

LECTURE NOTE ON FIS 305

FIS 305 – LIMNOLOGY (2 UNITS)

This Course is taught by 2 lecturers – Dr. I.T. Omoniyi and Dr. (Mrs) N.B. Ikenweiwe.

The Course Synopsis is further outlined on lecture basis as follows:

Lectures 1-3: Limnology and classification of aquatic environment and inland freshwaters

Lectures 4-5: Physical features/properties of inland water including their stratification.

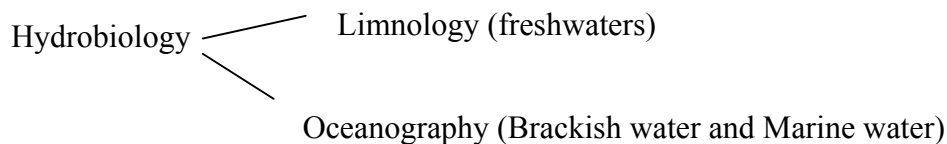
Lectures 6-7: Chemical properties of inland water including their stratification

Lecture 8: Eutrophication in freshwater

Lectures 9-10: Life forms in freshwaters.

Lecture 11-12: Hydrological Cycles

What is Limnology? It is simply defined as the science or study of freshwater bodies. The study involves the physical and chemical features of the freshwater (FW) and the life forms that exist in such bodies mainly the streams, rivers, lakes and reservoirs. It is a branch of Hydrobiology



Give further illustrations in the class. The Course is introductory.

Classification of Aquatic environment

Based on salinity or chlorinity is equivalent to the salt content in the water (i.e. Cl⁻ present in one litre of water) aquatic environments are described as thus:

- (a) Oligohaline – water contains very low salinity usually less than 1‰
- (b) Mixohaline – volume of water with highly variable salinity, it can be from 1-30‰
- (c) Mesohaline – water with medium salinity ranging from 10-20‰
- (d) Metahaline – water contains very high salinity usually above 30‰

Note that it is assumed that life started from aquatic environment and this view is further supported by the marine plankton (especially phytoplankton) supplying O₂ for the earth. Hence, study of aquatic environment is vital to life on earth. Aquatic environment serves not only as habitat for its inhabiting organisms but it is a source of gaseous exchange, source of nutrients and medium for disposal of waste products of metabolism.

Also, based on the nature of habitat, aquatic environment can be divided into 3 groups for easy description:

- (i) Marine water/habitat – is metahaline, very high salinity ranging from 30-40‰ (av. 35‰). Exception is found e.g. Baltic sea in Europe has salinity ranging from 7-35‰. Above this range are the Red sea and Mediterranean sea having salinity range of 40-43‰ - thus referred to as hypersaline. This is due to high evaporation in their locations. One feature of the marine water is that the relative concentrations of different salts do not vary markedly. Salinity along the coast is usually lower than the normal range due to rivers and flood water with virtual zero salt flowing into it thereby lowers the salinity. Other examples of marine water are the oceans e.g. Atlantic, Indian, Pacific oceans etc.

(ii) Brackish water – is mixohaline ranging from 1-33‰ depending on the season e.g. Lagos lagoon in rainy season is as low as 0.9‰ and at the peak of dry season – 31.8‰. other examples are the estuaries, creeks and bays.

(iii) Freshwater – is oligohaline i.e. low salinity. In most cases, the salinity is less than 0.5‰. Examples are the rivers, streams, ponds, lakes and reservoirs which are inland waters. Note that some inland waters may not be fresh water by having more than 1‰ e.g. the Great salt lakes in North America have higher salinity, Lake Elmentia (East Africa) has about 43‰. Hence, not all inland waters are necessarily fresh water.

Classification of Freshwater (FW). FW is the core of this course.

FW may be considered into 2 groups based on the presence or absence of unidirectional current.

(A) 1st Series – Lotic water is otherwise called ‘running water’ i.e. lotic water shows unidirectional movement. It includes spring, streams, rivulets, rivers. Rivers column of water moving from inland areas towards the sea. They usually have slow motion during dry season. Note that motion is expressed as rate of flow or stream velocity. Also, note that rate of flow is equivalent to discharge rate defined as the volume of water passing an observation point in a specific unit of time. Expressed as cubic metreSec⁻¹ or cu.ftSec⁻¹. The discharge rate increases towards the sea as the main river is joined by many tributaries. Motion may be even i.e. water particles move parallel to one another.

In such column, water is said to exhibit laminar flow. Motion may be quite irregular hence showing turbulence. High turbulent water has higher erosive power and high concentration of dissolved O₂ than rivers with Laminar flow.

Lotic water is sub-divided into 3 types:

(i) Ephemeral lotic water – short living, water appears for a short time e.g. few hours or days especially during the rainy periods e.g. run offs.

(ii) Intermittent lotic water – Are streams or even rivers which flows seasonally i.e. seasonal rivers. Live longer than ephemeral. Give your local example e.g. Alaata river

(iii) Perennial lotic water – permanently flowing rivers e.g. R.Ogun, Niger river etc.

