NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSECODE: BIO 405

COURSE TITLE: HYDROBIOLOGY

COURSE GUIDE

BIO 405
HYDROBIOLOGY

Course Developer/Writer

Programme Leader	Professor A. Adebanjo National Open university of Nigeria
Course Coordinator	Adams Abiodun E. National Open University of Nigeria

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island
Lagos

Abuja Office
No. 5 Dares Salaam Street
Off Aminu Kano Crescent
Wuse II, Abuja
Nigeria

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

Published by
National Open University of Nigeria

Printed 2009

ISBN: 978-058-367-X

CONTENTS **PAGE**

Introduction

BIO 405: Hydrobiology is a one-semester, 2 credit- hour course in Biology. It is a 400 level, second semester undergraduate course offered to students admitted in the school of science and technology, school of education who are offering Biology or related programmes.

The course guide tells you briefly what the course is all about, what course materials you will be using and how you can work your way through these materials. It gives you some guidance on your Tutor- Marked Assignments.

There is/are Self-Assessment Exercise(s) within the body of a unit and/or at the end of each unit. The exercise(s) is/are an overview of the unit to help you assess yourself at the end of every unit.

What You will Learn from this Course

This course contains nineteen (19) units which cover a generalized survey of the plant and animal kingdom based mainly in the study or similarities and differences in the external features, ecological adaptation of plant and animal forms.

Plants and animals consist of different forms: from the simple forms to the complex forms. At the end of this course, you would have acquaint yourself of the different forms of the plant and animal kingdom, especially their external features and ecological adaptation.

Course Aims

The aim of this course is to provide a generalized survey of the freshwater ecosystem with reference to African freshwater ^&&plant and animal kingdom based mainly on the study, or similarities and differences in the external features, ecological adaptations of plants and animals forms.

Course Objectives

In addition to the aim of this course, the course sets an overall objective which must be achieved. In addition to the course objectives, each of the units has its own specific objectives. You are advised to read properly the specific objectives for each unit at the beginning of that unit. This will help you to ensure that you achieve the objectives.

As you go through each unit, you should from time to time go back to these objectives to ascertain the level at which you have progressed.

By the time you have finished going through this course, you should be able to:

Know the similarities and differences in the different forms of freshwater

Understand the different freshwater flora and fauna

Describe the characteristics of African Freshwater

Understand the nature and problems associated with eutrophication and water pollution

Determine water qualities

Working through this Course

In this course, you will be advised to devote your time in reading through the material. You would be required to do all that has been stipulated in the course: study the course units, read the recommended reference textbooks and do all the unit(s) self-assessment exercise(s) and at some points, you are required to submit your assignment (TMAs) for assessment purpose. You should therefore avail yourself of the opportunity of being present during the tutorial sessions so that you would be able to compare knowledge with your colleagues.

Course Materials

You are to be provided with the two major course materials. These are:

Course Guide

Study Units

The course comes with a list of recommended textbooks. These textbooks are supplement to the course materials so that you can avail yourself of reading further. Therefore, it is advisable you acquire some of these textbooks and read them to broaden your scope of understanding.

Study Units

This course is divided into 3 modules with a total of fifteen units which are divided as follows:

MODULE 1:

UNIT 1: PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER

UNIT 2: FRESHWATER ENVIRONMENT

UNIT 3: FRESHWATER FLORA AND FAUNA

UNIT 4: PLANKTONIC BENTHIC INVERTEBRATES

UNIT 5: PRODUCTION AND ENERGY FLOW

MODULE 2: AFRICAN FRESHWATER

UNIT 1: CHARACTERISTICS OF AFRICAN FRESHWATER

UNIT 2: LAKE CHILWA

MODULE 1:

UNIT 1:

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Physical and chemical nature of freshwater

3.2: Water distribution

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0: INTRODUCTION

Life on Earth depends upon water. Water comprises 99% of our own bodies and covers 71% of the earth's surface. It serves different functions ranging from its transport function through serving as solvent for most chemicals to serving habitat to many organisms. Many organisms also depend on water for certain stages of their life. For instance, some insects and amphibians use water as their breeding sites while it serves as an agent of dispersal for many plant seeds and fruits. The biological diversity of aquatic areas is neglected world- wide, even in coral reefs that rival tropical rain forests in their extraordinary diversity of life

Water is a critical issue for the survival of all living organisms. Some can use salt water but many organisms including the great majority of higher plants and most mammals must have access to fresh water to live. Some terrestrial mammals, especially desert rodents appear to survive without drinking but they do generate water through the metabolism of cereal seeds and they also have mechanisms to conserve water to the maximum degree.

Hydrobiology is the science of life and life processes in water. Much of modern hydrobiology can be viewed as a sub-discipline of ecology but the sphere of hydrobiology includes taxonomy, economic biology, industrial biology, morphology, physiology etc. The one distinguishing aspect is that all relate to aquatic organisms. Much work is closely related to limnology and can be divided into lotic system ecology (flowing waters) and lentic system ecology (still waters).

Much of the early work of hydrobiologists concentrated on the biological processes utilised in sewage treatment and water purification especially slow sand filters. Other historically important work sought to provide biotic indices for classifying waters according to the biotic communities that they supported.

2.0: OBJECTIVES

At the end of this unit, you should be able to

Understand the different physical and chemical properties of water

Know the distribution of water

3.0 MAIN CONTENTS

3.1: Physical and Chemical Nature of Freshwater

a) Colour and Turbidity: Often it is the colour of freshwater or how clear or hazy the water is that is the most obvious visual characteristic. Unfortunately neither colour nor turbidity are strong indicators of the overall chemical composition of water. However both colour and turbidity reduce the amount of light penetrating the water and can have significant impact on algae and macrophytes. Some algae in particular are highly dependent on water with low colour and turbidity. Many rivers draining high moor-lands overlain by peat have a very deep yellow brown colour caused by dissolved humic acids**.**

b) Organic constituents: One of the principal sources of elevated concentrations of organic chemical constituents is from treated sewage. Dissolved organic material is most commonly measured using either the Biochemical oxygen demand (BOD) test of the Chemical oxygen demand (COD) test. Organic constituents are significant in river chemistry for the effect that they have on dissolved oxygen concentration and for the impact that individual organic species may have directly on aquatic biota.

Any organic and degradable material consumes oxygen as it decomposes. Where organic concentrations are significantly elevated the effects on oxygen concentrations can be significant and as conditions get extreme the river bed may become anoxic.

Some organic constituents such as synthetic hormones, pesticides, pthalates have direct metabolic effects on aquatic biota and even on humans drinking water taken from the river. Understanding such constituents and how they can be identified and quantified is becoming of increasing importance in the understanding of freshwater chemistry.

c) Metals: A wide range of metals may be found in rivers from natural sources where metal ores are present in the rocks over which the river flows or in the aquifers feeding water into the river. However many rivers have an increased load of metals because of industrial activities which include mining and quarrying and the processing and use of metals.

Iron

Iron, usually as Fe^{+++} is a common constituent of river waters at very low levels. Higher iron concentrations in acidic springs or an anoxic hyporheic zone may cause visible orange/brown staining or semi-gelatinous precipitates of dense orange iron bacterial floc carpeting the river bed. Such conditions are very deleterious to most organisms and can cause serious damage in a river system.

Coal mining is also a very significant source of Iron both in mine-waters and from stocking yards of coal and from coal processing. Long abandoned mines can be a highly intractable source of high concentrations of Iron. Low levels of iron are common in spring waters emanating from deep-seated aquifers and maybe regarding as health giving springs. Such springs are commonly called Chalybeate springs and have given rise to a number of Spa towns in Europe and the United States.

Zinc

Zinc is normally associated with metal mining, especially Lead and Silver mining but is also a component pollutant associated with a variety of other metal mining activities and with Coal mining. Zinc is toxic at relatively low concentrations to many aquatic organisms. *Microregma* starts to show a toxic reaction at concentrations as low as 0.33 mg/l [3]

Heavy metals

Lead and silver in river waters are commonly found together and associated with lead mining. Impacts from very old mines can be very long-lived. In the River Ystwyth in Wales for example, the effects of silver and lead mining in the 17th and 18th centuries in the headwaters still causes unacceptably high levels of Zinc and Lead in the river water right down to its confluence with the sea. Silver is very toxic even at very low concentrations but leaves no visible evidence of its contamination.

Lead is also highly toxic to freshwater organisms and to humans if the water is used as drinking water. As with Silver, Lead pollution is not visible to the naked eye.

Coal mining is also a very significant source of metals , especially Iron, Zinc and Nickel particularly where the coal is rich if pyrites which oxidises on contact with the air producing a very acidic leachate which is able to dissolve metals from the coal.

Significant levels of copper are unusual in rivers and where it does it occur the source is most likely to be mining activities, coal stocking, or pig farming. Rarely elevated levels may be of geological origin. Copper is acutely toxic to many freshwater organisms, especially algae, at very low concentrations and significant concentration in river water may have serious adverse effects on the local ecology.

d) Nitrogen: Nitrogenous compounds have a variety of sources including washout of oxides of nitrogen from the atmosphere, some geological inputs and some from macrophyte and algal nitrogen fixation. However for many rivers in the proximity of humans, the largest input is from sewage whether treated or untreated. The nitrogen derives from breakdown products of proteins found in urine and faeces. These products, being very soluble, often pass through sewage treatment process and are discharged into rivers as a component of sewage treatment effluent. Nitrogen may be in the form of nitrate, nitrite, ammonia or ammonium salts or what is termed albuminoid nitrogen or nitrogen still within an organic proteinoid molecule.

The differing forms of nitrogen are relatively stable in most river systems with nitrite slowly transforming into nitrate in well oxygenated rivers and ammonia transforming into nitrite/ nitrate. However, the process are slow in cool rivers and reduction in concentration may more often be attributed to simple dilution. All forms of nitrogen are taken up by macrophytes and algae and elevated levels of nitrogen are often associated with overgrowths of plants or eutrophication. These can have the effect of blocking channels and inhibiting navigation. However, ecologically, the more significant effect is on dissolved oxygen concentrations which may become super-saturated during daylight due to plant photosynthesis but then drop to very low levels during darkness as plant respiration uses up the dissolved oxygen. Coupled with the release of oxygen in photosynthesis is the creation of bi-carbonate ions which cause a steep rise in pH and this is matched in darkness as carbon dioxide is released through respiration which substantially lowers the pH. Thus high levels of nitrogenous compounds tend to lead to eutrophication with extreme variations in parameters which in turn can substantially degrade the ecological worth of the watercourse.

Ammonium ions also have a toxic effect, especially on fish. The toxicity of ammonia is dependent on both pH and temperature and an added complexity is the buffering effect of the blood/water interface across the gill membrane which masks any additional toxicity over about pH 8.0. The management of river chemistry to avoid ecological damage is particularly difficult in the case of ammonia as a wide range of potential scenarios of concentration, pH and temperature have to be considered and the diurnal pH fluctuation caused by photosynthesis considered. On warm summer days with high-bi-carbonate concentrations unexpectedly toxic conditions can be created.

e) Phosphorus: Phosphorus compounds are usually found as relatively insoluble phosphates in river water and, except in some exceptional circumstances, their origin is agriculture or human sewage. Phosphorus can encourage excessive growths of plants and algae and contribute to eutrophication. If a river discharges into a lake or reservoir phosphate can be mobilised year after year by natural processes. In the summer time, lakes stratify so that warm oxygen rich water floats on top of cold oxygen poor water. In the warm upper layers - the epilimnion- plants consume the available phosphate. As the plants die in the late summer they fall into the cool water layers underneath - the hypolimnion - and decompose. During winter turn-over , when a lake becomes fully mixed through the action of winds on a cooling body of water - the phosphates are spread throughout the lake again to feed a new generation of plants. This process is one of the principal causes of persistent algal blooms at some lakes.

f) Arsenic: Geological deposits of arsenic may be released into rivers where deep ground-waters are exploited as in parts of Pakistan. Many metalloid ores such as lead, gold and copper contain traces of arsenic and poorly stored tailings may result in arsenic entering the hydrological cycle.

g) Solids : Inert solids are produced in all montane rivers as the energy of the water helps grind away rocks into gravel, sand and finer material. Much of this settles very quickly and provides an important substrate for many aquatic organisms. Many salmonid fish require beds of gravel and sand in which to lay their eggs. Many other types of solids from agriculture, mining, quarrying, urban run-off and sewage may block-out sunlight from the river and may block interstices in gravel beds making them useless for spawning and supporting insect life.

pH

pH in rivers is affected by the geology of the water source, atmospheric inputs and a range of other chemical contaminants. pH is only likely to become an issue on very poorly buffered upland rivers where atmospheric sulphur and nitrogen oxides may very significantly depress the pH as low as pH4 or in eutrophic alkaline rivers where photosynthetic bi-carbonate ion production in photosynthesis may drive the pH up above pH10

Pressure, Density and Buoyancy -

- The pressure on a lake dwelling organism is the weight of water column above it and also the weight of atmosphere.
- The absence of animal life from deep water is ordinarily a consequence of low oxygen supply or low temperature rather than pressure.
- Water is most dense at 4 degree centigrade
- dissolved salts increase the water density. Few algae and protozoa are capable of living in salty lakes.
- Buoyancy varies with density of water and is influenced by factors affecting density.

Temperature

- Thermal properties of water are best demonstrated by freshwater environment.
- Seasonal and diurnal temperature variations are evident in these environments than in marine environments.
- Difference in day and night temperatures remain more conspicuous in the shallow waters.
- Thermal stratification is observed more frequently in the lakes of tropical countries. Hence, lakes are classified into 3 types- Tropical lakes, Temperate lakes and Polar lakes

Light

- Light affects freshwater ecosystem greatly.
- Freshwater have a lot of suspended particles which affect the light to reach to the bottom and hence affects productivity.
- Shallow lake receives light greatly to the depth and hence more abundant growth than deep lakes.
- Light also controls the orientation and changes in position of attached species and their nature of growth and it also causes diurnal planktonic species migration.

Oxygen

- Chemically pure water is biologically inhabitable. Hence, oxygen is the essential chemical component that remain dissolved in water.
- The aquatic environment which remain in contact with the atmosphere is abundant in oxygen concentration.
- The atmospheric oxygen reaches to the water either by diffusion or by water movements.
- Aquatic plants supply water with oxygen.
- Oxygen is utilised in respiration by aquatic animals and in dead organisms decomposition.

Carbon dioxide-

- Aquatic vegetation and phytoplankton requires carbon dioxide for photosynthesis.
- It is produced as a result of respiration and decomposition.
- It gets dissolved in water and forms bicarbonic acid that affects water pH.
- Photosynthesis is the major cause for drain of carbon dioxide.

