Semester -I

19MBP105A **MARINE MICROBIOLOGY** **4H – 4C**

Instruction Hours / week: L: 4 T: 0P: 0 **Marks:** Internal: **40** External: **60** Total:**100**
End Semester Exam: 3 Hours

COURE OBJECTIVES

- This course has been intended to provide knowledge about the origin and maintenance of microbial diversity and its role in the structure and function of marine ecosystems.

COURE OUTCOME

1.Students undertaking this course shall get an idea about isolation, Identification and preservation of the marine microbes and its application in various fields.

UNIT I - Marine microorganisms

Introduction of coastal, shallow and deep sea. Marine microorganisms- important and their significance. Marine micro and macro organisms-Collection, enumeration, identification based on morphological, physiological and biochemical characteristics and preservation. International and national collection centres.

.

UNIT-II- Extremophiles and Marine bio-diversity

Thermopiles, basophiles, halophiles, psychrophiles, alkalinophiles, oligotroph, toxitolerant, xerotolerant, endolith – Extremophiles and their environment. Coral reefs, Sea grass, Mangroves, Hydrothermal vents and water currents.

UNIT III- Marine food pathogens and microbial toxin

Marine food pathogenic microorganisms, distribution, indicator organism's prevention and control. Microbiology of processed -finfish and shellfish products. Microbial diseases- diagnosis and control. Introduction, microbial toxin, algal blooms, types. Harmful effect- Human health, Economic impact and Environmental impact, Potential remedies.

UNIT IV – Xenobiotics and Marine nutrient cycles

Microbiology of degradation of xenobiotic environment: Ecological considerations, decay behavior, degradative plasmids, hydrocarbons, oil pollution, surfactants, pesticides, plastics and heavy metals. Factors affecting bioremediation – role of microbes in the marine nutrient cycles.

UNIT V – Marine Microbes bioproducts

Microalgae and seaweeds – Food products- Human food and animal feed, Biomedical Products-Antimicrobial, antioxidant, antiviral and anticancer activity. Aquaculture products - Edible and ornamental fish live feed and pellet feed. Agriculture products - Biofertilizer, biopesticide and biostimulants Industrial Application- Biodiesel and bioethanol production. Biopigment products - Phytoplanktons, Bioluminescence**.**

SUGGESTED READINGS

1. Colin Munn. (2011). *Marine Microbiology: Ecology & Applications*. (2nd ed.). Black Well Publishers.
2. David Sigee. (2005). *Freshwater Microbiology: Biodiversity and Dynamic Interactions of Microorganisms in the Aquatic Environment*. (1st ed.). Black wellPublishers.
3. Joanne, M.W., Linda, S., and Christopher, J.W., (2008). *Prescott, Harley, and Klein's Microbiology*. (7th Ed). McGraw-Hill Higher Education, UnitedStates.
4. Se-Kwon Kim. (2013). *Bioactive compounds and biotechnological applications*. CLSPublishers

5. Dube, H.C. (1994). *A text book of fungi, bacteria and viruses*. Vikas Publishing House, New Delhi.
6. Dale, J.W. (1994). *Molecular genetics of Bacteria*. John Wiley andStones.
7. Pelczar, M., JR., Chan, E.C.S., and Noel, R. K., (2006). *Microbiology*. Tata McGraw, Hill. Co. (5th ed.). NewDelhi.
8. Presscott, L.N., Harley, J.P. and Klein, D.A., (1999). *Microbiology*. W.C. BrownPublishers.
9. Stanier, R.Y., Ingharam, J.L., Wheelis, M.L., and Painter, P.R., (1986). *General Waste water engineering Treatment, Disposal and Reuse*. Metcaff and Eddy. Inc., Tata Mc Grew Hill, New Delhi.
10. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications
11. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons. Hans G. Truper et. al 1991.

DEPARTMENT OF MICROBIOLOGY
KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act, 1956)
Eachanari Post, COIMBATORE - 641 021, INDIA

I-M.Sc., Microbiology (Batch 2018-2020)

Marine Microbiology (Semester-I) (18MBP105A)
LECTURE PLAN

UNIT1

S. no		Lecture duration(Hr)	**Topics covered**		**Supporting materials**
1		1	Marine microbes – Collection, Preservation		W1
2		1	Enumeration TVC		T1 99-111
3		1	Isolation and identification of marine microbes		T1 110-121
4		1	Morphological identification		T2 39-79
5		1	Physiological identification		T2 39-79
6		1	International and national collection centres		W1
7		1	Unit I test		

Textbooks : T1-Microbiology- pelczar – McGraw Hill publishing
T2-Microbiology- presscott – McGraw hill publishing
T3-Microbial genetics – David friefelder-

Reference books:

Website: W1- www.microbiology.com
W2 – www.marinestudy.com

Journals:

Prepared by: Mrs. KEERTHANA. K Assistant Professor Department of Microbiology

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UNIT II

S. no		Lecture duration(Hr)	**Topics covered**		**Supporting materials**
1		1	Extremophiles- Thermophiles, Basophiles		T2 643-646
2		1	Halophiles, Psychrophiles		T2 647-648
3		1	Acid – alkalinophiles, oligotroph Toxitolerant, Xerotolerant		T2 648 - 649
4		1	Endolith – extremophile		T2 652
5		2	Biodiversity		T1 543
6		1	Genomics and phylogeny of extremophiles		T2 673-675
7		1	16s r RNA classification and phylogenetic tree		W1
8		1	RAPD and RFLP		T3 640-645