Each of these lotic water can be divided into zones as Rapid zone – shallow, fast current and firm bottom and the Pool zone which is deeper, slower current and soft substratum. Illustrate all these with further examples.

(b) 2nd Series – Lentic waters – Have multidirectional currents. Can move in any direction and hence referred to as ‘standing’ waters. Examples are swamps, ponds, lakes, man-made lakes/reservoirs. A lentic water has basically three zones:

Littoral zone – shallow parts of the water with light penetrating to the bottom

Limnetic zone – Ends where the light penetration is effective. It is the open part of the water.

Profundal zone – This is the bottom and deep part of the water which is beyond the part of effective light penetration. It is called the dark region of the water and usually no green plants survive in the zone. Give the diagram during lecture hours.

It has to be noted that the boundaries between these zones are not rigidly defined. For example, seasonal rivers may be lotic in the rainy season and turns lentic in dry season.

Rivers can be turned into artificial lakes e.g. through human factor or geographical/geological factors. For example Oxbow lake, volcanoes forming crater lakes, tectonic lakes or Graben lakes formed by movement of the deeper portion of the earth (i.e. upward e.g. Caspian sea; downwarp e.g. L. Tangayika, L. Baikal (deepest). Thus, the classification of the freshwater bodies is not rigid and can be changed by any of these factors.

Importance of FW: FW habitat is very small and confined. Usually surrounded by land and thus the organisms are localized. FW provides the cheapest and most convenient source of water for domestic and industrial uses to man, useful for waste disposal system especially in advanced countries. FW is also important for agriculture e.g. irrigation and raising fish for human consumption.

Important features of comparison between lotic and lentic waters will be fully discussed in class. For instance, in lotic water, the flow is often turbulent but in standing water the flow if any is rather gentle: stratification is rare and unimportant in lotic water in view of the turbulent flow but this is important in lentic water even though convection currents sometimes mix up the layers/strata. In running water, plankton are poorly developed because most of them are eliminated by floods and turbidity e.g. rotifers and diatoms. The benthic flora and fauna are richer in species and adapted to movement of the water. Whereas in standing water, the fauna and flora are well developed. Etc

EUTROPHICATION IN FRESHWATER

Note, the word trophic is a Greek word which means nourishment. The word is often used to refer to the nature of organic nutrients and its concentration thus it is used to qualify the fertility of water body. Eutrophication of lakes may be considered as high or excessive enrichment of water body which may be desirable or not. If it is desirable, the increase is looked upon as a fertilizing enrichment but more frequently the results are undesirable and thus eutrophication receives the connotation of pollution. Types of eutrophication include: natural eutrophication which is a gradual process of enrichment and it is part of ageing process; and artificial/cultural eutrophication which occurs after discharge of industrial and

domestic effluents and the run-offs from agricultural and which has been 'dressed' with nitrate and phosphate artificial fertilizers.

When a lake is young, it typically has a very low concentration of dissolved nutrients, because of this, gross production in the water body is limited and it is a typical oligotrophic lake. As time proceeds, the nutrient materials accumulate in the lake either as substrate dissolved in the river or as solid sediments carried by the river. As nutrient level rises, its role in limiting production declines and thus allowing productivity to increase.

Based on this concept, there are 3 types of trophic lakes, though some degrees of intermediate conditions can exist. The lake with relatively rich plant nutrients and low O₂ tension are termed eutrophic while the lakes with low plant nutrients and are highly oxygenated are termed oligotrophic. Brown water lakes where high concentration of humic acid inhibits bacterial decay and recycling of nutrients occur are termed dystrophic lakes.

Eutrophic and oligotrophic lakes are distinguished by the bathymetric characteristics. Find these out during the lectures.

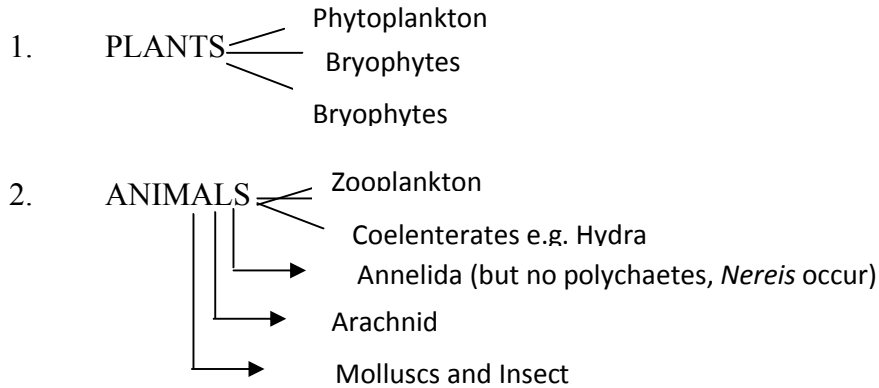
Causes of eutrophication include: (i) urbanization where water bodies are polluted by wastes from industries, referred to as industrial pollution e.g. Ogunpa river in Ibadan (ii) water use-organic wastes accompany water being used either in the homes, schools, hospitals and from other sources (iii) Rainfall-the dusts/floods of debris that settle down inside water bodies after each rainfall act as pollutants in water

(iv) Municipal sewage – In some urban cities, man turned water bodies to refuse deposition centres and these refuses, pollute such water bodies e.g. Ogun River in Abeokuta.

