

Course: B.Sc. Microbiology

Semester IV.

MBIO GE 404. Microbes in Environment

AQUATIC ECOSYSTEM

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Aquatic Ecosystem

- Deals with the study of biotic community associated or present in water bodies.
- Based on water's salinity i.e., amount of salts such as NaCl, it can be broadly categorized into two groups:
 - A. Freshwater ecosystem
 - B. Marine or Salt ecosystem
- However, on this basis, Moore (1961) classified water bodies based on the salt content as follows:
 - 0.5% = fresh water
 - 0.51% - 29.9% = brackish water
 - 30.0% and above = marine (sea and ocean) water
- Saltwater and freshwater aquatic life zones cover almost 3/4th of the earth's surface with oceans dominating the planet.



Biotic community associated with aquatic community

The key factors that determine biodiversity of any aquatic ecosystem are temperature, dissolved oxygen content, availability of food, and availability of light and nutrients necessary for photosynthesis. Biotic community of any aquatic ecosystem can be categorized into following groups:

1. **Planktons**-weakly swimming, free floating

i. **Phytoplanktons**: drifting plants, includes various algae, rooted plants near shorelines

ii. **Zooplanktons**: drifting animals, includes primary consumers and secondary consumers that feed on other zooplankton. They range from single celled protozoa to large invertebrates like jelly fish. Dominant members- protozoa, rotifera, copepod.

iii. **Ultraplanktons**: much smaller plankton consisting of extremely small photosynthetic bacteria.

2. **Nektons**- strongly swimming consumers (independent of water current) such as turtles, fish, whales, dolphin, shark, crustaceans and even squids.

3. **Benthos**- consist of bottom dwellers such as oysters, worms, lobsters, crabs etc. that attach themselves to one spot or burrow in sand or mud or walk on sea floor.

4. **Decomposers** – break down organic compounds in the dead bodies and wastes of aquatic organisms into nutrients that can be used by aquatic primary producers. Mostly consists of bacteria.

Freshwater Ecosystem

- Covers less than 2.2% of earth's surface.
- 3.9 % of earth's water is not saline with polar ice and ground water (3.7%) and surface freshwater (0.2%).
- Like any ecosystem, it provides a number of ecological and economical services.
- Ecological services- nutrient cycling, climate moderation, waste treatment, ground water recharge, habitat for many species, genetic resources and biodiversity
- Economic services- food, drinking water, irrigation water, hydroelectricity, transportation, recreation.
- May be of two types:
 - A. Lentic- standing water eg., lakes, ponds, inland wetlands.
 - B. Lotic-running water eg., rivers, springs.
- These habitats are collectively called LIMNETIC and study of physical, chemical and biological properties of freshwater bodies is called LIMNOLOGY.
- Biotic community- planktons (free floating organisms), nektons (free swimming organisms), benthos (bottom dwellers), epineuston (float on the surface of water), hyponeuston (live right under the surface) and periphyton (organisms attached to submerged surfaces)

Zonation of lakes based on penetration of light

A. Littoral zone

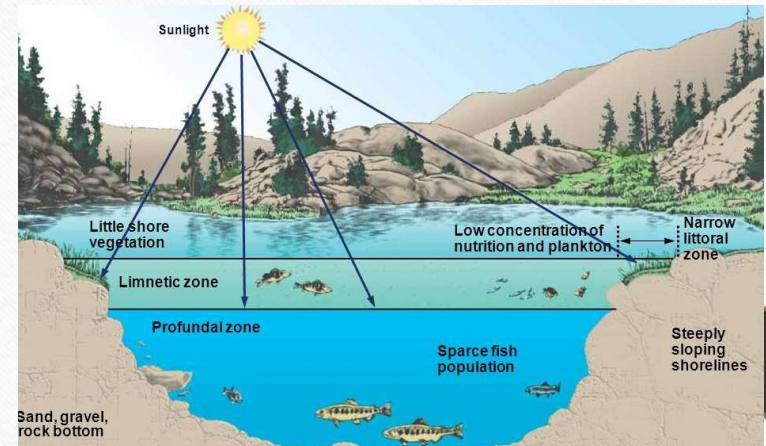
- Area of closest to the shore
- Extends down to the light compensation level
- Has high biological diversity due to ample sunlight and input of nutrients from surrounding land.
- Producers- rooted submerged or partially submerged plants and filamentous and epiphytic algae.
- Production is greater than respiration ($P/R > 1$)