Textbooks :
T1-Microbiology- pelczar – McGraw Hill publishing
T2-Microbiology- presscott – McGraw hill publishing
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UNIT III

S. no		Lecture duration(Hr)	Topics covered		Supporting materials
1		1	Biodegradation of Xenobiotics		
2		1	Degradative plasmids, hydrocarbons		T2 647-652
3		1	Oil pollution and surfactants, Pesticides		T2 653-655
4		2	Bioremediation- Factors affecting Bioremediation		T2 656-657
5		1	Role of microbes in marine		T2 667-682
6		1	Marine nutrient cycles		T2 667-682
7		1	Disease of marine microbes		T2 667-682
8		1	Marine biodiversity impacts		T2 667-682
9		1	Revision of Unit III		T2 667-682

Textbooks : T1-Microbiology- pelczar – McGraw Hill publishing
T2-Microbiology- presscott – McGraw hill publishing
T3-Microbial genetics – David friefelder-

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UNIT IV

S. no		Lecture duration(Hr)	**Topics covered**		**Supporting materials**
1		1	Photosynthetic pigments		T2 167-168
2		1	Accessory pigments		T2 168 - 200
3		1	Phytoplanktons and Zooplanktons		T2 200-210
4		1	Redtides and Zones		T2 200-210
5		1	Bioluminescence and Biopigment		T2 210-220
6		1	Marine micro and macro organisms		T2 210-220
7		2	Coral reefs and Mangrooves		T2 220-240
8		1	Hydrothermal vents and water currents		T2 240-260
9		1	Revision		

Textbooks : T1-Microbiology- pelczar – McGraw Hill publishing
T2-Microbiology- presscott – McGraw hill publishing
T3-Microbial genetics – David friefelder-

Reference books:

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UNIT V

S.		Lecture	**Topics covered**		**Supporting**
no		duration(Hr)			**materials**
1		1	Bar coding		W1
2		1	Genome sequencing		W1
3		1	Physical mapping		W1
4		1	Marine exploration		T1 643
5		1	Aquaculture inland and freshwater		T1 646
6		1	Cryopreservation		T1 569
7		1	Bio active compounds		T1 618
8		1	Revision of Unit V		
9		1	Unit V test		

Textbooks : T1-Microbiology- pelczar – McGraw Hill publishing
T2-Microbiology- presscott – McGraw hill publishing
T3-Microbial genetics – David friefelder-

Reference books:

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UNIT-1

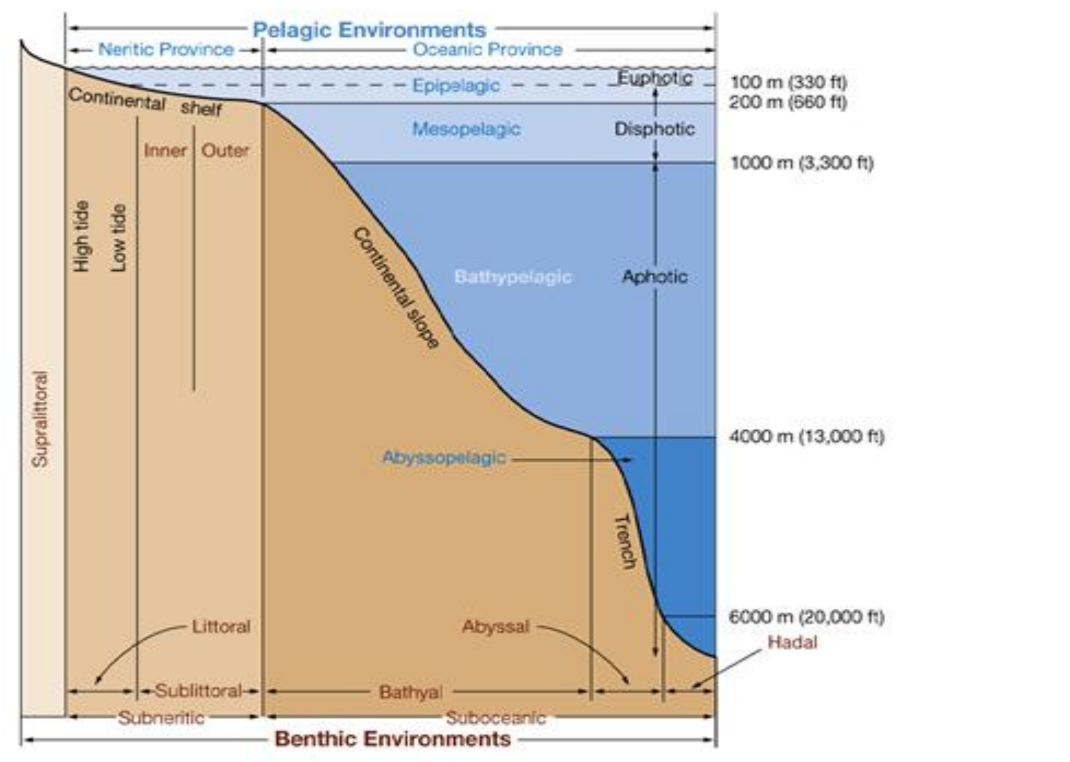
INTRODUCTION

What is marine microbiology?