3.2: Water distribution

Out of all the water on Earth, only 2.75 percent is fresh water, including 2.05 percent frozen in glaciers, 0.68 percent as groundwater and 0.011 percent of it as surface water in lakes and rivers. Freshwater lakes, most notably Lake Baikal in Russia and the Great Lakes in North America, contain seven-eighths of this fresh surface water. Swamps have most of the balance with only a small amount in rivers, most notably the Amazon River. The atmosphere contains 0.04% water. In areas with no fresh water on the ground surface, fresh water derived from precipitation may, because of its lower density, overlie saline ground water in lenses or layers. Most of the world's fresh water is frozen in ice sheets.

4.0 CONCLUSION

Water quality is affected by several physical and chemical factors. The suitability of water for different purposes depends on such factors. As a habitat, the well being of aquatic organisms depend on such factors. Such factors have been highlighted in this unit.

5.0 SUMMARY

In this unit, you have learnt;

The physical and chemical nature of water
The distribution of water

6.0 TUTOR-MARKED ASSIGNMENT

Explain how heavy metals, phosphorus, oxygen, and carbon dioxide affect the quality of water

7.0 References/Further Readings

UNIT 2: FRESHWATER ENVIRONMENT

CONTENTS

1.0: INTRODUCTION

Freshwater is generally described as water with low salinity. It is naturally occurring water and covers about 0.8% of the earth. It is divided into lentic and lotic waters and serves as habitat to different organisms. This unit looks at the general nature of fresh water, the types, the habitats and the sources.

2.0 OBJECTIVES:

At the end of this unit you should be able to;

Know what freshwater ecosystem is
Describe the types of freshwater ecosystem
Understand the various freshwater habitats
Describes the sources and distribution of freshwater

3.0 MAIN CONTENT

3.1: FRESH WATER ECOSYSTEM

Fresh water is naturally occurring water on the Earth's surface in ice sheets, ice caps, glaciers, bogs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids. The term specifically excludes seawater and brackish water although it does include mineral rich waters such as chalybeate springs. The term "sweet water" has been used to describe fresh water in contrast to salt water.

Freshwater ecosystems cover 0.80% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems contain 41% of the world's known fish species.

The major zones in river ecosystems are determined by the river bed's gradient or by the velocity of the current. Faster moving turbulent water typically contains greater concentrations of dissolved oxygen, which supports greater biodiversity than the slow moving water of pools. These distinctions forms the basis for the division of rivers into upland and lowland rivers. The food base of streams within riparian forests is mostly derived from the trees, but wider streams and those that lack a canopy derive the majority of their food base from algae. Anadromous fish are also an important source of nutrients. Environmental threats to rivers include loss of water, dams, chemical pollution and introduced species.

3.2: Types of Freshwater

There are three basic types of freshwater ecosystems:

Lentic: slow-moving water, including pools, ponds, and lakes.

Lotic: rapidly-moving water, for example streams and rivers.

Wetlands: areas where the soil is saturated or inundated for at least part of the time

3.3: Freshwater Habitats

Scientifically, freshwater habitats are divided into lentic systems, which are the stillwaters including ponds, lakes, swamps and mires; lotic systems, which are running water; and groundwater which flows in rocks and aquifers. There is, in addition, a zone which bridges between groundwater and lotic systems, which is the hyporheic zone, which underlies many larger rivers and can contain substantially more water than is seen in the open channel. It may also be in direct contact with the underlying underground water.

The freshwater Major Habitat Types (MHTs) reflect groupings of ecoregions with similar biological, chemical, and physical characteristics and are roughly equivalent to biomes for terrestrial systems. The MHTs refer to the dynamics of ecological systems and the broad habitat structures that define them, and these groupings can provide a structured framework for examining and comparing the diversity of life in freshwater systems. Because of the large scale of ecoregions, all contain patches of multiple habitat types. For instance, ecoregions in the large lakes habitat type can contain swamps, floodplains, and grassy savannas in addition to the dominant lake habitat. Smaller habitats cannot be mapped at the scale of the ecoregion map, but such habitat diversity contributes to species and ecosysem process diversity within ecoregions. For instance, globally 99% of lakes and ponds are less than 10 hectares in area.

Large Lakes are freshwater ecoregions that are dominated and defined by large lentic systems. Freshwater ecosystems in these ecoregions may include in-flowing and out-flowing rivers and various peripheral wetlands in addition to the lakes themselves. This MHT includes large tropical, temperate, and polar lakes, as well as Inland Seas included in this analysis (Aral and Caspian). Examples include Lake Baikal in Siberia, Lake Malawi in Africa, or Michigan-Huron in North America.

Large River Deltas are freshwater ecoregions that are dominated and defined by deltaic features (e.g., tidal influences) and their associated fish faunas, which are distinctive from those occurring upstream. Examples include the Niger River Delta ecoregion and the Mekong River Delta ecoregion. Ecoregions containing deltas but not defined by specific deltaic fauna, such as the Lower Mississippi ecoregion, are not considered Large River Delta ecoregions.

Montane Freshwaters are freshwater ecoregions comprised of small streams, rivers, lakes or wetlands at higher elevations, regardless of latitude. These ecoregions include either high gradient, relatively shallow, fast-flowing streams, with rapids or complexes of high-altitude wetlands and lakes, and montane climatic conditions. Examples include Mount Nimba and Western Equatorial Crater Lakes in Africa and Orinoco Piedmont and Andes Mountains in South America.

Xeric Freshwaters and Endorheic (Closed) Basins are freshwater ecoregions dominated by endorheic aquatic systems or freshwaters that are found in arid, semi-arid, or dry sub-humid environments. These ecosystems tend to have specific fauna adapted to ephemeral and intermittent flooding regimes or lower waters levels during certain times of the year. Examples include the lower Nile River, or the Death Valley ecoregion in the US.

Temperate Coastal Rivers are freshwater ecoregions dominated by several small to medium coastal basins in mid-latitudes (temperate). These ecoregions are characterized by riverine ecosystems, but may also contain small lakes, coastal lagoons, and other wetlands. Migratory species that spend part of their life cycles within marine environments may inhabit these ecoregions. Although floodplains may occur along rivers within this MHT, the dominant features are numerous, small to medium-sized basins that drain to the ocean,, instead of one large river predominating with an extensive fringing floodplain.. This MHT also encompasses island ecoregions with these characteristics. Examples include the North Pacific Coastal and South Atlantic ecoregions in North America.

Temperate Upland Rivers are freshwater ecoregions that are dominated and defined by mid-latitude non-floodplain rivers, including headwater drainages and tributaries of large river systems. These rivers are characterized by moderate gradients and the absence of a cyclically flooded, fringing floodplain. Examples include the Ozark Highlands and Ouachita Highlands in North America.

Temperate Floodplain Rivers and Wetland Complexes are freshwater ecoregions that are dominated by a single mid-latitude large river system, including the main stem river drainage and associated sub-basins, which are either currently or were historically characterized by a cyclically flooded, fringing floodplain. These ecoregions may also contain wetland complexes composed of internal deltas, marshes, and/or swamps, associated with the main river system. Examples include the Mississippi and Middle Missouri Rivers.

Tropical and Subtropical Coastal Rivers are freshwater ecoregions dominated by several small to medium coastal basins at low-latitudes (tropics). These ecoregions are characterized by riverine ecosystems but may also contain small lakes, coastal lagoons, and other wetlands. Although floodplains may occur along rivers within this MHT, the dominant features are numerous, small to medium-sized basins that drain to the ocean, instead of one large river predominating with an extensive fringing floodplain. This MHT also encompasses island ecoregions with these characteristics. Examples include Kenyan Coastal Rivers and Mata Atlantica.

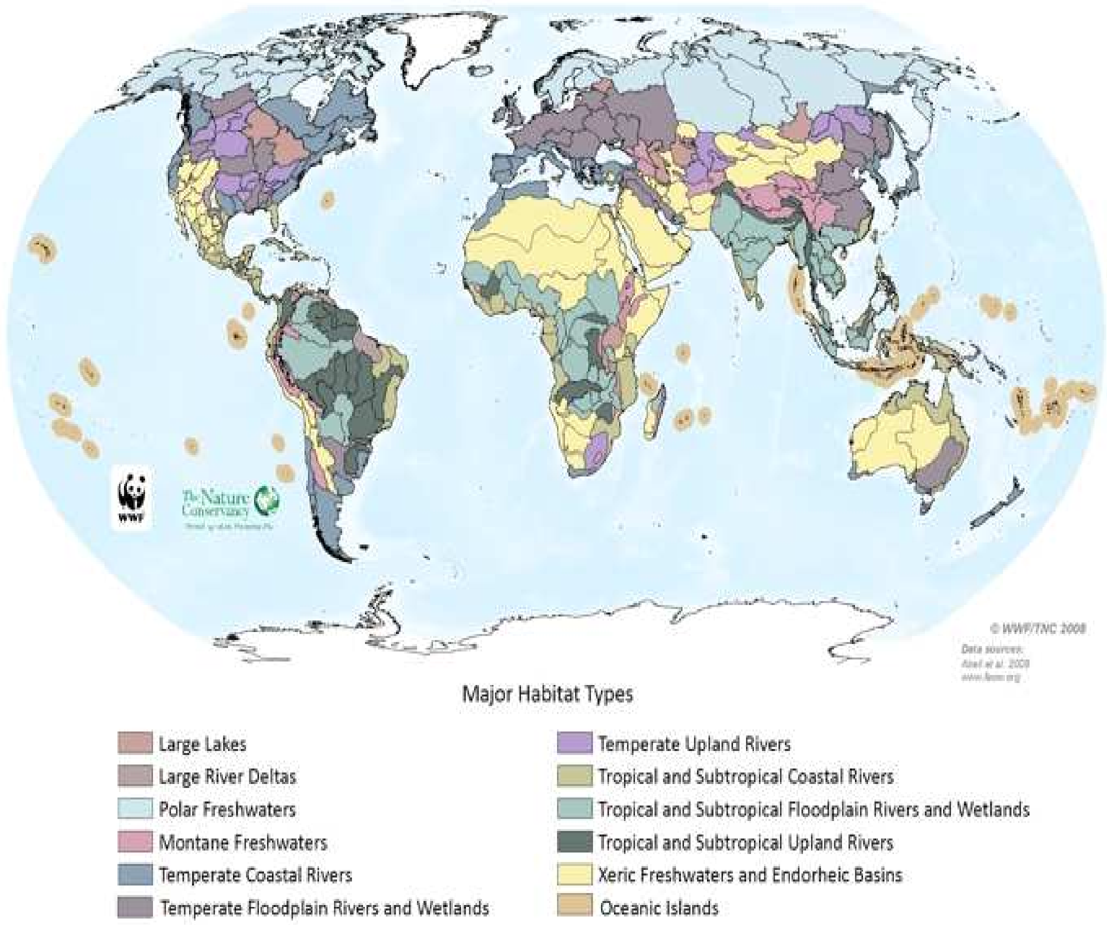
Tropical and Subtropical Upland Rivers are freshwater ecoregions that are dominated and defined by low-latitude non-floodplain rivers, including headwater drainages and tributaries of large river systems. These rivers are characterized by moderate gradients and absence of a cyclically flooded, fringing floodplain. Examples include the Zambezian Headwaters, Upper Niger, and the Brazilian Shield.

Tropical and Subtropical Floodplain Rivers and Wetland Complexes are freshwater ecoregions that are dominated by a single low-latitude large river system, including the main stem river drainage and associated sub-basins, which are either currently or were historically characterized by a cyclically flooded, fringing floodplain. These ecoregions may also contain wetland complexes composed of internal deltas, marshes, and/or swamps, associated with the main river system. Examples include the Lower Congo, Cuvette Central, Lower Niger-Benue, Amazonas Lowland, and Orinoco-Llanos.

Polar Freshwaters are freshwater ecoregions comprising entire drainages; from the headwaters to mouth, and found in high latitudes. Examples include the Lena River in Siberia and the Yukon in Alaska.

Oceanic Islands are freshwater ecoregions comprised of one or more islands completely surrounded by water, above high tide, and isolated from other significant landmasses. These ecoregions are characterized by freshwater biotas derived from marine ancestors. Examples include Fiji and the Hawaiian Islands.

The major freshwater habitats are shown in the figure below.

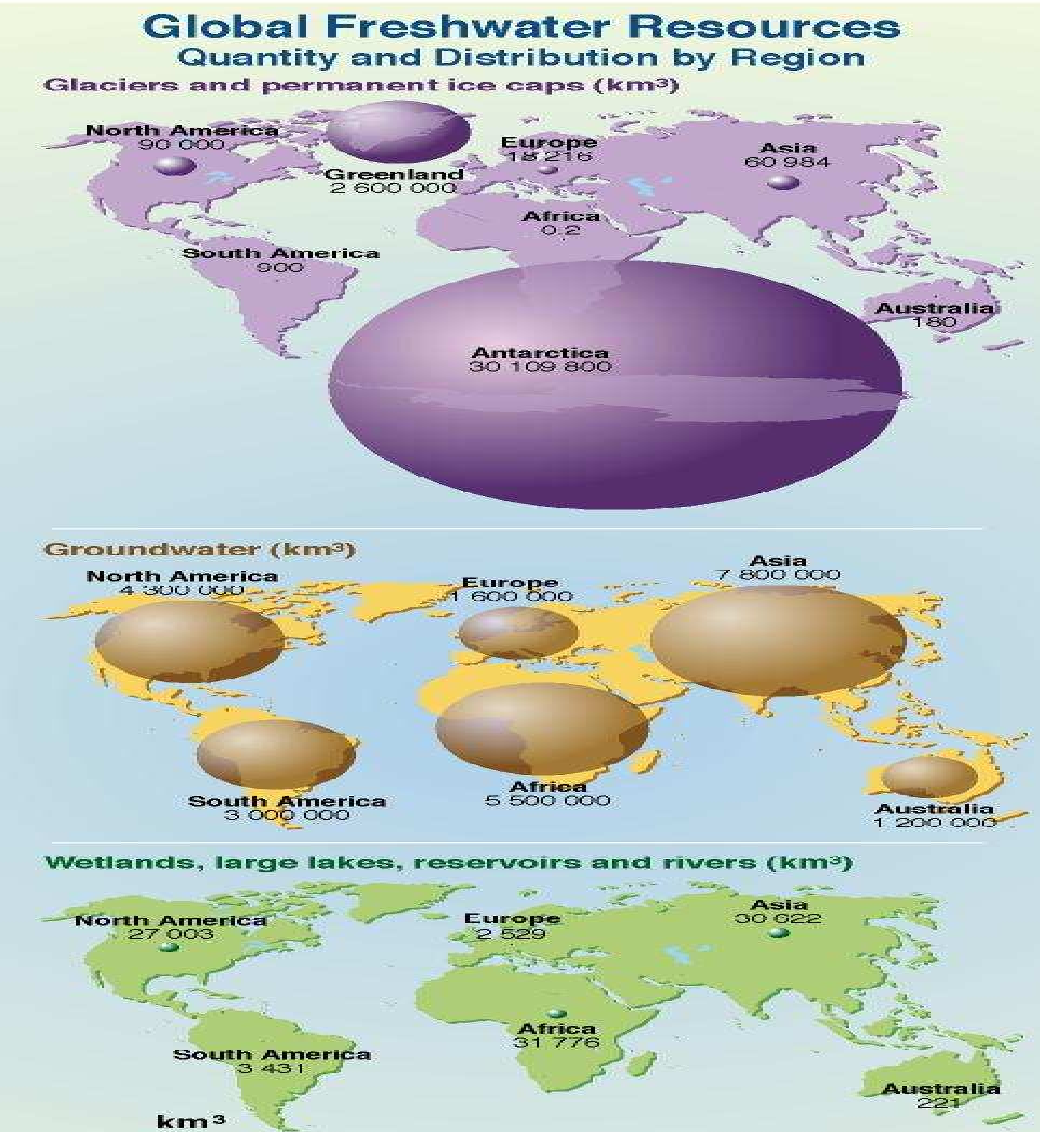


3.4: SOURCES OF FRESH WATER

The source of almost all fresh water is precipitation from the atmosphere, in the form of mist, rain and snow. Fresh water falling as mist, rain or snow contains materials dissolved from the atmosphere and material from the sea and land over which the rain bearing clouds have traveled. In industrialized areas rain is typically acidic because of dissolved oxides of sulfur and nitrogen formed from burning of fossil fuels in cars, factories, trains and aircraft and from the atmospheric emissions of industry. In extreme cases this acid rain results in pollution of lakes and rivers in parts of Scandinavia, Scotland, Wales and the United States.