(v) Sewage system – Soak-away faeces are dumped into water bodies which could lead to pollution of such water bodies etc.

LIFE FORMS IN FW ENVIRONMENT

In summary, life forms belong to both plant and Animal kingdoms. Can be schemed as:



Note that protochordates and echinoderms do not occur in FW. Cirripedia in crustacean class does not occur in FW. However, other many vertebrates e.g. fish, amphibians reptiles (snakes) and birds which depend on water and mammals do occur in FW. It has been noted that many fauna and floral varieties occur more in marine than in FW. These aquatic organisms are divided into different groups based on their micro-habitats. These include:

- (a) Neuston – organisms resting on water surfaces e.g. *Gerris*
- (b) Plankton – Live suspended in the water. Sometimes called drifters or floaters because they cannot control their movement but influenced by water current e.g. the phytoplankton (plant-origin) and zooplankton (animal-origin). Each member of plankton is called plankter.
- (c) Nekton – organism which can control their movement and swim in the water. They are macro-organisms e.g.

Crustaceans, molluscs, fishes. Plankton and Nekton are grouped together as pelagic or limnetic organisms because they live within the water column i.e. below the surface of water and above the bottom.

(d) Benthos – organisms which live in or on the bottom of the water.

Apart from all these, some organisms live attached to plants e.g. *Hydra*. This is called periphyton. Some are attached to rocks inside the water called Aufwuch.

Present diagram in class to show this distribution into the micro-habitats.

Discuss the classification of plankton under the two types: Phytoplankton are plant-origin while animal-origin are collectively called Zooplankton.

Phytoplankton are divided into 5 groups as:

- i. Diatomaceae
- ii. Myxophyceae
- iii. Dinophyceae
- iv. Euglenoaceae
- v. Chlorophyceae

Zooplankton are divided into

- i. Rotifera
- ii. Cladocera
- iii. Copepoda
- iv. Coelenterata
- v. Protozoa

Note that some nauplius larvae (crustacean larvae), insect larvae and pupae and fish larvae may be occasional in occurrence and hence referred to as adventitious plankton. Attend class for the discussion on the characteristic features of the organisms.

Features of biological success of planktonic organisms

- i. Members have very high surface area to volume ratio. This leads to an increase in frictional force which decreases the rate of sinking of the organism.
- ii. Cyclomorphosis is a process whereby planktonic organisms exhibit changes in length of their appendages (spines) with the density of water e.g. *Ceratium* shortens its spines during winter when density is high as it needs less energy to keep afloat. During summer when density is low, *Ceratium* elongates its spine to prevent sinking.
- iii. Many of them possess spines which increase the surface area to the small volume e.g. *Keratella*, *Lecane*, *Trichocera*
- iv. Secretion of oil droplets e.g. *Noticula*. Oil droplets decrease gravity of the organisms since it is lighter than water.
- v. Planktonic organisms exhibit patchiness whereby they are not evenly distributed to reduce pressure from predators.
- vi. Plankton shows seasonality in abundance. This depends on change in water current, water level, transparency and amount of nutrients available i.e. conductivity.
- vii. Most of the animal plankton are transparent which provide protection from the predators.

viii. Planktonic organisms show diurnal vertical migration. Explain this with the three theories of limnologists.

Nekton – Are fishes and crustaceans mainly. So also molluscs. This is your core course throughout the programme.

Benthos – Occur at the bottom of water, include bacteria and fungi, protozoan, leeches, oligochaetes, planarians, ostracods, crabs and prawns, coleopterans. They are many snails.

Periphyton include *Hydra* which attach to plants, water mites and rotifers.

Neuston – stay at surface of the water. These are mainly arthropods – *Gyrinus*, *Gerris* (Pond skater), adult mosquito (temporarily).

PLANTS

- a. Floating plants – float freely on water e.g. *Pistia*, *Lemna*, *Salvinia*
- b. Submerged Vegetation – Plants completely under water e.g. *Ceratophyllum*, *Utricularia*
- c. Rooted vegetation – Have roots at the bottom but leaves appear on the surface of water e.g. grasses and sedges

Discuss the relationship among the FW organisms. The relationship is mainly on feeding and hence called trophic relationship. Illustrate this in class.

These organisms also affect physico-chemical parameters of the water. The full discussion of this effect starts with phytoplankton which forms the base of the food. Higher plants tend to cover the water and therefore reduced illumination. Nekton activities in the system affect the gases and stir up the bottom when feeding thus turbidity will increase.

Secondly, we discuss how physico-chemical properties or features of FW can influence biotic aspect (i.e. the life forms). This situation in the water body becomes dynamic until stability may nearly be reached but it is never attained.

CAUTION!!!

References and textbooks would be recommended during introductory lecture. Inter-net lectures are incomplete for your excellent performance in my examination. Therefore, attend my class regularly and punctually for your good.

Dr. I.T. Omoniyi