Lecture (5)

Environmental Factors influencing phytoplankton growth

2- Temperature

Temperature has direct and indirect effects.

A- **Direct effects**:

1**-The temperature tolerance:-**

When the temperatures of water lakes are rising in summer season, some species of phytoplankton can tolerate this change in temperature. An example, the temperature of *Chlorella* species in a lake never rises above 7 ^{o}C, whereas in lab experiments its optimal temperature was 20 ^{o}C.

2**-Photosynthesis under temperature extremes**:**-**

The phytoplankton photosynthesis can proceed under temperature extremes: e.g. in Antarctic habitats below 0 ^{o}C & in tropical habitats reach 30 ^{o}C or more.

3-A seasonal pattern of phytoplankton controlled by temperature

Certain phytoplankton exhibit seasonal patterns which is temperature controlled.

a) Blooms of freshwater cyanobacteria in **temperate lakes** occur largely in **summer**,

b)The **summer** abundance of dinoflagellates in **temperate seas**.

c) The species succession in the **spring** outburst in **temperate seas**:**-**

i) The cold – tolerant species occurring in early spring and

ii) Those favoring **warmer conditions** following in **late spring or an early summer**.

d)Seasonal succession of phytoplankton are observed in both **Arctic and Antarctic** waters and the **tropical seas** although variations in temperature are not wide in the **tropical seas**.

4-The decreased solubility of oxygen in seawater with rise in temperature.

Whilst the availability of CO_2 rarely proves limiting to phytoplankton growth in the sea and in freshwater habitats, in all aquatic habitats there may be **deficiencies in dissolved oxygen** (O_2) content due to **temperature increases** (Table 2). This deficiency, with its consequent effect on respiration, may prove <u>limiting to plant growth</u>.

Table 2. Solubility of oxygen in water at different temperature (cubic centimeters of oxygen at NTP dissolved in 1dm ^{3} of water saturated with air at stated temperature and 760 mm pressure.)

Temperature (°C)	Freshwater	Seawater (salinity 35.4 parts per thousand)
°C	(O_2 mg/l)	(O_2 mg/l)
0	10.29	8.08
5	9.03	7.26
10	8.02	6.44
15	7.22	5.93
20	6.57	5.38
25	6.04	4.95
30	5.57	4.52

B- Indirect effects

The important indirect effect of temperature on phytoplankton organisms is to be seen in the thermal stratification in both sea and lakes. Temperature influences the water masses, forming water layers with different temperature degrees as well as densities. That is called "thermal stratification". This phenomenon is formed when the water surface of lakes, exposed to maximum air temperatures or calm weather, is heated in summer. Thermal stratification occurs apparently in both the deep sea, a land-locked water mass with minimal surface turbulence. The thermocline may never develop or last for a few days in shallow seas with continuous turbulence. The different layers formed in thermal stratification are shown as follow:-

1-**Epilimnion**; The upper layer of warmed water.

2-**Metalimnion**; A thin layer in which there is marked temperature and density change. It is called a thermocline or discontinuity layer

3-**Hypolimnion**: The deeper cold water, Fig (2) .

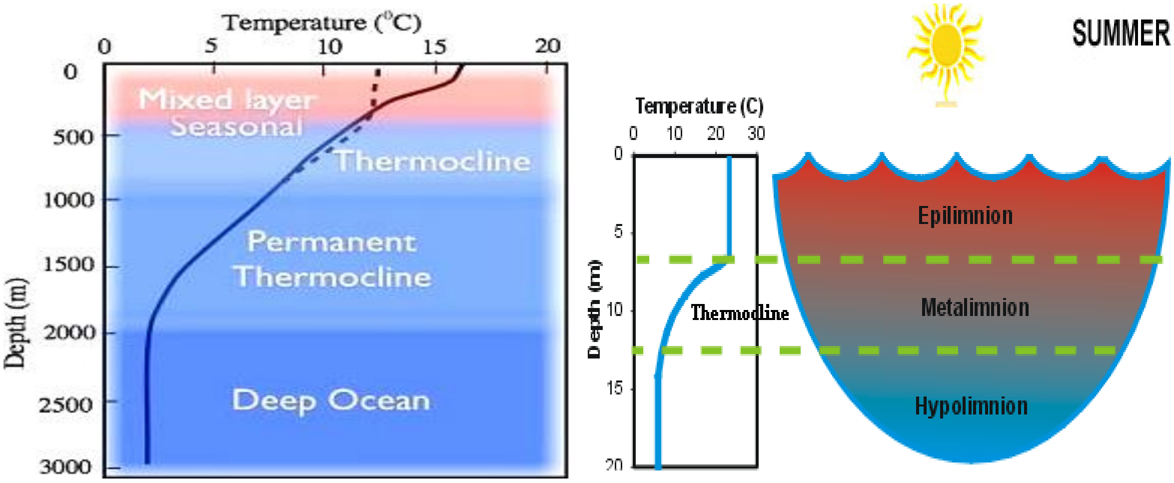
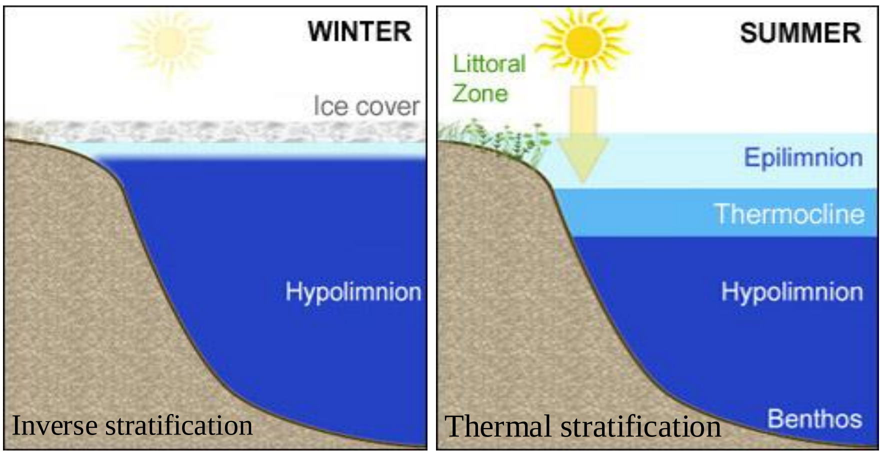