Ever since a detailed study of the microbial world began at the end of the nineteenth century, microbiologists have asked questions about the diversity of microbial life in the sea, its role in ocean processes, its interactions with other marine life and its importance to humans. However, despite excellent work by pioneering scientists, progress in understanding these issues was often slow and most microbiologists remained unaware of this field of study until recently. Towards the end of the twentieth century, a number of factors conspired to propel marine microbiology to the forefront of 'mainstream' science and it is now one of the most exciting and fast-moving areas of investigation. Powerful new tools (especially in molecular biology, remote sensing and deep-sea exploration) have led to astonishing discoveries of the abundance and diversity of marine microbial life and its role in global ecology. We now realize the vital role that marine microbes play in the maintenance of our planet, a fact that will have great bearing on our ability to respond to problems such as human population increase, overexploitation of fisheries, climate change and pollution. Study of the interactions of marine microbes with other organisms is providing intriguing insights into the phenomena of food webs, symbiosis and pathogenicity. Since some marine microbes produce disease or damage, we need to study these processes and develop ways to overcome them. Finally, marine microbes have beneficial properties such as the manufacture of new products and development of new processes in the growing field of marine biotechnology. Defining the terms microbiology and microorganism is surprisingly difficult! Microbiologists study very small organisms that are too small to be seen clearly with the naked eye (i.e. less than about 1 mm diameter), but many aspects of microbiology are concerned with the activities or molecular properties of microbial communities rather than viewing individual cells with a microscope. As usually defined, microbiology encompasses the study of bacteria, viruses and fungi, although the study of each of these groups is a specialized field. The term microorganism simply refers to forms of life that fall within the microscopic size range, but there is a huge spectrum of diversity concealed by this allencompassing term. Indeed, some 'microorganisms' are large enough to see without using a microscope, so this is not entirely satisfactory either living either. There is a huge diversity of interconnected microbial life forms in the marine environment and problems of definition and artificial divisions are often unhelpful.

The ocean

The ocean currently covers 71% of the earth's surface. Around two thirds of earth's land area is found in the Northern Hemisphere which means the ocean covers 61% of the total area. The rest (39%) is land however the southern Hemisphere the ocean covers of the area as much as 80% of the area and the rest (20%) is land. marine ecosystem is the largest aquatic system of the planet which includes oceans, coral reefs, and estuaries. Since it is a single large and a complex system, it is very difficult to deal with it as a whole. Therefore the oceanographers have divided the ocean into many zones according to physical characteristics, mainly based on depth, light and temperature. The two major zones of the ocean are the entire sea floor, or bottom region of the sea, called the **benthic realm** and the watery region above the sea floor is called the **pelagic realm**. Each of these is further subdivided into many different zones based on environmental conditions.



Pelagic realm

The pelagic realm is further subdivided vertically into five zones viz. epi pelagic, mesopelagic , bathypelagic , abyssopelagic and hadalpelagic zones.

i. **Epipelagic zone** It covers fromthe surface of the ocean and extends upto 200m depth (all light rays are seen here initially) It is also called as the photic zone or euphotic zone.

ii. **Mesopelagic zone** -It extends from 200 to1000 meters depth. It is also called as **disphotic zone as**; only blue light is seen here. It is also referred to as the ***"twilight zone***"; its lower boundary in the tropics is the 10º C isotherm.

iii. **Bathypelagic zone** - This zone extends from 1000 upto 4000 meters deep (**aphotic zone**; no light reaches this depth, there is total darkness); It lies between the boundaries of water with 10 and 4º C isotherm layers.

iv. **Abyssopelagic zone** – It lies below 2000 and extends upto 6000 meters depth (**aphotic zone**).

v. **Hadalpelagic zone** - has a depth of 6000-10000 meters (**aphotic zone**).

The epipelagic photic euphotic zone is the ideal place for about 90% of all ocean life to live because of warm temperature and sunlight .This is the only zone to support plant life because it has the light needed for photosynthesis. As this region supports diverse plant life, variety of animals such as zooplankton, crustaceans, moll usks, sharks, sting rays, mackerels, tuna, seals, sea lions, sea turtles, etc., are abundant here.

Therefore this region has to plant life though some sunlight penetrates through mesopelagic zone, it is not enough for photosynthesis. However this zone has octopus, squid, and hatchet fish. There animals tolerate cold temperatures, increased water pressure and darkness . Some fish have extra big eyes to help them see, while others produce their own light called bioluminescence using special organs in their bodies called photophores. Most fish do not don't chase their food but either wait for it or stalk it. Some have sharp fangs or big mouths to help them catch their food.

The bathypelagic and hadalpelagic zones, do not have as many fish as the earlier zones. The coloration of the fish is black or red, and have bioluminescence (used to lure prey). The shape of the fishes living have is globular (round is shape and no streamlining). Most the weak swimmers live here and the fishes are mostly small but some are large. The eyes of the fishes are almost small or absent.

This zone is also called midnight zone or dark zone. This zone has a very intense water pressure which can be as great as two tons per square inch. Just like the mesopelagic zone, there are no plants and fewer animals which include vampire squid, giant squid, amphipod, slime stars, snake dragon fish, anglerfish, oarfish and gulper eel. The sperm whale dives to these depths search of food. Only about 1 % of all ocean species live in this zone, and some do not have eyes.

The Hadal zone is covers the deepest parts of the ocean. This zone is totally dark and cold, with intense pressure. Creatures found here have adapted themselves to the darkness by reducing the use of eyesight. Fishes occurring heredo have eyes, and they are usually enormous, which indicates enough flashes of bioluminescent light to keep their eyes from totally deteriorating.