B. Limnetic zone

- It is an area of open water away from the shore, that extends to the depth penetrated by sunlight.
- Dominated by planktons algae
- Biotic components- phytoplankton, nekton and some neuston.
- Derives oxygen from photosynthetic activity of phytoplankton & the atmosphere immediately over the lake surface.
- Contains all the water beyond littoral zone and down the light compensation level.
- Production is greater than respiration ($P/R > 1$)

C. Profundal zone

- It is an area of dark zone i.e., bottom and deep water area beyond the depth of effective light penetration.
- Respiration is greater than production ($P/R < 1$)



D. Benthic zone

- It is the ecological region at the lowest level of a body of water.
- Includes sediment surface and some sub-surface layer.
- Inhabitants- bacteria of which mainly anaerobic decomposers, benthic invertebrates like crustaceans, polychaetes, etc.
- Represents the interface between hydrosphere and lithosphere

Trophic state of lakes

A. Oligotrophic lakes

- Low concentration of nutrients & relatively low net primary productivity.
- Remains oxic throughout year
- Contains deep clear water
- High species diversity with low population
- Generally are free of weeds and large algal blooms, small population of phytoplanktons
- Food chain highly structured
- Typically are deep and have a larger hypolimnion

B. Eutrophic lakes

- High concentration of nutrients especially nitrates and phosphates
 - Higher rate of net primary productivity
 - Typically shallow and have murky brown or green water with high turbidity
 - Low species diversity with high population
 - Algal bloom very frequent
-
- **Cultural eutrophication-** it is the process of acceleration of eutrophication of lakes due to human input of nutrients from atmosphere & nearby urban and agricultural areas. This process often puts excessive nutrients especially nitrates and phosphates into lakes, which are then describes as **hypereutrophic**.
 - Effect of eutrophication –
 - cyanobacteria produces hydroxamates, which binds iron, making this trace element less available to protists. Also using CO₂ at rapid rate, cyanobacteria increase the pH, making environment less suitable for protists.
 - Some cyanobacteria synthesize odour-producing compounds that detoriate the quality of drinking water.



Fig. A. Oligotrophic lake B. Eutrophic lake

Thermal stratification of lakes

- Changes in the temperature profile with depth in an aquatic ecosystem due to differential heating and cooling is called thermal stratification.
- It is generally observed in freshwater lentic ecosystem such as lakes of temperate regions and not observed in lotic ones.
- The three layers of a well stratified lakes are:
 - 1. Epilimnion**
 - Upper stratum containing more or less uniform warm, free circulating & fairly turbulent water.
 - Characterized by temperature gradient of less than 1°C per meters depth.
 - Aerobic, oxygenated.
 - 2. Metalimnion/Thermocline**
 - Transition layer where temperature declines with increasing depth.
 - Characterized by temperature gradient of more than 1°C per meter depth.
 - 3. Hypolimnion**
 - Deep cool layer with greatly reduced turbulence & insufficient light for growth.
 - Contains dense cooler & relatively quiet water.
 - Characterized by temperature gradient of less than 1°C per meters depth.
 - Anaerobic & deoxygenated.