In coastal areas fresh water may contain significant concentrations of salts derived from the sea if windy conditions have lifted drops of seawater into the rain-bearing clouds. This can give rise to elevated concentrations of sodium, chloride, magnesium and sulfate as well as many other compounds in smaller concentrations.

In desert areas, or areas with impoverished or dusty soils, rain-bearing winds can pick up sand and dust and this can be deposited elsewhere in precipitation and causing the freshwater flow to be measurably contaminated both by insoluble solids but also by the soluble components of those soils. Significant quantities of iron may be transported in this way including the well-documented transfer of iron-rich rainfall falling in Brazil derived from sand-storms in the Sahara in north Africa



4.0 Conclusion

5.0 Summary

In this unit, you have learnt;

The nature of freshwater ecosystem
The types of freshwater ecosystem,
The types of freshwater habitats
The sources of freshwater

6.0 Tutor-Marked Assignment

List and give the features of freshwater habitats
Distinguish between lotic and lentic freshwater ecosytems

7.0 References/Further Readings

UNIT 3: FRESHWATER FLORA AND FAUNA

CONTENTS

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Autotrophic Organisms

3.2: Heterotrophic organisms

3.3 Bacteria

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0: INTRODUCTION

The freshwater habitat is filled with different types of plants and animals that make the flora and fauna of the system. These organisms interact and are found in the different parts of the freshwater ecosystem. The freshwater has been described in unit 1 of this module. Some organisms peculiar to each habitat have also been mentioned in that unit. In this unit the freshwater flora and fauna are considered as autotrophs, heterotrophs and bacteria.

2.0: OBJECTIVES

At the end of this unit, you should be able to know the different types of plants and animals found in freshwater ecosystem

3.0: MAIN CONTENTS

3.1: Autotrophic organisms

Autotrophic organisms are producers that generate organic compounds from inorganic material. Algae use solar energy to generate biomass from carbon dioxide and are the most important autotrophic organisms in aquatic environments [Mann and Lazier 2006]. Chemosynthetic bacteria are found in benthic marine ecosystems. These organisms are able to feed on hydrogen sulfide in water that comes from volcanic vents. Great concentrations of animals that feed on these bacteria are found around volcanic vents. For example, there are giant tube worms (*Riftia pachyptila*) 1.5m in length and clams (Calyptogena magnifica) 30cm long. [Moustakas and Karakassis 2005]

Algae, including both phytoplankton and periphyton are the principle photosynthesizers in ponds and lakes. Phytoplankton are found drifting in the water column of the pelagic zone. Many species have a higher density than water which should making them sink and end up in the benthos. To combat this, phytoplankton have developed density changing mechanisms, by forming vacuoles and gas vesicles or by changing their shapes to induce drag, slowing their descent. A very sophisticated adaptation utilized by a small number of species is a tail-like flagella that can adjust vertical position and allow movement in any direction. Phytoplankton can also maintain their presence in the water column by being circulated in Langmuir rotations. Periphytic algae, on the other hand, are attached to a substrate. In lakes and ponds, they can cover all benthic surfaces. Both types of plankton are important as food sources and as oxygen providers.

Plants, or macrophytes, in freshwater systems live in both the benthic and pelagic zones and can be grouped according to their manner of growth:

1) emergent macrophytes = rooted in the substrate but with leaves and flowers extending into the air,

2) floating-leaved macrophytes = rooted in the substrate but with floating leaves,

3) submerged macrophytes = not rooted in the substrate and floating beneath the surface and

4) free-floating macrophytes = not rooted in the substrate and floating on the surface.

These various forms of macrophytes generally occur in different areas of the benthic zone, with emergent vegetation nearest the shoreline, then floating-leaved macrophytes, followed by submersed vegetation. Free-floating macrophytes can occur anywhere on the system's surface.

Aquatic plants are more buoyant than their terrestrial counterparts because freshwater has a higher density than air. This makes structural rigidity unimportant in lakes and ponds (except in the aerial stems and leaves). Thus, the leaves and stems of most aquatic plants use less energy to construct and maintain woody tissue, investing that energy into fast growth instead. In order to contend with stresses induced by wind and waves, plants must be both flexible and tough. Light is the most important factor controlling the distribution of submerged aquatic plants. Macrophytes are sources of food, oxygen, and habitat structure in the benthic zone, but cannot penetrate the depths of the euphotic zone and hence are not found there.

3.2: Heterotrophic organisms

Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and as raw materials to create their own biomass. Euryhaline organisms are salt tolerant and can survive in marine ecosystems, while stenohaline or salt intolerant species can only live in freshwater environments.

Water striders are predatory insects which rely on surface tension to walk on top of water. They live on the surface of ponds, marshes, and other quiet waters. They can move very quickly, up to 1.5 m/s.

Zooplankton are tiny animals suspended in the water column. Like phytoplankton, these species have developed mechanisms that keep them from sinking to deeper waters, including drag-inducing body forms and the active flicking of appendages such as antennae or spines. Remaining in the water column may have its advantages in terms of feeding, but this zone's lack of refugia leaves zooplankton vulnerable to predation. In response, some species, especially Daphnia sp., make daily vertical migrations in the water column by passively sinking to the darker lower depths during the day and actively moving towards the surface during the night

Very few invertebrates are able to inhabit the cold, dark, and oxygen poor profundal zone. Those that can are often red in color due to the presence of large amounts of hemoglobin, which greatly increases the amount of oxygen carried to cells. Because the concentration of oxygen within this zone is low, most species construct tunnels or borrows in which they can hide and make the minimum movements necessary to circulate water through, drawing oxygen to them without expending much energy.

Vertebrate taxa inhabit freshwater systems as well. These include amphibians (e.g. salamanders and frogs), reptiles (e.g. snakes, turtles, and alligators), and a large number of waterfowl species. Most of these vertebrates spend part of their time in terrestrial habitats and thus are not directly affected by abiotic factors in the lake or pond. Many fish species are important as consumers and as prey species to the larger vertebrates.

Fishes have a range of physiological tolerances that are dependent upon which species they belong to. They have different lethal temperatures, dissolved oxygen requirements, and spawning needs that are based on their activity levels and behaviors. Because fishes are highly mobile, they are able to deal with unsuitable abiotic factors in one zone by simply moving to another. A detrital feeder in the profundal zone, for example, that finds the oxygen concentration has dropped too low may feed closer to the benthic zone. A fish might also alter its residence during different parts of its life history: hatching in a sediment nest, then moving to the weedy benthic zone to develop in a protected environment with food resources, and finally into the pelagic zone as an adult

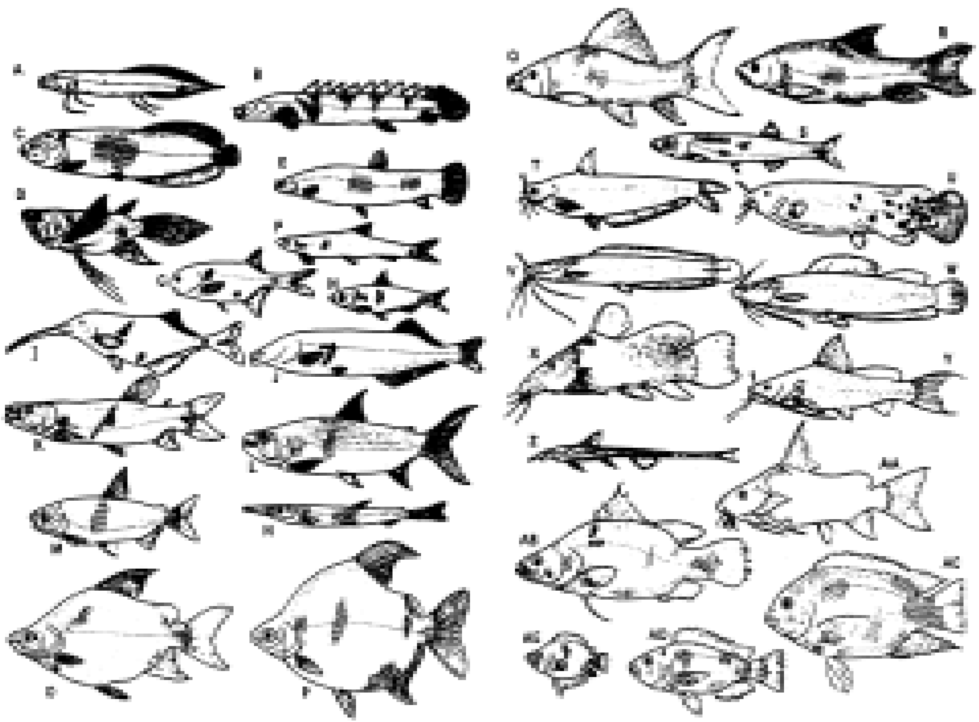


Figure 1. Representative African freshwater fishes. From R. Lowe-McConnell, 1987b. Reprinted with the permission of Cambridge University Press.

3.3: Bacteria

Under certain conditions bacteria can colonise freshwaters occasionally making large rafts of filamentous mats known as *sewage fungus* – usually *Sphaerotilus natans*. The presence of such organisms is almost always an indicator of extreme organic pollution and would be expected to be matched with low dissolved oxygen concentrations and high BOD vales.

E. coli bacteria have been commonly found in recreational waters and their presence is used to indicate the presence of recent fecal contamination, but E. coli presence may not be indicative of human waste. *E. coli* are harbored in all warm-blooded animals: birds and mammals alike. E. coli bacteria have also been found in fish and turtles. Sand also harbors *E. coli* bacteria and some strains of E. coli have become naturalized. Some geographic areas may support unique populations of E. coli and conversely, some E. coli strains are cosmopolitan (Liken et al 1987).

Bacteria are present in all regions of the freshwaters may be free-living or commensals. Free-living forms are associated with decomposing organic material, biofilm on the surfaces of rocks and plants, suspended in the water column, and in the sediments of the benthic and profundal zones. Other forms are also associated with the guts of lentic animals as parasites or in commensal relationships. Bacteria play an important role in system metabolism through nutrient recycling

4.0 Conclusion

The freshwater flora and fauna occur as autotrophs, heterotrophs and decomposers (bacteria). These organisms are found in different regions of freshwater ecosystem and perform different function.

5.0 Summary

In this unit, you have learnt the different types of organisms found in the freshwater ecosystem.

6.0 Tutor-Marked Assignment

Describe the type heterorophs found in the freshwater ecosystem.

7.0 References/Further Readings

UNIT 4: PLANKTONIC BENTHIC INVERTEBRATES

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Benthic Organisms

3.2: General Nature of Benthic Invertebrates

3.3 Importance of Benthic Invertebrates

3.4:

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

3.0: MAIN CONTENT

3.1: **Benthic Organisms**

Benthic organisms can be divided into three distinct communities:

- **Infauna:** Plants, animals and bacteria of any size that live in the sediment.
- **Epifauna:** Plants, animals and bacteria that are attached to the hard bottom or substrate (for example, to rocks or debris); are capable of movement; or that live on the sediment surface.
- **Demersal:** Bottom-feeding or bottom-dwelling fish that feed on the benthic

infauna and epifauna.

Benthic organisms link the primary producers, such as phytoplankton, with the higher trophic levels, such as finfish, by consuming phytoplankton and then being consumed by larger organisms. They also play a major role in breaking down organic material. Benthic algae and submerged aquatic vegetation (SAV) provide ideal habitat for juvenile fish.

Infaunal benthic communities often are considered to be "just worms." In reality, however, these groups that inhabit the sediment include animals from all trophic levels–the primary producers, such as diatoms, and primary consumers, such as mollusks and worms; secondary consumers, such as worms and crustaceans; and "decomposers," such as bacteria and flagellates.

Epifaunal Benthos: Epifauna are the most familiar of all the benthic organisms. They include the plants and animals one sees while wading in tidal pools or among pilings or rocks. These communities include seaweeds, oysters, mussels and barnacles; and snails, starfish and crabs. They also include animals that span a wide evolutionary range, from primitive sponges to early vertebrates (for example, tunicates, such as sea squirts). These varied organisms share an important characteristic: they live either attached to the hard substrate or move on the sediment surface.

The demersal community includes some of the most economically valuable fish. In order to adapt to life on the bottom, benthic fish have developed some of the most diverse physical characteristics found in any fish community. Soft-bottom fish include the flounders, puffers, searobins and cownose rays. Hard-bottom fish include those found near reefs, such as the oyster toadfish and the goby, which, when stationary, resemble rocks.

3.2: General Nature of Benthic Invertebrates

The invertebrates that inhabit the benthic zone are numerically dominated by small species and are species rich compared to the zooplankton of the open water. They include Crustaceans (e.g. crabs, crayfish, and shrimp), molluscs (e.g. clams and snails), and numerous types of insects. These organisms are mostly found in the areas of macrophyte growth, where the richest resources, highly oxygenated water, and warmest portion of the ecosystem are found. The structurally diverse macrophyte beds are important sites for the accumulation of organic matter, and provide an ideal area for colonization. The sediments and plants also offer a great deal of protection from predatory fishes.

Benthic invertebrates, due to their high level of species richness, have many methods of prey capture. Filter feeders create currents via siphons or beating cilia, to pull water and its nutritional contents, towards themselves for straining. Grazers use scraping, rasping, and shredding adaptations to feed on periphytic algae and macrophytes. Members of the collector guild browse the sediments, picking out specific particles with raptorial appendages. Deposit feeding invertebrates indiscriminately consume sediment, digesting any organic material it contains. Finally, some invertebrates belong to the predator guild, capturing and consuming living animals. The profundal zone is home to a unique group of filter feeders that use small body movements to draw a current through burrows that they have created in the sediment. This mode of feeding requires the least amount of motion, allowing these species to conserve energy. A small number of invertebrate taxa are predators in the profundal zone. These species are likely from other regions and only come to these depths to feed. The vast majority of invertebrates in this zone are deposit feeders, getting their energy from the surrounding sediments.