The term benthic, a means the bottom ranging from the deepest parts of the ocean to the tide influenced areas. The most productive region of the benthic zone is the area over the continental margin, which is unaffected by the tides. Many groups and varieties of animals live here, a few are worms, sea pens, crustaceans, stars, and protozoa. The life in this zone is mostly made up of bottom dwellers which get most of their food from dead and decaying organisms. Therefore most of the organisms in the benthic zone arescavengers because they depend on dead flesh as their main food source.

The benthic environment is further divided based on depth into five zones as given below.

A cross section of the ocean, from the shore line to the deepsea, showing the location of major habitats.

i. Intertidal zone – the area between the lowest low tide and highest high tide markings, it is sometimes called the littoral zone.

ii. Sublittoral zone – from the lowest low tide mark to the shelf break, about 200 m deep. This area essentially coincides with thecontinental shelf.

iii. Bathyal zone – from the shelf break to 4000 m. This area coincides with the continental slope and rise.

iv. Abyssal zone – from 4000 to 6000 m. This includes the average depth of the deep ocean floor.

v. Hadal zone – sea floor deeper than 6000 m. This includes the trenches, the deepest part of the sea floor.

1.1 What is marine microbiology?

Ever since a detailed study of the microbial world began at the end of the nineteenth century,microbiologists have asked questions about the diversity of microbial life in the sea, its role in ocean processes, its interactions with other marine life and its importance to humans. However, despite excellent work by pioneering scientists, progress in understanding these issues was often slow and most microbiologists remained unaware of this field of study until recently. Towards the end of the twentieth century, a number of factors conspired to propel marine microbiology to the forefront of 'mainstream' science and it is now one of the most exciting and fast-moving areas of investigation. Powerful new tools (especially in molecular biology, remote sensing and deep-sea exploration) have led to astonishing discoveries of the abundance and diversity of marine microbial life and its role in global ecology. We now realize the vital role that marine microbes play in the maintenance of our planet, a fact that will have great bearing on our ability to respond to problems such as human population increase, overexploitation of fisheries, climate change and pollution. Study of the interactions of marine microbes with other organisms is providing intriguing insights into the phenomena of food webs, symbiosis and pathogenicity. Since some marine microbes produce disease or damage, we need to study these processes and develop ways to overcome them. Finally, marine microbes have beneficial properties such as the manufacture of new products and development of new processes in the growing field of marine biotechnology. Defining the terms microbiology and microorganism is surprisingly difficult! Microbiologists study very small organisms that are too small to be seen clearly with the naked eye (i.e. less than about 1 mm diameter), but many aspects of microbiology are concerned with the activities or molecular properties of microbial communities rather than viewing individual cells with a microscope. As usually defined, microbiology encompasses the study of bacteria, viruses and fungi, although the study of each of these groups is a specialized field. The term microorganism simply refers to forms of life that fall within the microscopic size range, but there is a huge spectrum of diversity concealed by this allen compassing term. Indeed, some 'microorganisms' are large enough to see without using a microscope, so this is not entirely satisfactory either. Some scientists would argue that the distinguishing features of microorganisms are small size, cellularity and osmotrophy (feeding by

absorption of nutrients). The osmotrophic characteristic is important, because diffusion processes are a major limitation to cell size, as discussed in the next section. However, this characteristic would exclude many microscopic protists (algae and protozoa), many of which feed by phagotrophy(engulfment of particles). These 'plant-like' or 'animal-like' groups are most commonly studied by specialists who traditionally have a background in botany or zoology. However, many marine protists are mixotrophic and can switch from photosynthesis to phagotrophic feeding, so the plant or animal similarity is meaningless. Additionally, viruses are microscopic and are obviously included in the remit of microbiologists, but they are not cellular organisms and, arguably, they are not living either. There is a huge diversity of interconnected microbial life forms in the marine environment and problems of definition and artificial divisions are often unhelpful.

Importance and significance of marine micro organisms

Bacteria and allied micro-organisms are of direct economic concern to man in many ways besides causing diseases and bringing about the decomposition of marine a,nimals and commercial algae . There are many p roblems in the general economy of the ocean , the solutio n of which requires the a id of the microbiologist. The mic ro-organisms belong to a wide range of groups and include bacteria, blue-green algae (Cyanophyceae), ai atoms (Bacillariaceae) and possibly yeasts (Ascomycetes) and protozoa and early stages of brown seaweeds (Phaeophyta). Whe n micro-organisms from these groups are present, the y ar e often found as discrete colonies of a single species. If we consider the fac t that 720 0 of earth 's surface is covered with mostly salt w ater and that mic r o-organisms populate the surface reg ions as well as the bottom sediments, we can visualise the sea as the largest natura l environmen t inhabited by microbes. The role of micro-organisms in the ·carbon , nitrogen , sulphur and phosphorus cycles in th e sea as well as general circulatio n of organic compounds by processes analogous to those in the soil is usually taken for granted . By virtue of their effects upo n plant nutrients, th e micro-organisms wit hwhich microbiologists are concern edinfluenceth e productivity of the sea . The distribution of oxygen and carbondioxide in water is influenced by microbial ac tivity. Micro-organisms are the principal dynamic agencies which in fluence hydrogen ion concentration and oxydation-reductio n potential of natural bod ie s of water and of the underlying bottom deposits. There are several ways in which microbial activities affect the d iagnosis of sedimentary mate rials including protopetrol e um. Many marine microbes associated with aquatic plan ts and animals are parasitic while others are beneficia l in many ways. Mic robiology thus occupies a logica l and prominent position as an int e gral marine sCIence. Marine mIcrobiologists are confronted by several practical problems which are outlinEd below.