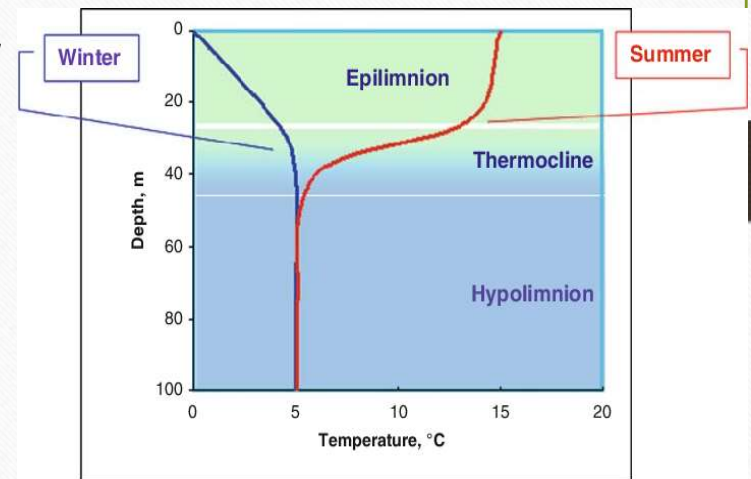
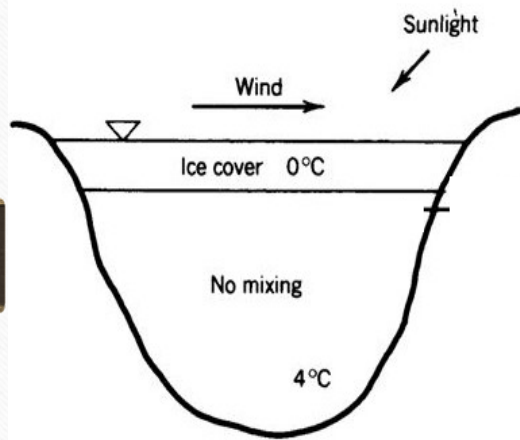


Fig. Thermal stratification of lake in **summer** and **winter**.

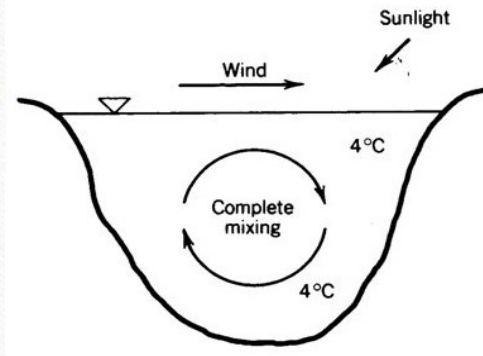
Seasonal variation in temperate lake

- **During Winter-** Surface water is cooled to 4 °C. As water temperature reaches 0°C, ice begins to cover lake surface. This ice cover prevents wind from mixing the lake water and stratification occurs. A layer of water colder than 4 °C but warmer than 0°C forms just under the ice. Below this layer, the remainder of lake water is usually near 4 °C.
- **During Spring-** Ice melts and lake water is mixed by wind flowing over the surface, which pushes the surface water to bottom and vice versa allowing large amount of oxygen to reach bottom. This complete mixing of water at this time of year resulting in no stratification is called **Spring overturn**.
- **During Summer-** As temperature rises, surface water warms, and stratifies lake into upper epilimnion (warm, less dense, illuminated water supporting microbial growth with a rich diversity of primary producers and consumers thus depleting nutrients) and hypolimnion (cool, deep, more dense, nutrient-rich water supporting benthic heterotrophs) separated with a metalimnion that acts as a barrier between mixing of water of epilimnion and hypolimnion.
- note: In summer, surface layer warms rapidly but there is little wind to mix the thermal energy. The top layer is warmer and less dense than the bottom layer. When the winds pick back up, the top layer is now too buoyant to be “pushed” down and mixed. Hence stratification occurs, with mixing of water is in only epilimnion.
- **During Autumn-** As temperature decreases, surface water which is in direct contact with cold air, gets cooled faster than the water below. This cold, dense water sinks and helps to mix the lake water. Also wind physically mixes the epilimnion and hypolimnion, resulting in complete mixing of water, thus no stratification called **autumn turnover**. Mixing of layers brings bottom nutrients to the surface supporting algal bloom.