Fig. (2). The thermal stratification of the water masses in both seas and lakes

<u>An inverse thermal stratification :-</u>

An inverse temperature stratification in water lakes can occur in the **late winter** or **early spring** when <u>the temperature of the top layers falls below that of the deeper</u> water. The <u>depth of the discontinuity</u> layer is determined by surface turbulence. It is usually a **<u>constant feature of low latitudes</u>** and it is of **<u>seasonal occurrence in higher latitudes</u>**.



The development of thermocline layer leads to separate the upper warmed water from the deeper cold water. According to the <u>depth of thermocline layer</u>, a well-marked thermocline developed in early summer is ranged between <u>13-14m depth in calm seas</u>. Whereas in <u>oceanic water it lies at 25-30 m</u>. <u>Wind action</u> on the surface can influence <u>the stability of the thermocline</u> whereas, <u>frequent gales may prevent thermocline</u>

formation in open oceans. **Turbulences** set by sea bed irregularities, are big enough the disturbances may extend up to the surface layers.

The effect of thermal stratification on phytoplankton growth

Thermocline layer isolate the water masses containing phytoplankton in the upper warmed layer from reaching to the deeper cold layer containing nutrient. In obviously, it prevent the water mixing in water column.

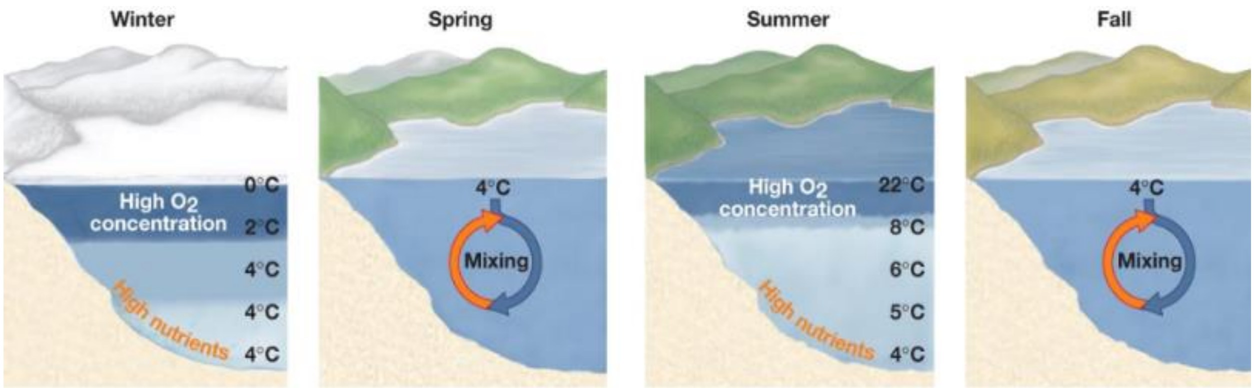
Thermocline layer is a significant annual feature in the life of phytoplankton. The thermal stratification confines the phytoplankton to the upper layers of sea and lakes, making as the barrier to water vertical mixing and replenishment of the nutrients.

Above the thermocline, phytoplankton cells will be circulated by water movements and often carried into adequately lighted regions. But when the nutrients in that layer decrease, the phytoplankton growth will be limited. The replenishment of the nutrients in the surface layers depends on recycling processes of mineralization in the deeper waters in both the sea bed and lake floors.