The role of micro-organisms in the spoilage of fish and other marine products

Prot e olytic bacteria are primarily responsIble for the spoilage of fis h, shell fish, crab me at and other marine food products. Marine fish are more susceptible than fres h water fish. Possibly marine bacteria may be more actively proteolytic at low temperatures than corresponding fresh water flora. Fish and other marine food products soon show signs of spoil age if not properly refrigerated. The consistency and colour of the muscle tissue are altered by bacterial activity and an odour of ammonia ,indol, Trimethylamine, or other protein decomposition products are manifested. Quantitative tests, for ammonia, indo!,trimethylamine, histamine, tyrosine and other protein decomposition products have been proposed by various workers as a means of detecting the early stages of fish spoilage. The spoilage of fish may be retarded or prevented by refrigeration. Proteolytic activities of bacteria are minimized by refrigeratio n at subzero temperatures. Some of the bacteria were actively proteolytic at _3°e. Fish having 1.000,000 or more bacteria per gram were not considered to be marketable. Bacteria often affect the marketability of fish by causing discolouration. Diplococcusgadidarum caused reddenning of cod and allied fishes. Micrococcus litoralis caused the reddenning in salted codfish. Micrococcus morrhauae, Sarcinamorrhauae and Bacteriamhalobium rub rum were found associated with dry cod. 30 species of halophilic bacteria including two species of Serratia was found to be associated with the reddening of salted fish.

A Pink yeast, Torulawemeri, along with Micrococcus and Bacteriu.1Y1 zoptii were isolat- ·ed from reddened codfish. The greenish yellow discolouration of halibut was attributed primarily to Pseudomonas fluorescens. It may also be due to the presence of Flavobacteriummarinum, Flavobacteriumfucatum and AchnomobacterpeJlucidam. Bedford (1933a) attributed th e discolouration and subsequent souring of halibut to the activity of various pink .orange and yellow marine bacteria in addition to the fresh water Pseudomonosfluorescens. All of the bacteria were active at O'C and 50me developed at 5°C.

Spoilage of fish and fish eggs by yeasts and molds

The importance of yeasts and molds in modifying the marine environment is strictly secondary to that of ubiquitous and more versatile bacteria. As the causative agents of diseases of marine plants and animals, fungi may be extremely important. Sparrow (1936) described a fungus, Peiersenia sp. which parasitises rotifer eggs. Malformed sardine eggs collected and preserved by the California Fish and Game Commission were found to be filled with fungi. The preliminary observation of those eggs suggest the possibility of fungus infections, accounting for extensive failure of sardine crops. The brown alga, Macrocystispyrifera. which is of considerable economic importance I may be subject to epidemics of fungus infections. 'Similarly other commercially valuable marine algae may be affected by parasitic or saprophytic fungi problem which invites attention.

Spoilage of O~-sters

The spoilage of oysters takes place in 3 stages. According to Eliot (1926) there is a period of rapid increase in acidrty due to the bacterial fermentation of glycogen followed by a period of abundant gas production. Proteolytic bacteria subsequently complete the disintegration of the oyster tissue. Oysters, clams and mussels are often eaten raw or in a partially cooked condition. Numerous cases of typhoid fever and Asiatic cholera have been traced to the ingestion of these contaminated shell fish. Though normally free from dangerous bacteria in clean water, oysters that have grown in polluted water are undesirable as articles of hum 10 food, regardless of whether or not they contain specific organisms of disease because there are recorded evidences of the survival of typhoid bacilli in oysters from 9 to 42 days and of Escherichia coli from 7 to 17 days. Large numbers of saprophytic bacteria are ordinarily associated with oysters. These are considered of little sanitary significance except that they promote the decomposition of shellfish .Decomoosition of oysters at the start is due to the m'!mbers of Serratia, Pseudomonas, Proteus, Clostridium, Bacillus Aerobacter etc. Later in the course of spoilage Sireptrocci, Lactobacilli and yeast find more suitable conditions for growth when oysters become verv sour and putrid. Yeasts are really a problem to the oyster industry. Pink yeast and Torula yeast are primarily responsible for spoilage of oysters

Spoilage of clams

3 d.ys have been accepted as the safe period of s!orage for clams. Clams followed the same pattern of increasing acidification as oysters. Bdcillus and Pseudomonas were the common organisms causing spoilage. Micro-organism's role in decomposition Decomposers are indispensable in a marine environment. Ellenberg (1971) considers the group decomposers which live on dead organic material especially fungi and bacteria as the 3rd group of se condary producers. Without continuous decomposition and mineralization of dead organic material , vast

quantities of undecomposed rema ins would pile up in the sea. This 'natural garbage' would ultimately make it impossible for other phytoplankton to get along with less nutrient materials As a consequence productivity of the seas under natura l conditions. nearly constantly quite high, would fall off considerably. Primary producers and decomposers are therefore essential components of every in dependent ecosystem.