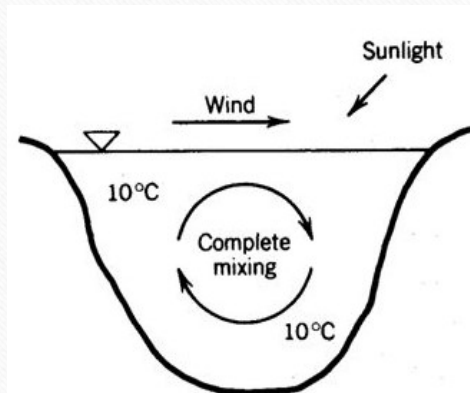
Representation of seasonal variation in temperate lake



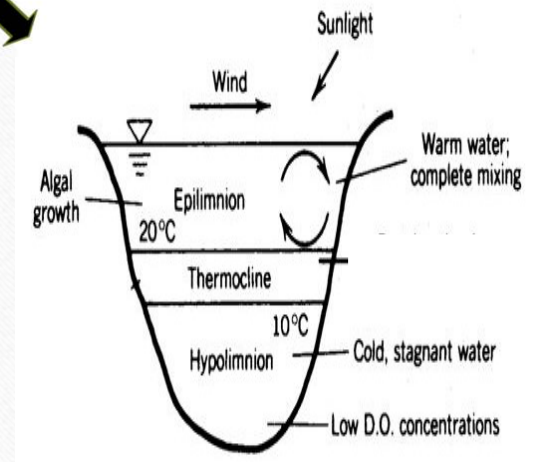
Winter



Spring



Autumn



Summer

Microflora of freshwater ecosystem

- Lentic ecosystem- source of nutrient usually autochthonous, net autotrophic metabolism, dominated by planktons and invertebrates.
- Lotic- source of nutrient usually allochthonous, generally heterotrophs, healthy benthic community.

Groups	Features with representative members
Bacteria	<ul style="list-style-type: none"> • Autotrophic bacteria are autochthonous members • Cyanobacteria (<i>Microcystis</i>, <i>Anabaena</i>, <i>Aphanizomenon</i> are dominant planktons) represents photoautotrophic bacteria involved in photosynthesis acting as primary producers • <i>Nitrosomonas</i>, <i>Nitrobacter</i>, <i>Thiobacillus</i> represents chemolithotrophic bacteria are involved in nitrogen, iron, sulfur cycling • Anaerobic bacteria found in sediments includes species of <i>Pseudomonas</i>, <i>Desulfovibrio</i>, <i>Clostridium</i> and methanogenic bacteria. • Some other common genera are <i>Flavobacterium</i>, <i>Achromobacter</i>, <i>Brevibacterium</i>, <i>Micrococcus</i>, <i>Bacillus</i>, <i>Nocardia</i>, <i>Spirillum</i>, <i>Cytophaga</i>, <i>Streptomyces</i>, <i>Caulobacter</i>, <i>Hyphomicrobium</i>, etc.
Algae	<ul style="list-style-type: none"> • Represented by members of chlorophyta, euglenophyta, chrysophyta, cryptophyta, pyrophyta • Support growth to heterotrophic organisms
Fungi	<ul style="list-style-type: none"> • Regarded as allochthonous member as they are often associated with foreign organic matter of freshwater bodies • Represented by <i>Rhodotorula</i>, <i>Candida</i>, <i>Cryptococcus</i>, <i>Torulopsis</i>
Protozoa	<ul style="list-style-type: none"> • Represented by members of flagellates, ciliates • <i>Vorticella</i>, <i>Amoeba</i>, <i>Paramecium</i>, <i>Didinium</i>, <i>Stentor</i> • Feed on phytoplankton and bacteria