Benthic invertebrates are among the most important components of estuarine ecosystems and may represent the largest standing stock of organic carbon in the sea. Many benthic organisms, such as hard clams, softshell clams and bottom-dwelling fish, are the basis of commercial fisheries. Other bottom-dwelling organisms, such as polychaete worms and crustaceans, contribute significantly to the diets of economically important fish.

3.3: **Importance of Benthic Invertebrates**

Benthic invertebrate communities are used as prime indicators of environmental conditions because:

- they have limited mobility and thus are unable to avoid adverse conditions;
- they live in sediments where they are exposed to environmental stressors, such as chemical contaminants and low dissolved oxygen levels;

- their life spans are long enough to reflect the effects of environmental stressors; and
- their communities are taxonomically diverse enough to respond to multiple types of stress.

4.0 CONCLUSION

Invertebrates that are found in the benthic zone comprise different types of organisms. They also exhibit different types of life forms. Some are grazers, some are filter feeders, while some are predators.

5.0 SUMMARY

In this unit, you have learnt the general nature of the invertebrates found in the benthic zone.

6.0 TUTOR-MARKED ASSIGNMENT

With the knowledge gained in this unit, show the classes of benthic invertebrates and at least two species of organism in each class.

7.0 References/Further Readings

Rumohr, H. (1990) Soft bottom macrofauna: Collection and treatment of samples. International council for the exploration of the sea, Copenhagen

UNIT 5: PRODUCTION AND ENERGY FLOW

CONTENTS

1.0: INTRODUCTION

The energy that is used in every ecosystem ultimately comes from the sun in form solar energy. Such energy is usually trapped and converted to chemical energy through the process of photosynthesis by photoautotrophic organisms. It is such energy that is converted to other forms of energy available in such ecosystems and is transferred from one organism to another through energy flow. The process of converting the solar energy and storing the chemical energy (in form of food) by green plants is called primary production while such process in heterotrophs is called secondary production.

2.0: OBJECTIVES:

In this unit you will learn:

The processes of production in freshwater ecosystem
How energy flows in freshwater ecosystem

3.0 MAIN CONTENT

In ecology, productivity or production refers to the rate of generation of biomass in an ecosystem. It is usually expressed in units of mass per unit surface (or volume) per unit time, for instance grams per square metre per day. The mass unit may relate to dry matter or to the mass of carbon generated. Productivity of autotrophs such as plants is called primary productivity, while that of heterotrophs such as animals is called secondary productivity

Freshwater systems gain most of their energy from photosynthesis performed by aquatic plants and algae. This autochthonous process involves the combination of carbon dioxide, water, and solar energy to produce carbohydrates and dissolved oxygen. Within a lake or pond, the potential rate of photosynthesis generally decreases with depth due to light attenuation. Photosynthesis, however, is often low at the top few millimeters of the surface, likely due to inhibition by ultraviolet light. The exact depth and photosynthetic rate measurements depend upon: 1) the total biomass of photosynthesizing cells, 2) the amount of light attenuating materials and 3) the abundance and frequency range of light absorbing pigments (i.e. chlorophylls) inside of photosynthesizing cells. The energy created by these primary producers is important for the community because it is transferred to higher trophic levels via consumption.

Algae, including both phytoplankton and periphyton are the principle photosynthesizers in ponds and lakes. Phytoplankton are found drifting in the water column of the pelagic zone. Many species have a higher density than water which should making them sink and end up in the benthos. To combat this, phytoplankton have developed density changing mechanisms, by forming vacuoles and gas vesicles or by changing their shapes to induce drag, slowing their descent. A very sophisticated adaptation utilized by a small number of species is a tail-like flagella that can adjust vertical position and allow movement in any direction. Phytoplankton can also maintain their presence in the water column by being circulated in Langmuir rotations. Periphytic algae, on the other hand, are attached to a substrate. In lakes and ponds, they can cover all benthic surfaces. Both types of plankton are important as food sources and as oxygen providers.

The freshwater biota are linked in complex web of trophic relationships. These organisms can be considered to loosely be associated with specific trophic groups (e.g. primary producers, herbivores, primary carnivores, secondary carnivores, etc.). Scientists have developed several theories in order to understand the mechanisms that control the abundance and diversity within these groups. Very generally, top-down processes dictate that the abundance of prey taxa is dependent upon the actions of consumers from higher trophic levels. Typically, these processes operate only between two trophic levels, with no effect on the others. In some cases, however, aquatic systems experience a trophic cascade; for example, this might occur if primary producers experience less grazing by herbivores because these herbivores are suppressed by carnivores. Bottom-up processes are functioning when the abundance or diversity of members of higher trophic levels is dependent upon the availability or quality of resources from lower levels. Finally, a combined regulating theory, bottom-up:top-down, combines the predicted influences of consumers and resource availability. It predicts that trophic levels close to the lowest trophic levels will be most influenced by bottom-up forces, while top-down effects should be strongest at top levels

The vast majority of bacteria in lakes and ponds obtain their energy by decomposing vegetation and animal matter. In the pelagic zone, dead fish and the occasional allochthonous input of litterfall are examples of coarse particulate organic matter (CPOM>1 mm). Bacteria degrade these into fine particulate organic matter (FPOM<1 mm) and then further into usable nutrients. Small organisms such as plankton are also characterized as FPOM. Very low concentrations of nutrients are released during decomposition because the bacteria are utilizing them to build their own biomass. Bacteria, however, are consumed by protozoa, which are in turn consumed by zooplankton, and then further up the trophic levels. Nutrients, including those that contain carbon and phosphorus, are reintroduced into the water column at any number of points along this food chain via excretion or organism death, making them available again for bacteria.

The decomposition of organic materials can continue in the benthic and profundal zones if the matter falls through the water column before being completely digested by the pelagic bacteria. Bacteria are found in the greatest abundance here in sediments, where they are typically 2-1000 times more prevalent than in the water column.

MEASUREMENT OF PRODUCTIVITY

In aquatic systems, primary production is typically measured using one of four main techniques:

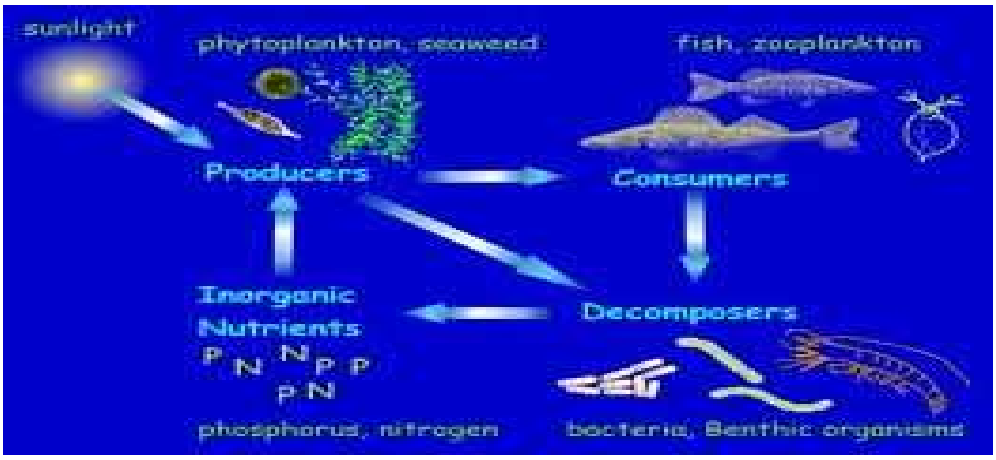
1. variations in oxygen concentration within a sealed bottle (developed by Gaarder and Gran in 1927)
2. incorporation of inorganic carbon^{-14} (^{14}C in the form of sodium bicarbonate) into organic matter.
3. Stable isotopes of Oxygen (^{16}O, ^{18}O and ^{17}O)
4. fluorescence kinetics

The technique developed by Gaarder and Gran uses variations in the concentration of oxygen under different experimental conditions to infer gross primary production. Typically, three identical transparent vessels are filled with sample water and stoppered. The first is analysed immediately and used to determine the initial oxygen concentration; usually this is done by performing a Winkler titration. The other two vessels are incubated, one each in under light and darkened. After a fixed period of time, the experiment ends, and the oxygen concentration in both vessels is measured. As photosynthesis has not taken place in the dark vessel, it provides a measure of ecosystem respiration. The light vessel permits both photosynthesis and respiration, so provides a measure of net photosynthesis (i.e. oxygen production via photosynthesis subtract oxygen consumption by respiration). Gross primary production is then obtained by adding oxygen consumption in the dark vessel to net oxygen production in the light vessel.

The technique of using ^{14}C incorporation (added as labelled Na_2CO_3) to infer primary production is most commonly used today because it is sensitive, and can be used in all ocean environments. As ^{14}C is radioactive (via beta decay), it is relatively straightforward to measure its incorporation in organic material using devices such as scintillation counters.

Depending upon the incubation time chosen, net or gross primary production can be estimated. Gross primary production is best estimated using relatively short incubation times (1 hour or less), since the loss of incorporated ^{14}C (by respiration and organic material excretion / exudation) will be more limited. Net primary production is the fraction of gross production remaining after these loss processes have consumed some of the fixed carbon.

Loss processes can range between 10-60% of incorporated ^{14}C according to the incubation period, ambient environmental conditions (especially temperature) and the experimental species used. Aside from those caused by the physiology of the experimental subject itself, potential losses due to the activity of consumers also need to be considered. This is particularly true in experiments making use of natural assemblages of microscopic autotrophs, where it is not possible to isolate them from their consumers.



Generally, Wetlands are the most productive natural ecosystems because of the proximity of water and soil. Due to their productivity, wetlands are often converted into dry land with dykes and drains and used for agricultural purposes. Their closeness to lakes and rivers means that they are often developed for human settlement

4.0 Conclusion

The continuous sustenance of the freshwater ecosystem depends on the amount of how long the organisms can be sustained. The energy availability and transfer depend on the productivity of the ecosystem. Nutrient availability determines the rate of production (productivity in the freshwater ecosystem)

5.0 SUMMARY

In this unit you have learnt,

The processes of productivity in the freshwater ecosystem
The methods of measuring the rate of production in the freshwater ecosystem
The factors that affect freshwater productivity.

6.0 TUTOR-MARKED ASSIGNMENT

Describe the methods of measuring primary productivity in freshwater ecosystem
What accounts for the difference between primary productivity and secondary productivity

7.0 References/Further Readings

Williams, P. J. leB., Thomas, D. N., Reynolds, C. S. (Eds.), Phytoplankton Productivity: Carbon Assimilation in Marine and Freshwater Ecosystems. Blackwell, Oxford, UK, (2002), pp. 78-108

MODULE 2: AFRICAN FRESHWATER

UNIT 1: CHARACTERISTICS OF AFRICAN FRESHWATER

CONTENTS

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

Characteristics of Freshwater Ecosystem: This can be considered as abiotic characteristics and biotic characteristics

Abiotic characteristics: Abiotic environmental factors of aquatic ecosystems include temperature, salinity, and flow [Levner et al 2005].

The amount of dissolved oxygen in a water body is frequently the key substance in determining the extent and kinds of organic life in the water body. Fish need dissolved oxygen to survive. Conversely, oxygen is fatal to many kinds of anaerobic bacteria [Mann and Lazier 2006].

The salinity of the water body is also a determining factor in the kinds of species found in the water body. Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. Freshwater used for irrigation purposes often absorb levels of salt that are harmful to freshwater organisms [Mann and Lazier 2006]. Though some salt can be good for organisms.

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

UNIT 2: LAKE CHILWA

CONTENTS

1.0 Introduction

3.0: MAIN CONTENTS

3.1: General Description of Lake Chilwa

This is located in the Southern, Malawi; and Niassa, Mozambique. It is on latitude 15:20S, longitude 35:40E; with altitude of 622 m above sea level. It is situated in the southern part of a NE-SW trending tectonic depression east of the main Rift Valley in Southern Malawi. It has an open water area of about 678 km^2, which is surrounded by about 600 km^2 of *Typha* swamps, 390 km2 of marshes and 580 km2 of seasonally inundated grassland floodplain. The area varies with the level of the lake in any year. Lake Chilwa has islands such as Njalo, Nsatu and Chenjerani in the south, Chisi in the Centre and Thongwe in the north. The total area of the Lake Chilwa ecosystem, including islands, is about 2248 km^2

Lake Chilwa (sometimes called Shilwa) is a shallow lake (maximum depth 2.7 m) on the border between Malawi and Mozambique in the southeastern part of the African continent. The water surface measures 1,750 km^2. Being in a tectonic epression south of L. Niassa, at the southern end of the Great Rift Valley, it lacks an outflowing stream; thus the water level fluctuates widely due to the balance between rainfall and evaporation. Four steps of lacustrine terraces encircle the lake and indicate its development history. In the age when the highest terrace, now at an altitude of 650 m, was formed, the lake may have been nearly three times as large its present size, being then connected with the Indian Ocean by an outlet river.

The northern half of the lake is now fringed by a vast area of swampy vegetation dominated by a species of cattail, *Typha domingensis*, while alkaline mud deposits are found along the southernmost part. The drainage basin, with abundant production of rice, tobacco, groundnut and other crops, supports a population of about 400,000 people. Fishery is extensively carried on in the lake with an annual catch of some 20,000 tons.

The lake is greyish and turbid. Its depth is less than 5 meters and seasonally fluctuates by 0.8 – 1 meters. Larger fluctuations of the order of 2 - 3 meters occur in good rainy years. Seven major rivers, namely Domasi, Naisi, Likangala, Thondwe, Namadzi , Phalombe and Sombani drain into Lake Chilwa. Other smaller but equally important inflowing rivers include Sumulu, Lingoni, Mnembo and Nalaua.

VEGETATION

The 5 major natural vegetation types of the Lake Chilwa wetland are: the floodplain grassland, neutral to acid marsh, alkaline marsh, swamp transition and swamp which borders with the open water.

The grassland floodplain located on the periphery of the Chilwa wetland, is a grass dominated habitat. The principal species include: *Hyparrhenia rufa*, *Cynodon dactylon* and *Sporobolus pyrramidalis*. To date, the floodplain is partly under cultivation.

The neutral to acid marshes vegetation occur opposite perennial river mouths where *Cyperus papyrus* (the dominant species) is surrounded by a zone of tall grasses such as *Phragmites maurittianus* and *Vossia cuspidata*.

On the western side of the lake, between the rivers is the marsh habitat dominated by *Cyperus procerus*, which grows together with marsh grass *Leersia hexandra*.

The alkaline marsh occurs widely at the southern end of Lake Chilwa, where *Vossia cuspidata* and *Cyperus longus* are interspaced with large clumps of *Aeshinomene phundii*.