Decomposition of CelIulose by Bacteria

Decomposition of Cellulose, Hemicellulose, Chitins, Pectin and Alginic acid ar e due to the respective bacteria concerned with the decomposition of the above things. The deterioration of fish-nets was found to be due to cellulGlse digesting bacteria. Decomposition of cellulose can proceed under either aerobic or anaerobic conditions. Both linen and cotton lines, seines and nets were attacked. The value of fiber seines, net traps, and lines used by commercial fisherman in Kerala was about Rs. 2000/-. Such equipment lasts an average of less than 2 years and it's durability is being affected by cellulcse-decomposing bacteria. The dluability of the net seines and lines can be extended by applying copper resin ate and other preservatives. The tendency of certa in preservatives, to decrease the flexibility , impart undesirable colours or otherwise, adversely affect the properties of the fiber equipment complicating the prOblem. Manila ropes and cotton nets were found by Atkins and Warren (1941) to be destroyed after 14 months of alternate wetting and drying as in ordinary use. Preliminary treatment of copper napthenate was found to prolong the useful life of th e rope by 400 o' According to several theories of petroleum formation, cellulose may also be converted into higher hydrocarbons like petroleum. Theoreticaily. cellulose could be reduced by either hydrogen or hydrogen sulphide to hydrocarbons. This is to be investiga ted. Lorge quantities of cork are used as floats with fish-nets. fish·lines, life preservers etc. Although relatively resistant to bacterial attack, cork is decomposed by m>rine micro-organisms which slowly destroy its buoyancy by rupturing the cell walls of the cork. Eventually pieces of cork continuously or p eriodically exposed to sea water break into pieces. Cork is lignocellulose suberin complex filled with air-spaces which are responsible for its buoyancy. Hemicellulose also forms a part of cork tissue.

Decomposition of cellulose by fungi

Marine fungi are mostly isolated from wood or rope which had been submerged in the sea. The fungi penetrate and ramify the cell walls of wood and cordoge fibers inducing decay by enzymatic hydrolysis of the cellulose and other c ell wall constituents. The fungi readily utilis e cellulose pectin and starch under experimental conditions. Barghoorn (1942) reports that the fungi c ause deterioration of both hard and soft woods as well as cordage fibers under marine conditions.

Decomposition of Hemi celIulose

Hemicellulose (Pentosans-arabansxylans, araboxylans, methyl pentosans and Hexosans) form a pan of the plant tissue. Decomposition of Hemicellulose proceeds most intensively under aerobic conditions. Different groups of micro-organisms like fungi ,actinomycetes and bacteria induce decomposition.

Lignin decomposition

Lignin is a complex carbohydrate like substance which constitute part of woody structure of plants. Lignin is slowly oxidized by certain bacteria like Micromonospra in muds. Lignin decomposing micro-organisms as well as those which attack cellulose are instrumental in the destruction of timbers. wooden pilings, ropes, fish nets or othe r cellulose or lignin containing structures.

Decomposition of Lignin by fungi

Marine fungi attack lignin and are dominantly responsible for the deterio ration of hemp , jute and sisal cordage as well as pilings and other wooden structures in the sea. According to Imshenetsky and Kokurina (1 941) microorganisms cause the destruction o f jute covering on ships.

Chitin decomposition

Exoskeletons of invertebrate animals such as crustacea, certain mollusca, coelenterata and protozoa have chitin as their chief component. If chitins were not decomposed .it would become a serious drain upon carbon and nitrogen in the cycles of these elements. From the lesions of live lobsters having a shell disease. Hess (1937) found chitinoclastic bacteria. Chitin is attacked more slowly than other types of organic matter. It is decomposed less readily anaerobically than aerobically. Johnso n (1932) found chitinoclastic bacteria growing on crabs packed in ice

Pectin decomposition

Clostridium pectinivorum, C, felsineum, C. h'lum'lnni, C. roseun, C. caral1inum, C. saturnisubrum and C. aurantibutyricin are bacteria capable of breaking down pectins. They are widely distributed in water masses and are significant in the recycling of matter. They are important economically because of their involvement in the setting of bast-fibrous plants such as flax. Pectin are broken down under natural conditions by anaerobic bacteria, aerobic bacteria and fungi.

Decomposition of alginic acid

The decomposition of alginic acid occur abundantly in marine algae was found by Waksman et. al. (1934) to be caused by certain specific bacteria. Three new marine species which decompose a lginic acid are , Bacterium alginicum, Bacterium alginivarum and Bacterium fucicola.

The decomposition of Ambergis

Ambergis is a solid, fatty substance produced by sperm whale .. Fresh ambergis has a solid sweet odour and is used as an ingredient in p erfumes but, that found floating in the sea has a disagreeable odour. Foul odour is due to the decomposing action of bacteria. From co ncretions of ambergis a bacteria has been isolated namely Spirillum recti phyreteris. .