Marine Ecosystem

- Covers 71% of earth's surface.
- Includes oceans, estuaries, coastal wetlands, shorelines, coral reefs.
- Actual salinity varies in different marine habitats, with an average salinity of 35 parts per thousand (ppt) of water.
- Ecological services- climate moderation, CO₂ absorption, nutrient cycling, waste treatment, genetic resources and biomass.
- Economic services- food, animal and pet feed, pharmaceuticals, harbors and transportation routes, coastal habitats for human, recreation, employment, oil and natural gases.

Zones of Ocean Ecosystem

Based on distance from shore, there are 3 zones (Horizontal zonation)

A. Intertidal/ littoral zone - the shoreline between land and open sea. Subjected to alternate period of flooding and drying at high and low tides, respectively.

B. Neritic/sub littoral zone/nearshore zone – extends from low tide mark to the edge of continental shelf with a water depth of about 200m.

C. Oceanic zone/open ocean zone - The sharp increase in water depth at the edge of the continental shelf separates the coastal zone from the vast volume of the ocean called the open sea. Similar to limnetic zone in lakes, it comprises the open ocean away from shore yet closer to the surface of water.

Based on water depth, there are 2 zones

A. Pelagic- open ocean

Epipelagic (Sunlight), mesopelagic (twilight) , bathypelagic (midnight), abyssopelagic, hadopelagic

A. Benthic – bottom

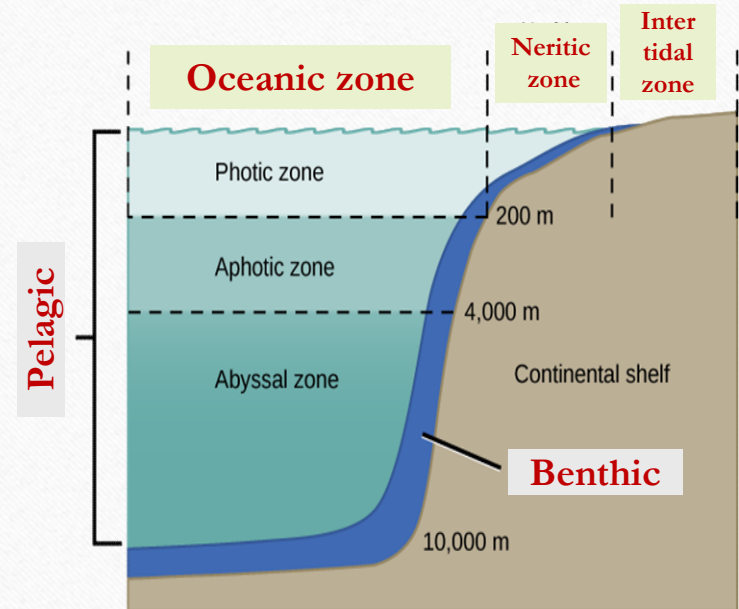


Fig. Zones of Ocean based on distance from shore and water depth

Zones of ocean based on penetration of light (Vertical Zonation)

Zones	Sub Groups	Features
PHOTIC ZONE	Euphotic zone (Epipelagic)	<ul style="list-style-type: none"> • brightly lit upper zone where drifting phytoplankton carry out about 40% of the world's photosynthetic activity • nutrient levels are low (except around upwellings), and levels of dissolved oxygen are high. Large, fast-swimming predatory • fishes such as swordfish, sharks, and bluefin tuna populate this zone
	Disphotic zone (mesopelagic)	<ul style="list-style-type: none"> • Lies beneath euphotic zone • Illuminated but so poorly that rates of respiration exceed those of photosynthesis
APHOTIC ZONE (sunlight penetration less than 1%)	Bathyal zone (bathypelagic)	<ul style="list-style-type: none"> • extending from 200 m (656 ft) to 2,000 m (6,562 ft) • dimly lit middle zone because it gets little sunlight • doesn't contain photosynthetic producers. • zooplanktons, fish, migrate to feed on the surface at night, populate this zone
	Abyssal zone (abyssopelagic)	<ul style="list-style-type: none"> • extending from 2,000 m (6,562 ft) to 6,000 m (19,685 ft) • dark, doesn't receive sunlight or precipitation, very low temperature, high pressure • has little dissolved oxygen • physical adaptation like camouflage and bioluminescence helps the species lure their prey
	Hadal zone (hadopelagic)	<ul style="list-style-type: none"> • extends from 6,000 m (19,685 ft) to the ocean floor

