generally found at the sea floor between the depth ranging from 1000 fathoms to 2000 fathoms. On the basis of principal organisms, calcareous oozes are further divided into two sub types i.e pteropod ooze and globigerina ooze.

(a) **Pteropod Ooze:-**Such type of ooze are formed of floating pteropod molluscs having thin shells of generally conical shape with average diameter of half inch. It contains 80 percent calcium carbonate and is mostly found in the tropical oceans and seas at the depth 300-1000 fathoms. It decreases with greater depth and practically disappeared beyond 2000 fathom depth. It is found mostly in the region of corals. The main location of ptreopod ooze includes the western and eastern parts of the Pacific Ocean, surroundings of Azores, Canary Island, Antiles, Mid mediterranean submarine ridge and Indian ocean.

b) **Globigerina Ooze:-** This ooze is formed from the shells of foraminifera, but also formed of germs called globigerina. It is mostly white in colour but also in blue, grey, yellow, and green colour. Such ooze is found between the depth of 2000 to 4000 fathoms and becomes absent at greater depth. Globigerina ooze is mostly found in the tropical and temperate zones of the Atlantic ocean, on the eastern and western shelves of the Indian ocean and in the eastern Pacific ocean.

ii) **Siliceous Ooze:-** When silica content dominates the ooze become siliceous in nature. Silica is derived from a group of protozoa or radiolarian and benthic animals mainly sponges. This ooze does not dissolve because of less calcium carbonate and dominance of silica. This group is further divided into two subtypes on the basis of dominance of a particular organism.

a) **Radiolarian Ooze:-** This ooze is formed by the shells of radiolarian and foraminifera. It changes to dirty grey powder when dried. Lime content decreases with increasing depth and it absolutely disappears at greater depth. This ooze is found upto the depth of 2000 to 5000 fathoms in the tropical oceans and seas. It covers the largest areas in the Pacific oceans.

b) **Diatom Ooze:-** Diatom ooze is formed of the shells of very microscopic plants containing silica in abundance. It also contains some clay. Calcium content varies from 3 to 30 percent. It is blue near the land and the colour changes yellow or cream away from the land. It becomes fine coherent white powder when dried Diatom ooze is very frequently found at greater depth in high latitude. This types of ooze is mostly found in the areas around Antarctica and a belt from Alaska to Japan in the North Pacific at the depth 600-2000 fathoms.

4) **Inorganic materials:-** The category of inorganic elements include those which fall down from above. It include dolomite, amorphous silica, iron, manganese oxide, phosphate, barite etc. the organic and inorganic materials are so mixed together due to chemical processes that it becomes very difficult to isolate them from each other. Previously, Red clay is considered to be of organic origin, is the most significant inorganic matter and very important member of pelagic deposits. It covers the largest area of deep sea deposits. Silicates of alumina and oxides of iron are the important constituents of red clay, but calcium, siliceous organisms and few minerals are also present. It is important to mention here that red clay contains more radioactive substances than any other marine deposit. It is soft, plastic and greasy in character. It becomes reddish brown powder when dried. Red clay is widely distributed at the greatest depth in all the oceans. Its dominate location include the zone between 40º N and 40º S in the Atlantic ocean, eastern part of the Indian oceans and the North Pacific ocean.

16.5 CLASSIFICATION OF OCEAN DEPOSITS

Ocean deposits are classified on different bases, like on the basis of location, on the basis of depth, on the basis of the origin of sediments etc.

1) **On the basis of location:-** This classification is based on typical locations of particular marine sediments. Though several scientist have attempted to classify ocean deposits

on the basis of their location, the classification of Sir John Murray and J.T. Jenkins are widely acclaimed.

i) **Classification of Murray:-** Sir John Murray has classified the ocean deposits into two broad categories i.e. terrigenous deposits and pelagic deposits. Terrigenous deposits are found mainly on the continental shelves and slopes, whereas pelagic deposits predominate on the deep sea floor. Terrigenous deposits are composed of coarser material and are derived from the continents through weathering and erosional processes and are transported to the ocean by various agencies. Their colour may be blue , yellow, grey or red. Pelagic deposits consists of fine material formed of skeletons and shells of marine organisms and a few inorganic substances. They are generally blue, grey or red in colour.

ii) **Classification of Jenkins:-** Jenkins has divided marine deposits into three groups. Deep sea deposits, shallow water deposits and littoral deposits. The following is the detailed classification of Jenkins on the basis of depth.

Deep Sea deposits (Below 100 fathoms)	**Shallow Sea Deposits (between low tide water & 100 fathoms)**	**Littoral deposits (Between high and low tides)**
A. Pelagic deposits		
Red clay	Gravels	Gravels
Radiolarian ooze		
Diatom ooze	Sands	Sands
Globigerina ooze		
Pteropod ooze	Mud	Mud
B. Terrigenous Deposits		
Blue mud		
Red mud		
Green mud		
Coral mud		
Volcanic mud		