Oxidation of hydrocarbons

a) Oxidation of petroleum hydrocarbons According to Z08ell ([934a) bacterial species of Nocardia , Actinomyices , Pseudomonas, Micromonspora and Mycrobacterium are geological agents which oxidize various kinds of petroleum hydrocarbons. There are many ways in which bacteria may b e instrumental in the formation and accumulation of petroleum hydrocarbons. Petroleum consists primarily of hydrocarbons which are believed to have been formed in the sea probably from the reduction of organic matter in anaerobic bottom deposits.
b) Oxidation of oil wax etc. Species of Actinomyces, Micromonospora, Mycrobaclerium, Pseudomonas and other genera attack aliphatic, aromatic napthenic and olefinic hydrocarbons in the presence of free oxygen. These species are widely distributed in sea water and marine mud. Desulphovibrio species of marine origin attack waxes and heavy oils with the formation of lighter hydrocarbons, Micromonospora species rapidly oxidize paraffin wax paraffin oil, toluene, napthelene, benzene, phenol etc.
c) Oxidation of Rubber Rubber is an unsaturated hydrocarbon having the chemical formula (C5H,) Unsaturated hydrocarbons are readily susceptible to bacterial oxidation. Rubber is regarded as a biologically inert material but even highly purified rubber is attacked by marine bacteria including species of Actinomycetes, Micrococcus, Nocardia Pseudomonas and bacillus. Hydrocarbon oxidizing bacteria play an important role in the carbon cycle in the sea . The decomposition of rubber is of little consequence in the carbon cycle but it i3 a grave problem of economic impertance.
d) Fouling For a long time economical considerations have made fouling a matter for study in many countries. Investigationsm3de throughout have provided a sound knowledge of fouling organisms, the annual settltng cycles of the main species, trophic relationship, resistance to toxic substances and other ecological aspects, In nautic3I pulance fouling is the attachment and growth of a heterogenous assemblage of plan ts and animals on ship's bottom, piles and other submerged structures, By increasing the resistance of ships in water. fouling organisms diminish the speed of the vessel, increase fuel consumption and cause wear and tear of the machinery. Fouling organisms necessitate the drydocking of vessels a t frequent intervals. The fouling problem is of gravest concern to the Navy particularly when operating far from home bases. Algae, diatoms, hydriods, barnacles, oysters, bryozoans, and serpulids are the most abundant organisms observed in sub - merged surfaces . On badly fouled surfaces bacteria may constitute as much as 8 or 9~o by volume of the total cumulation. Bacteria play

an important role in the fouling of submerged surfaces. This they may do in a variety of ways as:

a) by affording the planktonic larval stages of fouling organisms a foot held or otherwise mechanic ally facilitating their attachment.

b) by dis coloring glazed or b right surfaces .

c) by serving as a source of food (Barnacles, mussels, tunicates and other fouling organisms are nourished by bacteria).

d) by promoting the deposition of calcareous cements of &essile organisms.

e) by increasing the concentration of p lant nutrients includircgcarbondioxide andammonia which result from the bacterial decomposition of organic matter.

Biocontrol of fouling organisms

Fouling in vessels can be successfully dealt with at present by passing el ectric current. In a number of cases this method cannot be applied and special paints which contain antifouling compounds with various toxic substances are used. According to Wisely (1964) on painted surfaces of the ships, barnacles showed post-attachment mortality. Bryoyoans and tube worm larvae showed pre-attachment mortality. Mollusc larvae are repelled long before they become attached. The progress of marine microbiology in explaining the presence of many chemical compounds and biogenic substances like petroleum in the sea is still very insufficient. The obvious part played by microorganisms prompts geochemists to expect an explanation from microbiology. Only very generalised data have so far accumulated concerning the so-called geological activity of microorganisms such as oxidation of petroleum hydrocarbons, C'il etc. The improvement of old methed s and the working out of new methods for the quantitative study of biochemical activity of microorganism under natural conditions of their environments is the most important task of microbiology to be handled yet. At this time of energy crisis it is necessary to intensify marine microbiological and geological investigations in order to satisfy the energy demands of the country.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB | COURSE NAME: MARINE MICROBIOLOGY

COURSE CODE: 19MBU105A | BATCH-2018-2021

UNIT-1

	Questions	Option A	Option B	Option C	Option D	ANSWER
1	The ocean currently coversof the earth surface	71%	27%	47%	35%	71%
2	_______is the largest aquatic ecosystem of the planet	Marine ecosystem	Terrestial ecosystem	Land ecosystem	Water ecosystem	Marine ecosystem
3	The watery region above the. Sea is called__________	Benthic	pelagic	Photic	Both A and B	Both A and B
4	The pelagic realm is divided into __ zones	2	3	4	5	5
5	Epipelagic zone is also known as	Photic zone	Euphotic zone	Both A and B	None of A and B	Both A and B
6	Mesopelagic zone is also known as	Disphotic	Twilight	Aphotic	Both A and B	Both A and B
7	Bathypelagic zone extends upto __ m	1000-4000	200-2000	2000-6000	8000-6000	1000-4000
8	Abyssopelagic zone extends upto __m depth	2000-4000	2000-6000	2000-8000	2000-10000	2000-6000
9	Epipelagic eutrophotic zone is a deal place of about __of all ocean	71%	90%	80%	28%	90%
10	The bathypelagic zone and hadal pelagic zone is also called	Midnight	Dark	Light	Both A and B	Both A and B
11	____zone covers the deepest part of the ocean	Hadal	Bentic	Bathyl	Abyssal	Hadal
12	. ____means the bottom ranging from deepest part of the ocean	Benthic	Hadal	Abyssal	Bathyl	Bentic
13	Most of the organisms in Benthic zone are	Scavengers	Algae	Zooplankton	Protozoa	Scavengers
14	Benthic environment is further divided into	5	4	3	2	5
15	Intertidal zone is also called as	Twilight	Photic	Littoral	Dark	Littoral