The grasses *Diplachne fusca* and *Panicum repens* form the bulk of plant biomass of the swamp transition vegetation belt, which occurs in the northern half of Lake Chilwa.

Lake Chilwa open waters are surrounded by the swamp which is uniquely dominated by *Typha domingensis* (rather than *Cyperus papyrus* as is the case in similar lakes elsewhere). Free floating species such as *Pistia stratiotes*, *Ceratophyllum demersum* and *Utricularia* spp. are found on the lake edge of the swamp. The large sedge *Scirpus littoralis* and the aquatic grass *Paspalidium germinatum* commonly occur on open water. The vegetation of Lake Chilwa is greatly influenced by the seasonal fluctuations of water levels which in drier years has seen disappearance of some species and also by human activities such as farming.

ORGANISMS IN LAKE CHILWA

The flora of lake Chilwa comprises the following**:**

Emerged macrophytes: *Typha domingensis, Aeschynomene pfundii, Cyperus alopecuroides, Vossia cuspidata*.

Floating macrophytes: *Nymphaea caerulea, Pistia stratiotes*.

Submerged macrophytes: *Ceratophyllum demersum, Utricularia* spp.

Phytoplankton : *Oscillatoria* sp., *Trachelomonas* spp., *Euglena spirogyra, Phacus* sp., *Cyclotella* sp., *Nitzschia* sp., *Anabaena* sp., *Scenedesmus quadricauda, Peridinium* sp.

The animals in lake Chilwa comprise the following**:**

Zooplankton : *Diaphanosoma excisum, Tropodiatomus kraepelini, Daphnia barbata, Moina micrura, Ceriodaphnia cornuta, Mesocyclops leukarti*.

Benthos : *Nilodrum brevibucca, N. brevipalpis, Ecnomus* sp., *Dipseudopsis* sp., *Lanistes ovum, Bulinus globosus, Biomphalaria* sp.

Fish: *Barbus paludinosus, Clarias gariepinus, Sarotherodon shiranus chilwae, Haplochromis callipterus, Hemigrammopetersius barnardi*.

Fish of Lake Chilwa mainly inhabit the open waters of the lake and swamps. The three important fish species are the caprinid *Barbus paludinosus*, the (catfish) clariid *Clarias gariepinus* and the only endemic fish of the lake, a mouth breeding cyclid, *Oreochromis shiranus chilwae*. Every year, an average fishing yield of 160 kg/ha/year is obtained. Lake Chilwa fishery contributes about 20,000 metric tonnes which account for about 25-30% of total annual fish production in Malawi

Birds *:* Lake Chilwa has about 153 species of resident and 30 species of palearctic migrant waterbirds respectively. About 22 species of palearctic birds are regular visitors to Lake Chilwa between September and April every year. The lake supports about 23 species which attain the Ramsar criterion of 1% level of individuals per population. These include the African Spoonbill *Platalea alba*, Fulvous Whistling Duck *Dendrocygna bicolor*, Blackheaded Heron *Ardea melanocephala* and secretive marsh birds like Lesser Moorhen *Gallinula angulata* and Lesser Gallinule *Gallinula alleni*. The total waterfowl population of Lake Chilwa is estimated at a conservative figure of about 354,000. The predators such as the resident Pinkbacked Pelican *Pelecanus rufescens*, the Grey-headed Gull *Larus cirrocephalus* and the migrant White-winged Black Tern *Chlidonias leucoptera* are common in the open water, especially in Kachulu Bay, a major fishing centre. Birds of prey found at the Lake

Chilwa wetland include the African Marsh Harrier *Circus aeruginosa* and the much less common Fish Eagle *Haliaetus ranivorus*. The Yellow-billed Kite *Milvus aegypticus* and the Lesser Kestrel *Falco naumannii* represent the palearctic migrant birds of prey in the Lake Chilwa wetland.

4.0 CONCLUSION

Lake Chilwa is located in the Southern, Malawi; and Niassa, Mozambique. It is a shallow lake that has five types of vegetation in its wetland. It is endowed with wide diversity of animals.

5.0 Summary

In this Unit, you have learnt the

General feature of Lake Chilwa
biological resources in Lake Chilwa

6.0 TUTOR-MARKED ASSIGNMENT

With the information on the organisms in Lake Chilwa, draw a food chain and food in such lake

7.0 References/Further Readings

UNIT 3: WIKKI SPRING

CONTENTS

1.0 Introduction

2.0 Objectives

3.0 Main Content

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0: INTRODUCTION

2.0: OBJECTIVEs

3.0: MAIN CONTENT

WIKKI SPRING

Wikki Warm Springs, in the Yankari Game Reserve in Nigeria, is a veritable *river* flowing out from underneath a sheer rock cliff. The water is so pure that it is bottled and sold, and tens of thousands of gallons flow out every day at a constant 75 degree temperature. It comes from under the cliff into a wide rock basin floored with white sand which varies in depth from one to seven feet. The whole area is shaded from the hot African sun by tall verdant trees. The only thing that kept it from being completely perfect was the baboon threat

There are four different warm water springs in the Yankari National Park that came about due to underground geothermal activity. The area is called Wikki springs because it was named after the largest of the four which is approximately 13 metres wide and 1.9 metres deep. The name Wikki means "where are you?" in the local Duguri language while the other warm water springs are named Dimmil, Nawulgo and Gwan. There is a fifth spring in the park but it only sprouts cool water, named Tungan Naliki.

Wikki spring sprouts out beautiful spa-bath-worthy warm water that has a temperature of 31.1 degrees celsius all year round and amazingly it pushes out 21,000,000 litres of clear spring water out in the Gaji River. Located about 42 kilometres from the main entrance of the park, you can stay in one of the many furnished chalets at the "Wikki Camp" which is the tourist centre of the Park and you can make use of this graceful and elegant natural phenomenon

The Wikki Warm Springs is one of the best features of the game reserves. It is crystal-clear, disease free and naturally warm. For many individuals, the Wikki Springs with white sand resting at the bottom, is the main reason for visiting the Yankari.

4.0 Conclusion

Wikki spring is a warm freshwater which is located in Yankari Game Reserve in

Nigeria. It disease free and naturally warm and attracts visitor to the reserve.

5.0 Summary

In this unit, you have learnt the nature of Wikki Spring and its importance

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

UNIT 4: LAKE TANGAYIKA

CONTENTS

3.1: General features of Lake Tanganyika

Lake Tanganyika is the longest lake in the world, boasting a length of 420 miles, and is the second deepest in the world, reaching a depth of 4,710 feet. It is the second largest lake in Africa, after Lake Victoria, covering about 12,700 square miles. At its widest point it is 45 miles wide. It is bordered on the east by

Tanzania, on the north by Burundi, on the west by the Democratic Republic of the Congo (formerly Zaire), and on the south by Zambia. Lake Tanganyika's only outlet is the Lukuga River, which flows into the Congo River.

As a result of having just one outlet, this rift lake has a particularly high mineral content. This is because most of the salts that flow into it don't leave, but rather get left behind as the water evaporates.

Coordinates	6°30′S 29°30′ECoordinates: 6°30′S 29°30′E
Lake type	Rift Valley Lake
Primary inflows:	Ruzizi River, Malagarasi River, Kalambo River
Primary outflows	Lukuga River
Catchment area	: 231,000 km2 (89,000 sq mi)
Basin countries:	Burundi, DR Congo, Tanzania, Zambia
Max. length	673 km (418 mi)
Max. width	72 km (45 mi)
Surface area	32,900 km2 (12,700 sq mi)
Average depth	570 m (1,870 ft)
Max. depth	1,470 m (4,820 ft)
Water volume	18,900 km3 (4,500 cu mi)
Shore length	11,828 km (1,136 mi)
Surface elevation	773 m (2,536 ft)[1]
Settlements	Kigoma, Tanzania, Kalemie, DRC

Lake Tanganyika is an African Great Lake. It is estimated to be the second largest freshwater lake in the world by volume, and the second deepest, after Lake Baikal in Siberia; it is also the world's longest freshwater lake. The lake is divided among four countries – Burundi, Democratic Republic of the Congo (DRC), Tanzania and Zambia, with the DRC (45%) and Tanzania (41%) possessing the majority of the lake. The water flows into the Congo River system and ultimately into the Atlantic Ocean.

The lake is situated within the Western Rift of the geographic feature known as the Great Rift Valley formed by the tectonic East African Rift, and is confined by the mountainous walls of the valley. It is the largest rift lake in Africa and the second largest lake by volume in the world. It is the deepest lake in Africa and holds the greatest volume of fresh water. It extends for 676 km (420 mi) in a general north-south direction and averages 50 km (31 mi) in width. The lake covers 32,900 km2 (12,700 sq mi), with a shoreline of 1,828 km (1,136 mi) and a mean depth of 570 m (1,870 ft) and a maximum depth of 1,470 m (4,820 ft) (in the northern basin) it holds an estimated 18,900 cubic kilometres (4,500 cu mi. It has an average surface temperature of 25 °C and a pH averaging 8.4.

The enormous depth and tropical location of the lake prevent 'turnover' of water masses, which means that much of the lower depths of the lake is so-called 'fossil water' and is anoxic (lacking oxygen). The catchment area of the lake covers 231,000 km², with two main rivers flowing into the lake, numerous smaller rivers and streams (due to the steep mountains that keep drainage areas small), and one major outflow, the Lukuga River, which empties into the Congo River drainage. The major river that flows into this lake, beginning 10.6 ka, is the Ruzizi River, entering the north of the lake from Lake Kivu. The Malagarasi River, which is Tanzania's second largest river, enters the east side of Lake Tanganyika. The Malagarasi is older than Lake Tanganyika and was formerly continuous with the Congo river. Lake Tanganyika is presently the second largest freshwater lake in the world by volume

3.2: **Chemical Nature of Lake Tanganyika**

The water chemistry of Lake Tanganyika, is much more alkaline and hard than is the water from Lakes Malawi and Victoria. Its pH levels range from 8.6 to 9.5, with a total hardness of 11-17 dH, and carbonate hardness being between 16 and 19 dH. The water in the lake is very clear, with visibility up to 70 feet. In the upper 130 feet, the water is oxygen-rich. This is an important point to consider when caring for Tanganyikans in captivity. Their water should be as close to saturation as possible. Surface temperature ranges from 76 to 82 degrees, while the temperature at lower levels of the lake remain at a constant 70 degrees. It is important to keep the temperature of the water within this range, as water with a temperature higher than 84 degrees can be lethal to Tanganyikans. This is because as the temperature increases, their metabolism speeds up, and their demand for oxygen increases with it. At 85 degrees the oxygen content must be near saturation of they will die of suffocation

3.3: **Biological Resources in Lake Tanganyika**

The lake is known for its many varieties of fish, of which are almost 200 unique Cichlid species. Crocodiles and hippopotamuses are often found on the shores of the lake. The biotope of the lake is sandy, and therefore, these fish are best kept in an aquarium with sand, not gravel. This is especially true of the sand-dwelling species. Many of the Tanganyikan species are small and can be housed in 10 and 20-gallon aquariums, such as the shell-dwelling genera *Neolamprologus* and *Lamprologus*.

The lake holds at least 250 species of cichlid fish and 150 non-cichlid species, most of which live along the shoreline down to a depth of approximately 180 metres (590 ft). Many species of cichlids from Lake Tanganyika are popular fish among aquarium owners due to their bright colors. Recreating a Lake Tanganyika biotope to host those cichlids in an habitat similar to their natural environment is also popular in the aquarium hobby.

Lake Tanganyika is thus an important biological resource for the study of speciation in evolution. The largest biomass of fish, however, is in the pelagic zone (open waters) and is dominated by six species: two species of "Tanganyika sardine" and four species of predatory lates (related to, but not the same as, the Nile perch that has devastated Lake Victoria cichlids). Almost all (98%) of the Tanganyikan cichlid species are endemic to the lake and many, such as fish from the brightly coloured Tropheus genus, are prized within the aquarium trade. This kind of elevated endemism also occurs among the numerous invertebrates in the lake, most especially the molluscs (which possess forms similar to those of many marine molluscs), crabs, shrimps, copepods, jellyfishes, leeches, etc.

4.0 CONCLUSION

Lake Tanganyika is the longest lake in the world and the second largest lake in Africa. It surrounded by Burundi, DR Congo, Zambia and Tanzania. It more or alkaline and has wide biological resources

5.0 SUMMARY

In this unit, you have learnt

The nature of Lake Tanganyika, its location and biological resources

6.0 TUTOR-MARKED ASSIGNMENT

Explain the chemistry of Lake Tanganyika
State the biological resources found lake Tanganyika

7.0 References/Further Readings

UNIT 5: LAKE KAINJI AND LAKE TIGA

CONTENTS

1.0: INTRODUCTION

This unit looks at one of the man-made lakes. It is surrounded by sub-saharan and northern guinea savanna zones of Nigeria. It describes the lakes and states the importance of the lake as a natural park.

2.0: OBJECTIVES

At the end of this unit, you should be able to understand the nature of Lake Kainji, knowing its location and resources it has and problems it is facing.

3.0: MAIN CONTENT

Lake Kainji, is the largest man - made lake in Nigeria. It was created in 1968 after the damming of River Niger for electricity generation by the National Electric Power Authority (NEPA). The Lake lies between Latitudes 90 50'and 100 55'N, and Longitudes 40 25' - 40 45' E and between the borders of Sub - Saharan and Northern Guinea Savanna zones (between Yelwa and Kainji). It has a maximum length of 134km, maximum width of 24.1km, mean and maximum depth of 11mand 60m respectively, surface area of 1270 km^2, a volume of 13 × 109 m^3, and catchment's area of 1.6 x 106 km^2. The maximum length, maximum width, maximum and mean depths are 136.8km, 24.1km, 60m and 11m respectively.

Kainji Lake, is a reservoir on the Niger River, formed by the Kainji Dam. It was formed in 1968 and is a part of Niger State and Kebbi State. Kainji Lake measures about 135 kilometres (84 mi) long and about 30 kilometres (19 mi) at its widest point, and supplies a local fishing industry. In 1999, uncoordinated opening of floodgates led to local flooding of about 60 villages.

Kainji Lake National Park (KNLP), situated around the lake, is Nigeria's oldest National Park, established in 1976. It comprises two sectors (Borgu and Zugurma) which are separated by Kainji Lake. Only the Borgu (western) sector is currently used for tourism; the Zugurma (eastern) sector lacks infrastructure, including access roads. The topography of the park is gently undulating with a general decrease in elevation from west to east. The Borgu sector is drained mainly by the Oli, Timo and Doro rivers and their tributaries, while the Zugurma sector is drained by the Maingyara and Nuwa Tizururu rivers. The vegetation of the park is typical of the Guinean forest-savanna mosaic, although in some areas it appears more Sahelian. Riparian forests occur on the banks of the larger watercourses.

Although the area around the park has a relatively low population density, numerous human activities adversely affect the park. These include deforestation, uncontrolled burning and illegal grazing and are particularly prevalent in the Zugurma sector. Wild mammals occur at relatively low densities due to illegal hunting. Lake Kainji has suffered a dramatic decline as a fishery due to the high numbers of artisanal and subsistence fisherfolk using the lake. It has been suggested that a period of closure, together with controlled fishing rights may help improve fish stocks.