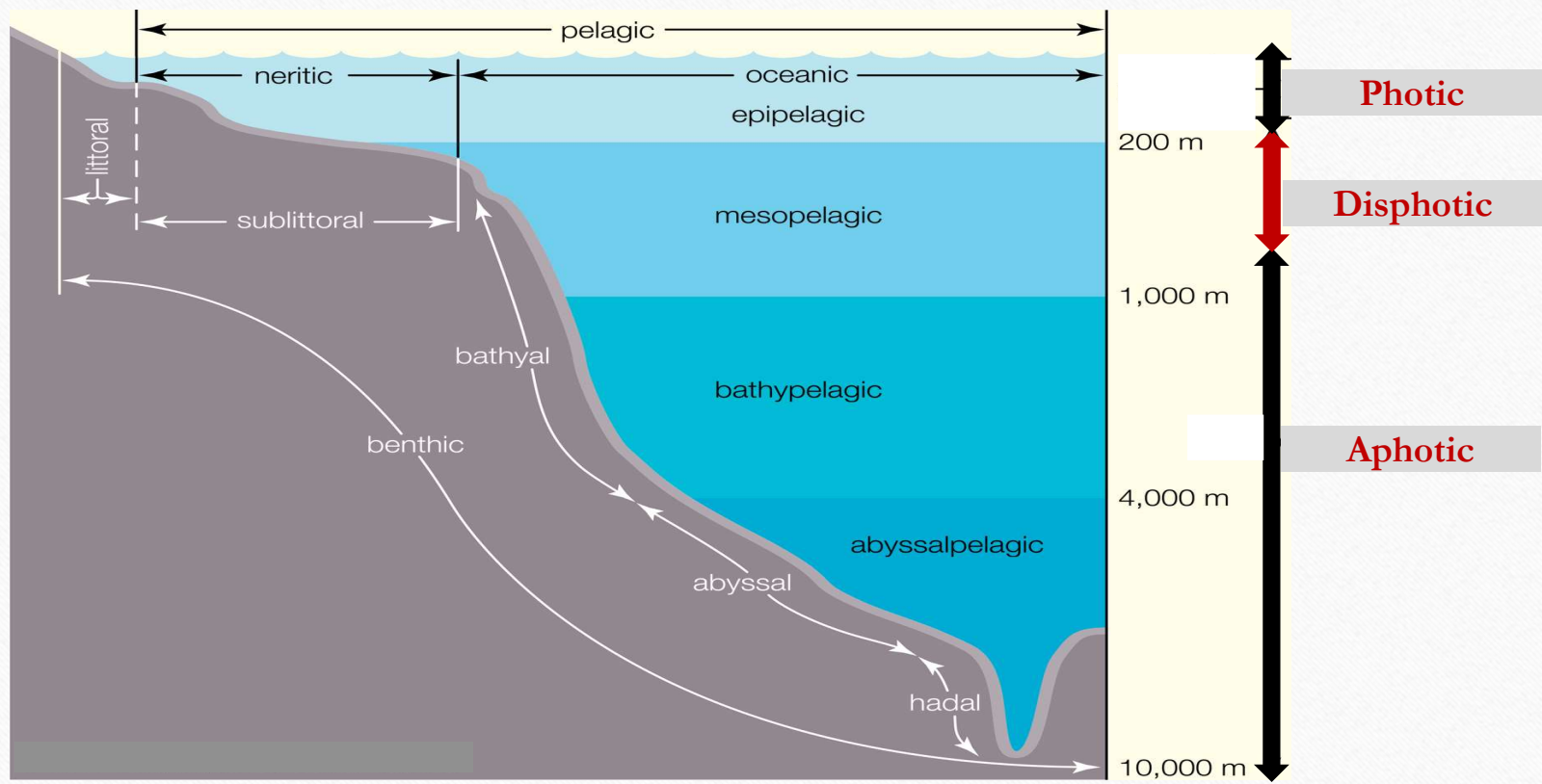


Fig. Vertical Zones of an ocean

Microflora of marine ecosystem

Groups	Features with representative members
Bacteria	<ul style="list-style-type: none"> • Mostly Gram negative and motile with some Gram positive members too. • Usually aerobes and facultative anaerobes with relatively few obligate anaerobes. • Species of <i>Vibrio</i>, <i>Pseudomonas</i> and <i>Flavobacterium</i> represents dominant members. • Others are <i>Spirillum</i>, <i>Alcaligenes</i>, <i>Cytophaga</i>, <i>Hyphomicrobium</i>, <i>Microcycylus</i>, <i>Bacillus</i> and actinomycetes. • Anaerobic <i>Desulfovibrio species</i> and methanogens are found in sediments. • <i>Nitrosococcus</i>, <i>Nitrosomonas</i>, <i>Nitrospina</i>, <i>Nitrococcus</i> & <i>Nitrobacter</i> are involved in nitrogen cycling
Algae	<ul style="list-style-type: none"> • Members of chlorophyta and chrysophyta are planktonic forms • Others are members of Euglenophyta, Cryptophyta, Pyrrophyta, Phaeophyta (<i>Fucus</i>, <i>Sargassum</i>), Rhodophyta • Involved in Carbon input • bloom of pyrrophytes (dinoflagellates) causes rides tides and and paralytic shellfish poisoning (PSP) in human.
Fungi	<ul style="list-style-type: none"> • Represented by <i>Candida</i>, <i>Torulopsis</i>, <i>Cryptococcus</i>, <i>Trichosporon</i>, <i>Saccharomyces</i>, <i>Rhodotorula</i>, <i>Rhodosporidium</i>