Classification on the basis of origin of sediments

i) **Littoral deposits (derived from land)**

Shore deposits

Shelf deposits

ii) **Hemipelagic deposits (partly from land and partly from marine origin)**

green mud

volcanic mud

coral mud

iii) **Eupelagic deposits (of marine and cosmic origin)**

red clay

radiolarian ooze

globigerina ooze

pteropod ooze

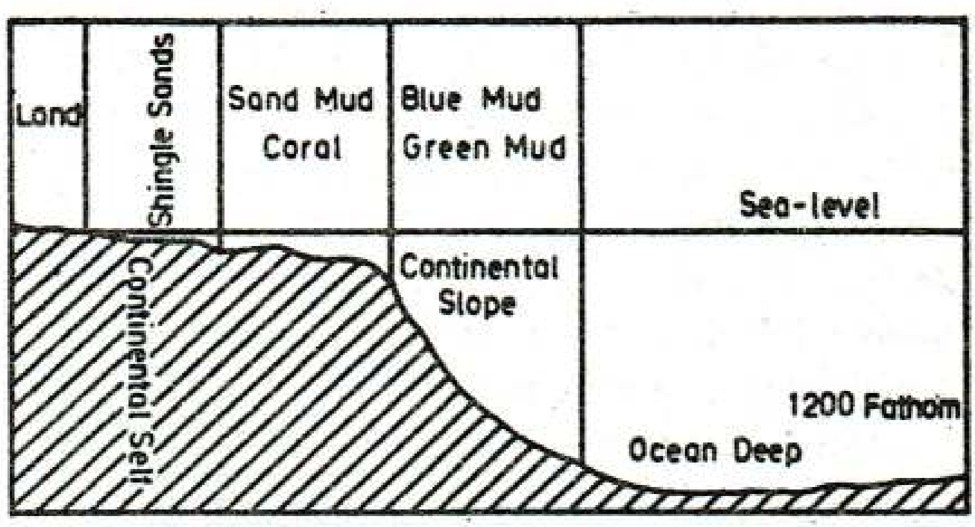

Fig 16.A General distribution of marine sediments

16.6 SUMMARY

In the concluding lines, it is important to mention here that ocean deposits are the unconsolidated materials that are derived from the various sources like terrigenous volcanic and organic matters. The complete study of marine sediments, or say ocean deposits, helps us to known their origin about various sources from where they obtained their importance for marine life and their classification as well as distribution.

16.7 GLOSSARY

Biogenic sediment:- The sediments formed through the deposition of skeletal remains of marine organisms on sea floors are called biogenous sediments and deposits which have at least 30 percent by volume of remain of marine organisms.

Continental Shelf:- The broad, flat, shallow and gently sloping sea floor extending from the coast to the point of shelf break or upper part of continental slope is called continental shelf.

Continental Slope:- Steeply sloping submerged sea bottom extending from the outer marging of continental shelf or from the points of shelf break and ending into deep sea trenches is called continental slope.

Cosmogenous Sediments:- The sediments of extraterrestrial origin, say from the meteorites in the space, are called cosmogenous sediments.

Neritic Sediment:- The marine sediments deposited on the floor of continental shelves are called neritic sediments.

Pelagic matter:- The sediments deposited on deep sea floors through slow sedimentation are called pelagic matter.

Radiolarian:- These are unicellular marine animals having siliceous tests and belong to plank tonic and benthos community.

16.8 SHORT ANSWER TYPE QUESTION

Q1. What are Terrigenous Sediments?

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Q2. Write a short note on the classification of ocean deposits given by Murray.

Q3. What do we mean by calcareous ooze?

Q4. How the human activities affect the ocean deposits?

16.9 EXAMINATION ORIENTED QUESTIONS

Q1. What are ocean deposits? What are the main factors that help in the sedimentation of ocean deposits?

Q2. Give the classification of ocean deposits on the basis of origin of sediments.

Q3. What do we mean by ocean deposits. Write a note on the types of marine sediments.

Q4. How the organic materials are considered to be very important in the sedimen tation of ocean deposits?

16.10 SUGGESTED READING

1) Ocean and Sea, By Steve Parker
2) Physical Geography, By Savindra Singh

16.11 REFERENCES

1) Oceanography: An Invitation to Marine Science, By Tom S. Garrison
2) Oceanography, By Sharma and Wattal
3) Oceanography, By D.S. Lal
4) The Ocean, By Ellen Prager

16.12 MODEL TEST PAPER

Time Allowed- 3 hrs **Maximun Marks:- 80**

Note: This paper has two sections

Section A:- Compulsory, contains 8 questions carrying 2 marks each. Answer should be limited in 20 words each

Section B:- Contains 8 questions students have to answer one question from each unit. Each question carries 16 marks. Answer should be limited in 450 words each.

SECTION-A

(8x2=16)

Q1. Define Sirocco and Blizzard.

Q2. Write a note a troposphere.

Q3. What are orographic rainfalls?

Q4. What is difference between the red mud and the blue mud?

Q5. Write a short note on the periodic winds.

Q6. What are constructive waves?

Q7. Name the factors affecting the salinity.

Q8. What do you mean by sub-tropical high pressure belts?

Section B

Unit-I

Q1. Define Atmosphere. Explain in details the composition of atmosphere.

Q2. Give the vertical and horizontal distribution of temperature.

Unit-II

Q3. Give the climatic classification of Thornwaits.

Or

Q4. What do you mean by Humidity? Explain the types of Humidity.

Unit-III

Q5. Write a detailed note on the vertical and horizontal distribution of temperature of oceanic water.

Or

Q6. What are the important factors affecting the distribution of salinity?

Unit-IV

Q7. What are waves? Write a note on the types of waves.

Or

Q8. What are ocean deposits? Explain the various types of ocean deposits