4.0 CONCLUSION

Lake Kainji is man-made lake found in parts of Kebbi and Niger States of Nigeria. It serves as a national park and is faces with certain problems like deforestation, illegal grazing and uncontrolled burning.

5.0 SUMMARY

In this unit you have learnt about lake Kainji, its location and the problems facing it.

6.0 Tutor-Marked Assignment

Describe the feature of Lake Kainji stating its location problems facing it

7.0 References/Further Readings

MODULE 3: PROBLEMS ASSOCIATED WITH TROPICAL FRESHWATER

UNIT 1: EUTROPHICATION

UNIT 1: EUTROPHICATION

CONTENTS

3.0 Main Content

3.1 Eutrophication

3.2: causes of eutrophicaion

3.3 Sources of Eutrophication

3.4: Symptoms/signs of eutrophication

3.5 effects of eutrophication

3.6 ways of measuring eutrophication

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0: INTRODUCTION

In this unit, the problems that water bodies face as a result of excess nutrients will be highlighted. The unit will also highlight the causes of eutrophication and the general features of eutrophic waters, the effects and ways of preventing and/reducing eutrophication

2.0 OBJECTIVES

At the end of this unit, the students should be able to:
Understand what eutrophication means
Explain the causes of eutrophication
Understand the causes of eutrophication

3.0: MAIN CONTENTS

3.1: EUTROPHICATION

Eutrophication" is the enrichment of surface waters with plant nutrients. It is the process of change from one trophic state to a higher trophic state by the addition of nutrient. Eutrophication is the process of nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, amongst which increased production of algae and aquatic macrophytes, deterioration of water quality and other symptomatic changes are found to be undesirable and interfere with water uses. Eutrophication is the process of excessive nutrient enrichment of waters that typically results in problems associated with macrophyte, algal or cyanobacterial growth. It is derived from a Greek word: eutrophia—healthy, adequate nutrition, development; and German word: Eutrophie. is the movement of a water body�s trophic status in the direction of more plant biomass, by the addition of artificial or natural substances, such as nitrates and phosphates, through fertilizers or sewage, to an aquatic system.

While eutrophication occurs naturally, it is normally associated with anthropogenic sources of nutrients. The "trophic status" of lakes is the central concept in lake management. It describes the relationship between nutrient status of a lake and the growth of organic matter in the lake.

Eutrophic systems contain a high concentration of phosphorus (~30+µg/L), nitrogen (~1500+µg/L), or both. Phosphorus enters lentic waters from wastewater treatment effluents, discharge from raw sewage, or from runoff of farmland. Nitrogen mostly comes from agricultural fertilizers from runoff or leaching and subsequent groundwater flow. This increase in nutrients required for primary producers results in a massive increase of phytoplankton growth, termed a plankton bloom. This bloom decreases water transparency, leading to the loss of submerged plants. The resultant reduction in habitat structure has negative impacts on the species' that utilize it for spawning, maturation and general survival. Additionally, the large number of short-lived phytoplankton result in a massive amount of dead biomass settling into the sediment. Bacteria need large amounts of oxygen to decompose this material, reducing the oxygen concentration of the water. This is especially pronounced in stratified lakes when the thermocline prevents oxygen rich water from the surface to mix with lower levels. Low or anoxic conditions preclude the existence of many taxa that are not physiologically tolerant of these conditions.

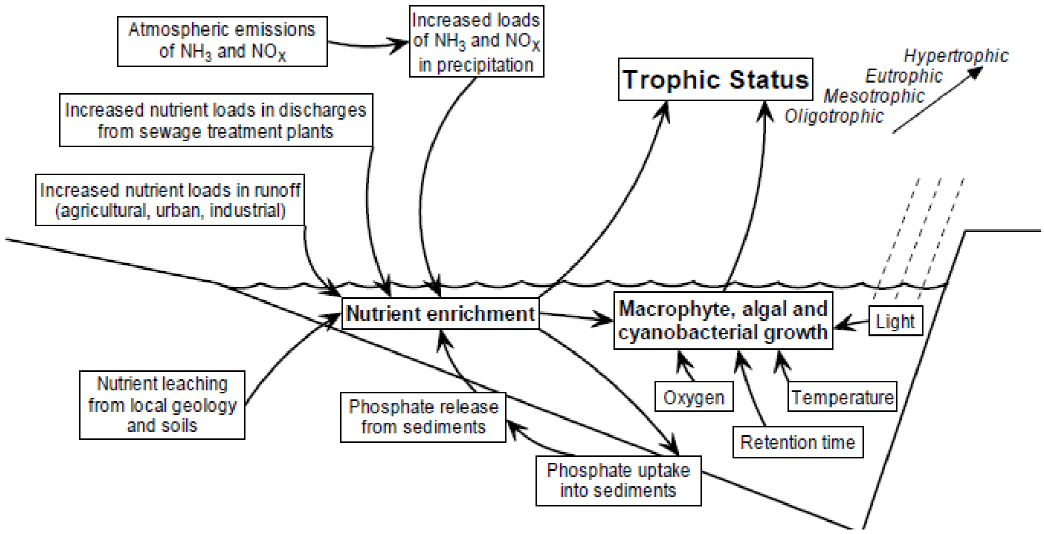
Although both nitrogen and phosphorus contribute to eutrophication, classification of trophic status usually focuses on that nutrient which is limiting. In the majority of cases, phosphorus is the limiting nutrient. While the effects of eutrophication such as algal blooms are readily visible, the process of eutrophication is complex and its measurement difficult.

In natural lakes a distinction is sometimes made between ‘natural’ and ‘cultural’ (anthropogenic) eutrophication processes. Natural eutrophication depends only on the local geology and natural features of the catchment. Cultural eutrophication is ssociated with human activities which accelerate the eutrophication process beyond the rate associated with the natural process (e.g. by increasing nutrient loads into aquatic ecosystems). In South Africa where impoundments are man-made, the conceptual difference between ‘natural’ and ‘cultural’ seems less appropriate.

Cultural eutrophication causes excessive algal bloom in water bodies, with consequent algal overload. Under certain conditions of darkness and warm temperatures these blooms may die, decompose and produce offensive sewage-like odour. If the receiving water is used as a raw water supply for some public or private agency, algae may be difficult to remove and hence add certain objectionable tastes to the delivered water. Algae also have the tendency to absorb and concentrate mineral nutrients in their cells. When they die, at the end of the growing season, they settle to the stream or lake bottom, from which they release these mineral and organic nutrients at the beginning of the next growing season. In this way they serve as a form of secondary pollution.

3.2: CAUSES OF EUTROPHICATION

Increased nutrient enrichment can arise from both point and non-point sources external to the impoundment as well as internal sources like the impoundment’s own sediments (that can release phosphate). Agriculture is a major factor in eutrophication of surface waters. Nutrients usually washed off from farmlands into water cause gradually accumulation of the nutrients in the water bodies. Such accumulation continues until the nutrients reach very high level causing eutrophication. The different causes of eutrophication are shown in the diagram below.



3.3: **SOURCES OF EUTROPHICATION**:

These are point sources and nonpoint sources. The point sources of eutrophication include:

- Wastewater effluent (municipal and industrial)
- Runoff and leachate from waste disposal systems
- Runoff and infiltration from animal feedlots
- Runoff from mines, oil fields, unsewered industrial sites
- Overflows of combined storm and sanitary sewers
- Runoff from construction sites less than 20,000 m^2 (220,000 ft^2)
- Untreated sewage

The Nonpoint sources of eutrophication include:

- Runoff from agriculture/irrigation
- Runoff from pasture and range
- Urban runoff from unsewered areas
- Septic tank leachate

- Runoff from construction sites >20,000 m²
- Runoff from abandoned mines
- Atmospheric deposition over a water surface
- Other land activities generating contaminants

Role of agriculture in eutrophication

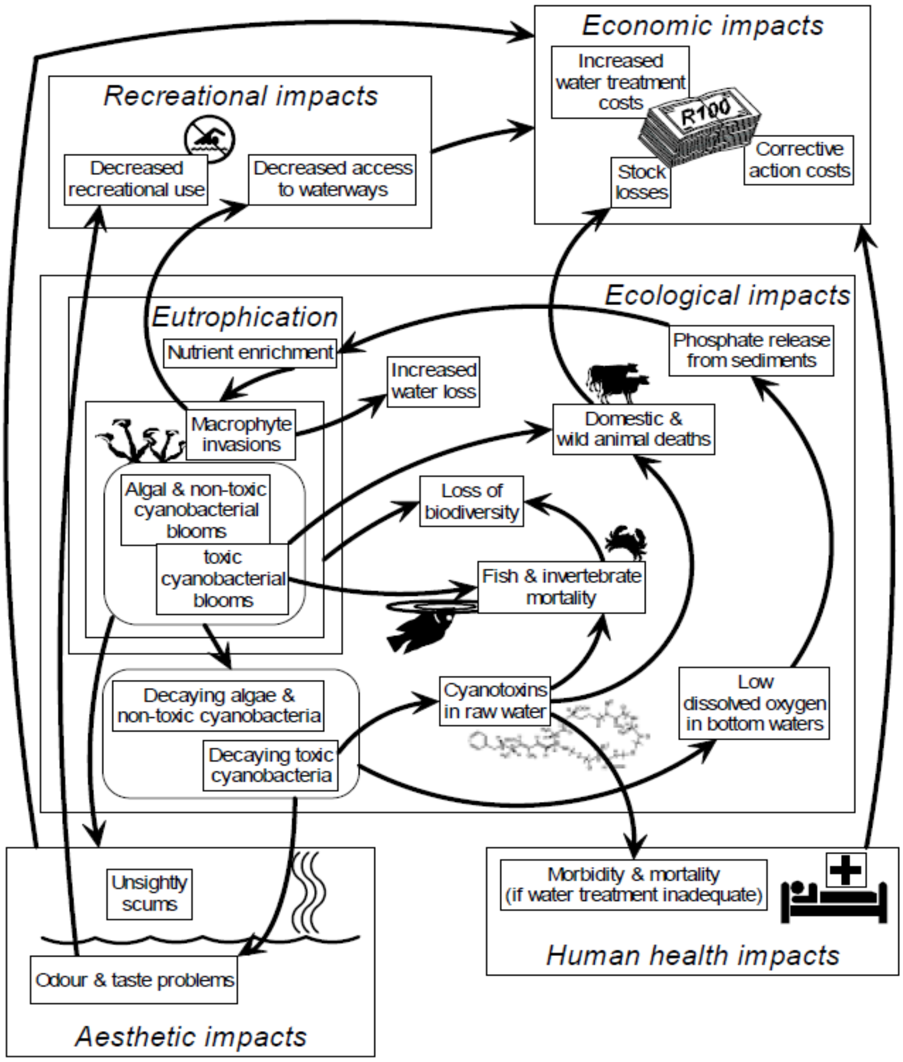
- Fertilization of surface waters (eutrophication) results in, for example, explosive growth of algae which causes disruptive changes to the biological equilibrium [including fish kills]. This is true both for inland waters (ditches, river, lakes) and coastal waters.
- Groundwater is being polluted mainly by nitrates. In all countries groundwater is an important source of drinking water. In several areas the groundwater is polluted to an extent that it is no longer fit to be used as drinking water according to present standards

3.4: **Symptoms of Eutrophication**

The symptoms and impacts of eutrophication are:

- Increase in production and biomass of phytoplankton, attached algae, and macrophytes.
- Shift in habitat characteristics due to change in assemblage of aquatic plants.
- Replacement of desirable fish (e.g. salmonids in western countries) by less desirable species.
- Production of toxins by certain algae.
- Increasing operating expenses of public water supplies, including taste and odour problems, especially during periods of algal blooms.
- Deoxygenation of water, especially after collapse of algal blooms, usually resulting in fish kills.
- Infilling and clogging of irrigation canals with aquatic weeds (water hyacinth is a problem of introduction, not necessarily of eutrophication).
- Loss of recreational use of water due to slime, weed infestation, and noxious odour from decaying algae.
- Impediments to navigation due to dense weed growth.
- Economic loss due to change in fish species, fish kills, etc

The diagram below summarises the symptoms and signs of eutrophication



3.5: Way of Measuring Eutrophication

The different parameters for measuring eutrophication in water are shown in the table below

Parameters for measuring and monitoring eutrophication (Source: Janus and Vollenweider, 1981)

Resultant variables		**Causal variables**
Short-term variability:	**Short-term variability:**	

high	**moderate-low**	
Phytoplankton biomass	Zooplankton standing crop	**Nutrient loadings** Total phosphorus Ortho phosphates Total nitrogen Mineral nitrogen (NO_3+NH_3) Kjeldahl nitrogen **Nutrient concentrations** Same as above Reactive silica Others (e.g. micro-elements)

3.6: Effects of Eutrophication on Receiving Ecosystem

1) Decrease in species diversity and change of dominant biota
2) Increase in plant, algal and animal biomass
3) Increased turbidity; Penetration of light into the water is diminished. This occurs because the algae forms mats as a result of being produced faster than they are consumed. Diminished light penetration decreases the productivity of plants living in the deeper waters (and hence their production of oxygen).
4) Increased sedimentation and shortening of life span of lake
5) Development of anoxic conditions (The water becomes depleted in oxygen). When the abundant algae die and decompose, much oxygen is consumed by those decomposers. Oxygen in the water is also lowered by the lack of primary production in the darkened, deeper waters.
6) Lowered oxygen results in the death of fish that need high levels of dissolved oxygen ("DO"), such as trout, salmon and other desirable sport fish. The community composition of the water body changes, with fish that can tolerate low DO, such as carp predominating. As you can imagine,

changes in fish communities have ramifications for the rest of the aquatic ecosystem as well, acting at least in part through changes in food webs.

7) Further, some of the algal species that "bloom" produce toxins that render the water unpalatable.
8) Eutrophication also decreases the value of rivers, lakes, and estuaries for recreation, fishing, hunting, and aesthetic enjoyment.
9) Changes in macrophyte species composition and biomass, increased incidences of fish kills, loss of desirable fish species and reductions in harvestable fish and shellfish
10) Decreased biomass of benthic and epiphytic algae, decreases in perceived aesthetic value of the water body, Colour, smell, and water treatment problems.
11) Many ecological effects can arise from stimulating primary production, but there are three particularly troubling ecological impacts: decreased biodiversity, changes in species composition and dominance, and toxicity effects.

PROBLEMS OF EUTROPHICATION ON HUMAN SOCIETIES.