Protozoa	<ul style="list-style-type: none"> • Important component of zooplankton showing tolerance upto 10% NaCl concentration. • Includes flagellates, rhizopods, ciliates • Species of <i>Radiolaria</i>, <i>Acantharia</i> are major planktonic form • Feed on bacteria, phytoplanktons and smaller zooplanktons.

Terms

- **Holomictic** lakes are lakes that undergo annual mixing between stratified layers.
- **Dimictic** lakes mix twice a year, usually in the fall and spring.
- **Autochthonous**- it is the biologically available carbon that is produced within the system.
- **Allochthonous**- in most streams and rivers, the source of nutrients come from surrounding land. Such nutrients are called Allochthonous
- **Wetlands** -Are ecosystem in which the land surface is saturated or covered with water permanently or seasonally. Based on salt concentration they can be freshwater, marine or brackish. They are of following types based on hydrology or wetness, type of vegetation and type of soil

Types of wetlands	Properties
Marsh	<ul style="list-style-type: none">• Mineral soil• Dominated by grasses and floating leaved plants
Swamp	<ul style="list-style-type: none">• Mineral soil• Dominated by trees
Bogs	<ul style="list-style-type: none">• Organic soil• Dominated by moss• Receive water exclusively from rainfall• Acidic, unproductive
Fens	<ul style="list-style-type: none">• Organic soil• Receive water mostly from surface and ground water• Alkaline

Thankyou