Minerals dissolved in land drainage are also significant but may be insufficient for continued phytoplankton growth in the sea, this terrestrial influence is mainly confined to coastal waters. The gradual fall in air and water temperatures leads to the autumnal phenomenon of turbulence. Increased turbulence of the sea with the onset of autumnal gales sets the mass water movements which steadily lower and break up the discontinuity layer, causing upwelling, so that vertical mixing and overturn will occur.

Upwelling of deeper water occurs when currents carry away the surface water particularly in the coastal waters. Such features tend to increase the mixing of surface and deeper nutrient – rich waters, producing dense growths of phytoplankton.

Fig (3). Shown the effect of seasonal variation of temperature on water column.



Some phytoplankton groups prefer a stable stratification such as the motile dinoflagellates can be found in more stratified water columns. While other phytoplankton prefer a mixed water column such as the fast-growing and silicified diatoms thrive in strong water mixing conditions.

Salinity

Water salinity gradients range from strong salinity in marine environments (e.g. Oceans and Seas) to low salinity in freshwater (rivers and reservoirs), passing from the brackish water of estuaries). Seawater is primarily composed of the positive ions Sodium (Na^+), Magnesium (Mg^+), Calcium (Ca^{++}), and Potassium (K^+), and the negative ions Chloride (Cl^-) and Sulfate (SO_4^{-2}). The principal elements in sea water salinity are Na and Cl (as NaCl of sea water 30.4 ‰).

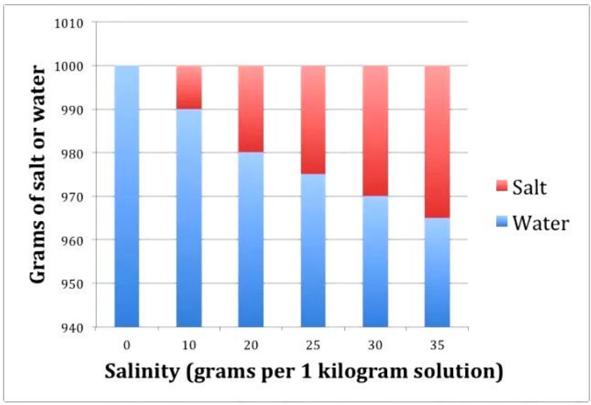
Table of the relative amounts of salts in seawater.

Ions Found in Seawater with 35‰ Salinity

	Ion	Concentration ‰
Major Ions	Chloride	19.3
	Sodium	10.6
	Sulfate	2.6
	Magnesium	1.3
	Calcium	0.4
	Potassium	0.3
	Bicarbonate	0.1
Minor Ions*	Bromide	0.067
	Borate	0.027
	Strontium	0.013
	Fluoride	0.001

*Other elements are found in trace amounts

The following chart offers approximate salinity values in ppt (parts per thousand) in different water sources.



	ppt
FRESHWATER	< 0.5
BRACKISH / ESTUARY	0.5 - 17
BLACK SEA	16
OCEAN RANGE	32 - 37
OCEAN AVERAGE	35

Salinity is a crucial factor affecting phytoplankton growth. Salinity creates barrier to the spatial distribution of phytoplankton organisms. Some phytoplankton are entirely restricted to fresh water (e.g. the desmids). Inflow of salt water into areas of fresh water have catastrophic effects on the phytoplankton. Some organisms can survive and grow in the variable salinities of estuaries. Some nanophytoplankton from estuaries, <u>markedly changes their volume if they subjected to low</u> salinities without damage to cell functions (e.g. in 15 ‰ compared with 35 ‰).

Marine diatom and dinoflagellates cells will damage if suddenly subjected to fresh water. on the contrary, when freshwater phytoplankton pass into the sea, they will subject to cell distortion and rupture, or rapidly plasmolysis where they aren't euryhaline in their properties.

Some species can adapt to low temperatures (-1.8 to 3.5°C) and salinities ranging from 32.6 to 34.5‰. Species which restricted to a range of temperature and salinity tolerance, they are described as stenothermal and stenohaline. In tropical seas temperature fluctuations but restricted salinity range certain organisms are eurythermal and stenohaline. Temperature and salinity fluctuations can be wide- ranging in estuaries, and organisms adapted to both types of stress are both eurythermal and euryhaline.

The regional species composition changes strongly with the salinity. The diversity seems to be lowest in the intermediate brackish water of approximately. Few marine and limnetic species survive at this salinity and there are few genuine brackish-water species. However, several cyanobacteria species are adapted to the intermediate salinity. The surface salinity in coastal areas affected by variable freshwater runoff.

Questions

1-Discuss the following:-

a) Water salinity affect the distribution of phytoplankton
b) Temperature affect directly on phytoplankton growth
c) Temperature affect indirectly on phytoplankton growth
d) Upwelling support the phytoplankton growth

2- Thermal stratification:-

a) Figure out its layers with full data
b) What are factors causing it
c) When does it happen

3- Compare thermal and inverse stratification

2- vertical mixing or turnover :-

a) Figure out its layers with full data
b) What are factors causing it
c) When does it happen