1) Water may be injurious to health
2) Impediment of water flow and navigation due increased vegetation in water
3) Disappearance of commercially important species (eg salmonids and coregonids)
4) Reduction in the amenity of water
5) Difficulty in treatment of water
6) Water supply may have unacceptable taste and odour

3.7: Control of Eutrophication: Best Management Practices

Nutrient enrichment poses serious threats to stream ecosystems. Managing nutrient loading into streams will reduce not only the magnitude of maximum algal biomass, but also the frequency and duration of benthic algal problems in streams. To better protect and restore streams, control of both point and nonpoint sources of nutrient loadings into streams is essential. Control of point sources, such as treated wastewater, can be improved with new technology. Still a persistent problem for implementation of criteria will be control of nonpoint sources. It will require innovative technologies and better understanding of stream ecosystems to decrease nutrient loadings from nonpoint sources into streams. Best management practices should be implemented including riparian buffer and wetland protection, and smart use of fertilizers in agricultural and silviculture. New technologies are contributing to some improvement in nutrient pollution from nonpoint sources. More cost-effective practices should be developed to better fulfill this goal

Problems of restoration of eutrophic lakes

Eutrophic and hypertrophic lakes tend to be shallow and suffer from high rates of nutrient loadings from point and non-point sources. In areas of rich soils such as the Canadian prairies, lake bottom sediments are comprised of nutrient-enriched soil particles eroded from surrounding soils. The association of phosphorus with sediment is a serious problem in the restoration of shallow, enriched lakes. P-enriched particles settle to the bottom of the lake and form a large pool of nutrient in the bottom sediments that is readily available to rooted plants and which is released from bottom sediments under conditions of anoxia into the overlying water column and which is quickly utilized by algae. This phosphorus pool, known as the "internal load" of phosphorus, can greatly offset any measures taken by river basin managers to control lake eutrophication by control of external phosphorus sources from agriculture and from point sources. Historically, dredging of bottom sediments was considered the only means of remediating nutrient-rich lake sediments, however, modern technology now provides alternative and more cost-effective methods of controlling internal loads of phosphorus by oxygenation and by chemically treating sediments *in situ* to immobilize the phosphorus. Nevertheless, lake restoration is expensive and must be part of a comprehensive river basin management programme.

4.0 CONCLUSION

Eutrophication occurs as a result of over enrichment of water with nutrients mainly nitrogen and phosphorus. It brings about overproduction of the water bodies and leads to badly consequences like dissolved oxygen, reduced biodiversity and foul odor among others.

5.0 SUMMARY

In this unit, you have learnt:
the concepts of eutrophication
the causes and effects of eutrophication
ways of controlling eutrophication

6.0 TUTOR-MARKED ASSIGNMENT

Explain how agricultural activities lead to eutrophication
State the effects of eutrophication

7.0 References/Further Readings

UNIT 2: POLLUTION

CONTENTS

1.0: INTRODUCTION

There's nothing worse that can happen to our environment than fresh water pollution. Fresh water pollution comes in many forms and can be as simple as polluted rain to a chemical spill, or a manufacture's toxic chemical run off. Oil drilling is also another way to get our ocean waters polluted. The world is 70% water and every living creature needs water to survive. The ocean's water is salt water and it can't be drank unless it is first treated so keeping our water fresh and unpolluted is a priority that the every country needs to do the best it can to deal with. We should work hard to see that all rivers, streams, lakes and oceans never get polluted and clean up the waterways that are already polluted.

Manufacturing facilities and factories cause a lot of pollution as they spew toxic chemicals in the waterways and the atmosphere. Polluted water can also cause and spread disease if not properly treated

2.0: OBJECTIVES:

At the end of this unit you should be able to:

Understand water pollution
Know the different causes and sources of water pollution
Know the effects of water pollution

3.0: MAIN CONTENTS

Water pollution is the introduction of materials or energy to water bodies to a level that the water quality gets depleted. The materials not only negatively affect the quality of the water but also affect the aquatic organisms and water dependent or water related organisms. The process of water pollution may occur as a result of direct discharge of materials into the water bodies or through runoff from nearby contaminated/polluted terrestrial environment. Increased microbial load, and change in physicochemical nature of water result due to water pollution.

3.2: Causes of Water Pollution

Industry, agriculture and domestic activities are major anthropogenic activities responsible for polluting soft water. The pollution can be caused by organic (waste being thrown out without being treated) and microbiological matter. This type of pollution causes aquatic wildlife to asphyxiate.

Organic matter, especially human excrement is the prime cause of river pollution. On the one hand, it saturates the water and stops ecosystems functioning normally and on the other hand, it puts pathogenic microorganisms into the water. These can transmit diseases to Man if the water is not purified before consumption.

There are basically two types of water pollution, in terms of their sources, and each is responsible for approximately half of the water pollution.

Point source pollution, which, as the name implies, is pollution that comes from a discrete source, such as where a pipe carrying factory wastes dumps into a river. Nonpoint source pollution, again as the name implies, is pollution that comes from more diffuse sources, such as runoff from parking lots and roads, or from agricultural fields.

Other types of pollution can degrade soft water: metallic pollution (non-biodegradable), radioactive pollution, thermal pollution (water is used as a cooling liquid) or acid pollution. Watercourses being developed, especially dams being built, can have disastrous consequences on soft water.

S/N	Point Sources	Non-Point Sources
1	Discharges from sewage treatment works to rivers	Run-off and underdrainings from agricultural land to rivers
2	Discharges of industrial wastewaters to rivers	General contamination of recharge rainfall to outcropping
3	Discharges of farm effluents to rivers	Septic tanks soakaways into permissible strata
4	Discharges from small domestic treatment plants to rivers	Wash-off of litter, dust and dry fallout, from urban roads to rivers
5	Discharges by means of well or bore-holes into underground strata	General entry of sporadic and widespread losses of contaminants to rivers
6	Discharges of collected landfill leachates to rivers	Seepage of landfill leachates to underground strata and to

		rivers

Pesticides contaminate watercourses as well as underground water by infiltration: they are scattered in the atmosphere and fall back down as rain. Aquifers are also affected by nitrates in fertilisers. Nitrate pollution, which is mainly caused by agriculture (66%), can have toxic effects on the human body if too many nitrates are ingested. Similarly to phosphates, they change the biological balance of aquatic environments and cause eutrophication problems.

Some water pollutants are shown in the table below

	Water pollutant	**Examples**	**Sources**
	Oxygen demanding waste	Animal manure, Plant residues	food processing plants, paper mills and tanneries, sewage, agricultural runoff
	Plant nutrients	Nitrates, phosphates, ammonium	detergents, fertilizers, and sewage treatment plants, manure
	Sediments	Soil, silt	soil erosion
	Thermal discharges	heat	power plants, industrial cooling plants
	Diseasing-causing agents	Bacteria, viruses, parasite	sewage (eg food poisoning and hepatitis), human and animal excreta
	Synthetic organic compound	Pesticides, industrial chemicals (eg PCBs), plastics, detergents, oil, grease	Industrial, household, farm use
	Inorganic Chemicals and Minerals	Acids, salts, caustics, metals	mines and air pollution; dissolved salts; heavy metals (eg mercury) from

			industry, household cleansers, surface runoff
	Radioactive substances	Uranium, thorium, cesium, iodine, radon production, natural sources	Nuclear power plants, medical and research facilities, and molecular weapon testing, mining and processing of ores, weapons

3.4: Effects of Water Pollution on ecosystems

Several negative effects arise as a result of water pollution. These include

- **a)** Reduced water depth as a result of siltation and sedimentation. This leads to reduced navigation and recreational use of water. This can also occur as a result of deposition of non-degradable metallic carcasses.
- **b)** Reduced light penetration and productivity due to increased turbidity as a result of coloured effluents and suspended dust particles.
- **c)** Inhibition of gaseous exchange between the water system and the atmosphere. This usually occurs due to deposition of hydrophobic materials like oil, grease and petroleum hydrocarbons.
- **d)** Water borne and water related diseases as result of high level of pathogenic microbes in water (eg *Vibrio cholerae* which cause cholera). Some water pollutants are carcinogenic, mutagenic and/or teratogenic leading to birth defects. Eg Minamata disease as a result of mercury poisoning in the Minamata bay in Japan.
- **e)** Depletion of dissolved oxygen content of water bodies and increase in biological oxygen demand due to high level biodegradable materials in water bodies.
- **f)** Death of aquatic organisms and water dependent organisms due to oxygen depletion and presence of harmful materials in water bodies. Increased temperature (thermal pollution) can also lead to death of aquatic organism

g) Change in the abundance and composition of aquatic biotic community. Some species may have increased richness while the abundance gets reduced.

An aquatic ecosystem becomes unsanitary or unhealthy when the balance of its natural state is disturbed. These disturbances can be physical (for example: hot water being poured into a watercourse), chemical (for example: toxic waste being poured out) or biological (for example: the introduction and propagation of non-indigenous animal or vegetable species). Soft water pollution can cause: the death of certain species, eutrophication, tumours and deformations in animals, the development of bacteria.

Many symptoms of an ailing ecosystem occur at the same time. For example, the increased acidity of water in a lake can cause the death of certain species and thus allow the temporary proliferation of species that can withstand acidity better.

4.0 Conclusion

Water pollution arises through natural and man-made activities. Human activities are the major sources of pollution. The effects of water pollution is enormous

5.0 Summary

In this unit, you have learnt:

The nature of water pollution
The causes and sources of water pollution
The effects of water pollution

6.0 Tutor-Marked Assignment

Explain point source and non-point source of pollution
Describe the effects of water pollution

UNIT 3: WATER LINKED DISEASESS

UNIT 3: WATER-RELATED DISEASES

CONTENTS

1.0: **INTRODUCTION**:

Over 2.2 million people, mainly in developing countries, die from illnesses linked to poor water quality and appalling sanitary conditions every year. Every eight seconds, somewhere in the world, a child dies from an illness linked to dirty water. There are many microorganisms in dirty water because of animal and human faeces.

Some of these bacteria cause severe diarrhoea that can lead to the body being severely dehydrated. This results in death. In hot countries which do not have septic tank latrines, sick people's faecal matter rapidly contaminates drinking water. Malaria and dengue fever are other examples of diseases where polluted water infects mosquitoes which then pass on the infection to humans

2.0: OBJECTIVES

At the end of this unit, you should be able to:

Know the water related diseases

Understand in details one example of water related diseases

3.0: MAIN CONTENTS

Water related diseases are diseases which affect man and/ animals as a result of contact with water, drinking of water or by being attacked by aquatic organisms. Such diseases are caused by bacteria, viruses, parasites and protozoa which live entirely in water or spend part of their lives in water. Some of these organisms are either deposited directly into the water bodies or are carried by runoff to the water bodies. Consumption of the untreated or nonproperly treated water can lead to these diseases.

3.2: **Examples of Water Linked Disease**: The table below shows examples of some of the water borne/ water related diseases, their causative organisms, means of transmission and symptom

S/N	Vectors/Organisms	Water Borne Disease	Sources of Agent in Water	General Symptoms
	Bacterial			
	Vibrio cholorae	cholera	Contamination of drinking water with the bacterium	Symptoms include very watery diarrhoea, rapid vomiting, hypovolemic shock which can lead to death within 12-18 hours

	Escherichia coli	Diarrhoea, dysentry	Water contaminated with bacterium	Death in immune compromised individuals, the very young, the elderly due to dehydration
	Salmonella typhi	Typhoid fever	Ingestion of water contaminated with faeces of infected person	Characterised by sustained fever upto 40^{0}C, profuse sweating, diarrhoea, delirium, enlarged spleen and liver, death if untreated for weeks
	Salmonella	Salmonellosis	Drinking of contaminated water	Diarrhoea, fever, vomiting and abdominal cramp
	Shigella	Shigellosis (dysentery)	Water contaminated with the bacterium	Frequent passage of faeces with blood and/or mucus and some cases vomiting of blood
	Clostridium botulium	botulism	Bacteria enter wound from contaminated water, can enter gastrointestinal tract through drinking of contaminated water	Dried mouth, blurred and/or double vision, difficulty swallowing, muscle weakness, difficulty breathing, slurred speech, vomiting, sometimes diarrhoea, death due to respiratory failure.

	Legionella pnuemophila	Legionellosis (Legionnaries disease and Pontiac diseases)	Contaminated water; bacterium thrives in warm aquatic environment	Influenza without pneumonia, fever, chills, pneumonia (with coughs that sometimes produces sputum) ataxia, anorexia, muscle aches, occasional diarrhoea and vomiting
	Camphylbacter jejani	Camphylo-bacteriosis	Drinking water contaminated with faeces	Dysentery symptoms with high fever that lasts for 2-10 days
	Leptospira	leptospirosis	Water Contaminated by animal urine carrying the bacterium	Flu-like, symptoms, meningitis, , liver damage, jaundice, renal failure
	Viral			
	Aedes aegypti	Dengue fever; yellow fever		
	Enterio Virus	Viral gastroenteritis		
	Polio virus	Hepatitis A Poliomyelitis		
	Adenovirus	Adenovirus infection	Improperly treated water	Common cold, pnueomonia, croup and bronchitis
	Coronavirus	SARS (severe acute respiratory symdrome)	Improperly treated water	Fever, myalgia, letharsy, gastrointestinal symptoms, cough,

				sore throath
	Protozoa			
	Entamoeba histolytica	Amaebiasis; dysentery	Sewage, non-treated drinking water, flies in water supply	Abdominal discomfort, fatigue, diarrhoea, bloating fever, light loss
	Giardia lambila	Giardiasis (diarrhea); meningoencephalitis; malaria infection	Untreated water, poor disinfection, pipe breaks, leaks, groundwater contamination	Diarrhoea, abdominal discomfort
	Cyclopora cayentaensis	Cycloporasis	Sewage, non-treated drinking water	Cramps, nausea, vomiting, muscle pain, fever and fatigue
	Cryptospordium parvum	Cryptosporichiosis	Water filters than cannot be disinfected, animal manure, seasonal runoff of water	Flu-like symptoms, watery diarrhoea, loss of appetite, substantial loss of weight, bloating, nausea.
	Parasites			
	Schistosoma	Schistosomiasis	Freshwater contaminated with certain types of snails that carry schistosoma	Rash and itchy skin, fever, chills, coughs and muscle aches
	Dracunculus medinesis	Dracunliasis (Guinea worm	Stagnant water containing	Allergic reactions, urticaria, rash, nausea, vomiting,

		disease)	larvae	diarrhoea, asthmatic attack
	Enterobius vermicularis	Enterobiasis	Drinking water contaminated with egg	Peri-anal itch, nervous irritability, hyperacting and insomnia
	Ascaris lumbricoides	Ascariasis	Drinking water contaminated with faeces containing eggs	Inflammation, fever and diarrhoea; severe cases involve loffer's syndrome in lungs, nausea, vomiting, malnutrition and underdevelopmen t.

3.3: One Example of Water-related diseases: Diarrhoea

Diarrhoea occurs world-wide and causes 4% of all deaths and 5% of health loss to disability. It is most commonly caused by gastrointestinal infections which kill around 2.2 million people globally each year, mostly children in developing countries. The use of water in hygiene is an important preventive measure but contaminated water is also an important cause of diarrhoea. Cholera and dysentery cause severe, sometimes life threatening forms of diarrhoea.

The disease and how it affects people: Diarrhoea is the passage of loose or liquid stools more frequently than is normal for the individual. It is primarily a symptom of gastrointestinal infection. Depending on the type of infection, the diarrhoea may be watery (for example in cholera) or passed with blood (in dysentery for example).

Diarrhoea due to infection may last a few days, or several weeks, as in persistent diarrhoea. Severe diarrhoea may be life threatening due to fluid loss in watery diarrhoea, particularly in infants and young children, the malnourished and people with impaired immunity.

The impact of repeated or persistent diarrhoea on nutrition and the effect of malnutrition on susceptibility to infectious diarrhoea can be linked in a vicious cycle amongst children, especially in developing countries.

Diarrhoea is also associated with other infections such as malaria and measles. Chemical irritation of the gut or non-infectious bowel disease can also result in diarrhoea.

Causes of Diarrhoea : Diarrhoea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water. It is more common when there is a shortage of clean water for drinking, cooking and cleaning and basic hygiene is important in prevention.

Water contaminated with human faeces for example from municipal sewage, septic tanks and latrines is of special concern. Animal faeces also contain microorganisms that can cause diarrhoea. Diarrhoea can also spread from person to person, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation, and fish and seafood from polluted water may also contribute to the disease.

Distribution

The infectious agents that cause diarrhoea are present or are sporadically introduced throughout the world. Diarrhoea is a rare occurrence for most people who live in developed countries where sanitation is widely available, access to safe water is high and personal and domestic hygiene is relatively good. World-wide around 1.1 billion people lack access to improved water sources and 2.4 billion have no basic sanitation. Diarrhoea due to infection is widespread throughout the developing world. In Southeast Asia and Africa, diarrhoea is responsible for as much as 8.5% and 7.7% of all deaths respectively.

Scope of the Problem

Amongst the poor and especially in developing countries, diarrhoea is a major killer. In 1998, diarrhoea was estimated to have killed 2.2 million people, most of whom were under 5 years of age (WHO, 2000). Each year there are approximately 4 billion cases of diarrhoea worldwide.

Interventions

Key measures to reduce the number of cases of diarrhoea include:

- Access to safe drinking water.
- Improved sanitation.
- Good personal and food hygiene.
- Health education about how infections spread.

Key measures to treat diarrhoea include:

- Giving more fluids than usual, including oral rehydration salts solution, to prevent dehydration.
- Continue feeding.
- Consulting a health worker if there are signs of dehydration or other problems.

4.0 CONCLUSION

There are different types of diseases which as a result contact of contaminated water. Some of the diseases arise as result of the consumption of the water. Some of such diseases have been highlighted in this unit with special focus of dairrhoea.

5.0 SUMMARY

In this unit, you have learnt

Different diseases linked to use of water, their causal agents and symptoms
Details on dirrahoea, causes and treatment with efforts towards eradication

6.0 TUTOR-MARKED ASSIGNMENT

Explain the causes and symptoms of seven named water linked diseases

7.0 REFERENCES/FURTHER READINGS

Narayanan, P. (2007) Environmental Pollution Principles, Analysis and Control CBS Publishers and Distributors New Delhi, pp127-187

UNIT 4: MEASURMENT OF WATER QUALITY

CONTENTS

1.0: INTRODUCTION:

This unit highlights how the quality of a freshwater can be monitored. It begins with the techniques of collecting samples from the different types of freshwater, how to analyse the samples for different parameters and the factors that affect the quality of water bodies. It is h s hoped that at the end of his unit you should be able to understand those factors that affect the quality of water samples and to determine them.

2.0: **OBJECTIVES**:

At the of this study, you should be able to

Know how to collect water samples

Determine the quality of water sample

Understand the factors that affect water samples

3.0: MAIN CONTENT

Monitoring of environmental quality parameters is a key activity in managing the environment, restoring polluted environments and anticipating the effects of man-made changes on the environment. It involves collection of water samples and their analyses to determine the quality of water. The qualities usually analysed for in water samples include Chemical constituents: colour and turbidity, organic constituents, metals (iron, zinc, heavy metals), nitrogen, phosphorus, arsenic, solids, microbial load (bacteria, viral and parasite inputs) and physical characteristics like pH, colour, turbidity, dissolved oxygen, etc

3.1: Collection of Water Samples

The first step in understanding the chemistry of freshwaters is to take samples and analyse them for the chemical constituents that are of interest. Freshwaters are surprisingly difficult to sample because they are rarely homogeneous and their quality varies during the day and during the year. In addition the most representative sampling locations are often at a distance from the shore or bank increasing the logistic complexity.

Sampling of Rivers

Filling a clean bottle with river water is a very simple task, but a single sample is only representative of that point along the river the sample was taken from and at that point in time. Understanding the chemistry of a whole river, or even a significant tributary, requires prior investigative work to understand how homogeneous or mixed the flow is and to determine if the quality changes during the course of a day and during the course of a year. Almost all natural rivers will have very significant patterns of change through the day and through the seasons. Many rivers also have a very large flow that is unseen. This flows through underlying gravel and sand layers and is called the hyporheic zone. How much mixing there is between the hyporheic zone and the water in the open channel will depend on a variety of factors, some of which relate to flows leaving aquifers which may have been storing water for many years.

Ground-waters Samples: Ground waters by their very nature are often very difficult to access to take a sample. As a consequence the majority of ground-water data comes from samples taken from springs, wells, water supply bore-holes and in natural caves. In recent decades as the need to understand ground water dynamics has increased, an increasing number or monitoring bore-holes have been drilled into aquifers

Lakes Samples: Lakes and ponds can be very large and support a complex eco-system in which environmental parameters vary widely in all three physical dimensions and with time. Large lakes in the temperate zone often stratify in the warmer months into a warmer upper layers rich in oxygen and a colder lower layer with low oxygen levels. In the autumn, falling temperatures and occasional high winds result in the mixing of the two layers into a more homogeneous whole. When stratification occurs it not only affects oxygen levels but also many related parameters such as iron, phosphate and manganese which are all changed in their chemical form by change in the redox potential of the environment.

Lakes also receive waters, often from many different sources with varying qualities. Solids from stream inputs will typically settle near the mouth of the stream and depending on a variety of factors the incoming water may float over the surface of the lake, sink beneath the surface or rapidly mix with the lake water. All of these phenomena can skew the results of any environmental monitoring unless the processes are well understood.

3.2: Determination of water quality

a) **pH of Water Samples :** This can be determined using the universal indicator or pH probe. Dip the universal indicator test paper into the water sample and compare the colour produced with the colour with the chart of the indicator. In the case of the pH probe, it first rinsed with distilled water and the dipped into the water with the pH read off the pH meter.

b) **Water Current:** This can be measured by noting the time it takes a floating object to cover a known distance.

c) **Total Suspended Solids:** This can be measured by filtering a known amount of water through a pre weighed filter paper, drying the filter paper at 105^0Cand weighing the dried filter paper. The difference between the initial weight of the filter paper and the final weight of the filter paper is the total suspended solid.

d) **Total Dissolved Solid:** This can be determined using a total dissolved solid meter

e) **Dissolved Oxygen:** This is determined using the Winkler method or by using electronic oxygen meter. The Winkler method involves adding 1ml of each of $MnSO_4$ and alkaline iodine azide into 125ml of water sample. This is followed by the addition of 1ml conc H_2SO_4 and tilting of bottle until brown precipitate forms. 50ml of the aliquot is then titrated against 0.025N solution of sodium thiosulphate until the disappearance of blue colour using starch as indicator.

$$DO\ (mg/ml) = \frac{\text{ml of titrant X Normality of titrant X equi wt of } O_2 \text{ X 1000}}{\text{ml of sample}}$$

f) **Nitrite Level:** This can be done based on Diazotisation reaction. It involves mixing 40ml of water with 2ml of sulphanilamide solution. After shaking the mixture and allowing it to settle for 10minutes, 2ml of N-(naphyth) ethylene dimine dihydrochloride is added mixed thoroughly. The resulting purple azo dye is the measured at 543nm

g) **Phosphate level:** This can be determined using the spectrophotometric method. The level of phosphorus [P(mg/l)] is calculated as:

$$P(mg/l) = \frac{\text{mg P in 50ml}}{\text{Volume of sample}} \text{ X 1000}$$

h) **Chemical Oxygen Demand (COD):** This can be measured using potassium dichromate open reflux method. 20ml of water sample is mixed with 10ml of potassium dichromate, 30ml of COD reagent and

0.4gm of mercuric sulphate and refluxed for two hours on a hot plate. After two hours it is cooled and distilled water is added to make the volume upto 140ml. 2 or 3 drops of ferrion indicator are then thoroughly mixed with the mixture and titrated with 0.1N ferrous ammonium sulphate to brick red colour

$$COD\ (mg/l) = \frac{(B-A) \times N \times 1000 \times 8}{ml\ of\ sample}$$

A = ml of titrant used with sample

B = ml of titrant used with blank

N = Normality of titrant

3.3: Factors that Affect Water Quality: Water chemistry between systems varies tremendously. The major sources of variation are atmospheric inputs, anthropogenic inputs and toxicity

Atmospheric inputs: Oxygen is probably the most important chemical constituent of surface water chemistry, as all aerobic organisms require it for survival. It enters the water mostly via diffusion at the water-air interface. Oxygen's solubility in water decreases as water temperature increases. Fast, turbulent streams expose more of the water's surface area to the air and tend to have low temperatures and thus more oxygen than slow, backwaters. Oxygen is a by-product of photosynthesis, so systems with a high abundance of aquatic algae and plants may also have high concentrations of oxygen during the day. These levels can decrease significantly during the night when primary producers switch to respiration. Oxygen can be limiting if circulation between the surface and deeper layers is poor, if the activity of animals is very high, or if there is a large amount of organic decay occurring such as following Autumn leaf-fall.

Most other atmospheric inputs come from man-made or anthropogenic sources the most significant of which are the oxides of sulphur produced by burning sulphur rich fuels such as coal and oil which give rise to acid rain.[Likens et al

1987] The chemistry of sulphur oxides is complex both in the atmosphere and in river systems. However the effect on the overall chemistry is simple in that it reduces the pH of the water making it more acidic. The pH change is most marked in rivers with very low concentrations of dissolved salts as these cannot buffer the effects of the acid input. Rivers downstream of major industrial conurbations are also at greatest risk. In parts of Scandinavia and West Wales and Scotland many rivers became so acidic from oxides of sulphur that most fish life was destroyed and pHs as low as pH4 were recorded during critical weather conditions.

Anthropogenic Inputs: The majority of rivers on the planet and many lakes have received or are receiving inputs from human-kind's activities. In the industrialised world, many rivers have been very seriously polluted, at least during the 19th and the first half of the 20th centuries. Although in general there has been much improvement in the developed world, there is still a great deal of river pollution apparent on the planet.

Toxicity : In most environmental situations the presence or absence of an organism is determined by a complex web of interactions only some of which will be related to measurable chemical or biological parameters. Flow rate, turbulence, inter and intra specific competition, feeding behaviour, disease, parasitism, commensalism and symbiosis are just a few of the pressures and opportunities facing any organism or population. Most chemical constituents favour some organisms and are less favourable to others. However there are some cases where a chemical constituent exerts a toxic effect. i.e. where the concentration can kill or severely inhibit the normal functioning of the organism. Where a toxic effect has been demonstrated this may be noted in the sections below dealing with the individual parameters.

4.0 CONCLUSION

Different factors affect the quality of water bodies. Determination of water begins with collection of water sample and each type of water body has peculiar features that must be considered during sampling

5.0 SUMMARY

In this unit, you have learnt:

How to collect water samples from different types of freshwaters
How the water quality parameters are measured
Factors that affect the quality of water

6.0 Tutor-Marked Assignment

Explain the factors that contribute to freshwater quality
Explain how different water parameters are determined

7.0 References/Further Readings

UNIT 5: CHARACTERIZATION OF SOIL AND WATER MICROFAUNA

CONTENTS

3.0: MAIN CONTENT

3.1: **Water Sample Collection**

The water samples are usually collected as described in unit 4.

3.2: **Micrfauna Enumeration**

The microfauna are enumerated by subsampling with an automatic micropipette. The most convenient size of drop (usually 5 ~1) and number of replicate counts (usually 50 drops) will be selected on each occasion according to the technique described by Finlay et al. (1979).

Ciliates are recorded as belonging to one of three size classes based on cell length: <50,50-l 50, and > 150 pm. Flagellates are recorded as belonging to 1 lo-pm or large flagellates.

Estimates of biomass are obtained by multiplying numbers in each size class by individual cell volume using values approximating the mean for the size class. All cell volumes are converted to dry weight with the value 0.582 pg hm-3 calculated from data given by Gates et al. (1982).

Enumeration of Sediment Microfauna

In the case of sediment microfauna, each sediment sample (total volume of 0.95 cm3) will be immediately extruded into 30 ml centrifuge tubes (or into scintillation vials and transferred later) containing 2 m1 of a Percoll-sorbitol mixture .The samples will then be gently hand-mixed for 1 to 2 min, allowed to stand for 1 h and then centrifuged at 490 X g for 20 min. A 1 m1 aliquot will be placed into a scintilation vial containing 50 111 of a 5% sodium tetraborate buffered formalin solution with either methyl green or nigrosin black for estimation of nanoprotozoan numbers. These stains mix well in silica gel and formalin, unlike Lugol's solution which tends to clump in the gel mixture limiting identification to only the largest cells. The sample will then be gently mixed and kept cool (5°C) in the dark until counted in the laboratory.

The other 1 ml portion was poured into a small (4 cm diameter) Petri dish with the glass bottom lined into 0.5 cm2 grids. The extraction procedure was repeated again and the 2 m1 supernatant was added to the first 1 m1 solution in the dish. A fixed number of grids (n = 10 of 24) will be counted randomly for large (>20 pm) cells. To facilitate counting under a dissecting microscope, a 50 % (w/v) MgC12 solution in seawater was added dropwise into the dish to slow mobility of the organisms.

For enumeration of nanoprotozoans (5 to 20 pm), two 5 to 10 111 aliquots from each 1 ml formalin-preserved aliquot per sample are counted on duplicate 0.1 mm3 blocks on a hemocytometer at 400x (Collins & Lyne 1976). Including dilutions, the minimum number of cells which could be accurately counted is usually 4.2 x 104 cells ml-'

4.0 Conclusion

5.0 Summary

In this unit, you have learnt how to collect water sample and enumerate the microfauna present in such sample.

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

Finlay,B.J., J. Laybourn, and I. Strachan. 1979. A technique for the enumeration of benthic ciliated protozoa. Oecologia 39: 375-377.

Gates, M. A., A. Rogerson, and J. Berger. 1982. Dry to wet weight biomass conversion constant for *Tetrahymena elliotti* (Ciliophora, Protozoa). Oecologia 55: 145-148.

Daniel M. Alongi (1990) Abundances of benthic microfauna in relation to outwelling of mangrove detritus in a tropical coastal region, Marine Ecology Progress Series **63: 53-63,**