16	____zone essentially coincides with	Intertial	Sublittoral	Bathyl	Abyssal	Sublittoral
17	Bathyl zone from the shelf break into	1000	2000	3000	4000	4000
18	____zone includes the average depth of the ocean floor	Bathyl	Hadal	Abyssal	Intertidal	Abyssal
19	____includes the trenches the deepest part of the sea floor	Intertial	Hadal	Abyssal	Bathyl	Hadal
20	Many protist are_____	Autotrophic	Hetertrophic	Mixotrophic	Both A and B	Mixotrophic
21	The distribution of_____.in water is influenced	o2	co2	Both A and B	None of these	Both A and B
22	_____bacteria are primarily responsible for the spoilage of fish	Proteolytic	Marine	Micrococcus	Autolytic	Proteolytic
23	Marine fish are more susceptible than __fish	Aquatic	Sea	Freshwater	None of these	Freshwater
24	____bacteria are more proteolytic at lower temperatures	Freshwater	Marine	Sea	Both A and B	Freshwater
25	The spoilage of fish is prevented by___	Sterilization	Refrigeration	Salting	Heating	Refrigeration
26	Some of the bacteria are actually proteolytic at___degree celcius	2	3	4	5	3
27	_____caused redening of cord and allied fishes	*Diplococus*	*Micrococcus*	*Enterobacter*	*Methanococcus*	*Diplococcus*
28	____are found with dry cord	*Microccus*	*Sarcina*	*Halobacterium*	All of these	All of these
29	____are found to be associated with redening of salted fish	*Halophilic bacteria*	*Serratia*	Both A and B	None of these	Both A and B
30	The greenish yellow disclorization of habitat was found in	*Pseudomonas*	*Aspergillus*	*Azatobacter*	*E. coli*	*Pseudomonas*
31	California fish and game commission are filled with	Bacteria	Fungi	Virus	Parasites	Fungi
32	Which one is Brown algae	*California fish*	*Macrocystis pyrifera*	*Pseudomonas cholera*	*Asiatic pyrifera*	*Macrocystis pyrifera*
33	The spoilage of oysters takes place in ------stages	3	6	2	4	3
34	Survival of typhoid bacilli in oysters is	9 to 12	9 to 35	9 to 45	9 to 56	9 to 45
35	___are really a problem to the oyster industry	*Aspergillus*	Yeast	Bacteria	Virus	Yeast
36	Which is primarily responsible for spoilage	Pink yeast	Torula yeast	Both A and B	None of these	Both A and B
37	Which is indispensable in marine environment	Producers	Decomposers	Inducers	Oysters	Decomposer
38	Who discovered decomposers	Elernberg	Allen	Wareen	Barghoo	Elernberg

39	Which are essential components	Primary producers	Decomposers	Both A and B	None of these	Both A and B
40	The deterioration of fishnets was found due to	Chithin digesting	Cellulase Digesting	Pectinase Digesting	Lysozyme Digesting	Cellulose Digesting
41	The durablity of net seines&lines can be extended by	Tin	Silver	Copper	Nickel	Copper
42	Manila ropes and cotton nets are found by	Atkin	Warren	Both A and B	None of these	Both A and B
43	Cellulose are converted into hydrocarbons like	Coal	Petroleum gas	Biogas	Natural gas	Petroleum gas
44	Large quantities of___ are used as floats with fishnets	Cork	Hydrogen	Wood	Fibers	Cork
45	Cork is a_____ complex	Cellulose	Lignin	Lignocellulose	pectin	Lignocellulose
46	___forms a part of cork tissue.	Lignin	Pectin	Cellulose	Hemicellulose	Hemicellulose
47	The fungi readily use __under exoconditions	Pectin	Starch	Both A and B	None of these	Both A and B
48	Who reported the deteriration of hard and soft wood	Atkin	Warden	Hess	Barghoo	Barghoo
49	Which form pan of plant tissue	Cellulose	Pectin	Lignin	Hemicellulose	Hemicellulose
50	___is a compelex carbohydrtae	Lignin	Pectin	Cellulose	Hemicellulose	Lignin
51	Who found that microorganisms cause the destruction of jute covering on ships	Imshenetsky	Kokdunia both	None of these	Both A and B	Both A and B
52	Who found the chitinoclastic bacteria	Johnson	Hass	Waksman	Khem	Hass
53	____attacked more slowly than other types of organic matter	Lignin	Chitin	Suberin	Pectin	Chitin
54	Who found that chitinolastic bacteria grows on crab packed in ice	Johnson	Hass	Waksham	Khem	Johnson
55	Which sps is capable of breaking down pecrins	*Aspergillus*	*Clostridium*	*Salmonella*	None of these	Clostridium
56	Pectin are breakdown under natural conditiins by	Aerobes	Anaerobes	Fungi	All of these	All of these
57	The decompostion of alginic acid occur in algae	Freshwater	Sea	Aquatic	Marine	Freshwater
58	The species which decompose lignic acid are	*Bacterium*	*Clostridium*	*Pseudomonas cholera*	None of these	Clostridium
59	Father of marine microbiology	Claude Ephrahim	Wilson	Beijinrick	Hessely	Claude Ephrahim

UNIT-2

"Thermophiles" are microorganisms with optimal growth temperatures between 60 and 108 degrees Celsius, isolated from a number of marine and terrestrial geothermally-heated habitats including shallow terrestrial hot springs, hydrothermal vent systems, sediment from volcanic islands, and deep sea hydrothermal vents

Why are thermophiles *hot*?

In 1966, Thomas Brock made the remarkable discovery that microorganisms were growing in the boiling hot springs of Yellowstone National Park. Since Brock's discovery, thermopiles have been discovered in geothermal features all over the world including areas in Iceland, Kamchatka, New Zealand, Italy, Mt. Lassen, and other locations. While boiling hot springs are far beyond the comfort zone of humans and other animals, life, especially prokaryotic life, is able to adapt to environments that would prove fatal to most other lifeforms.

All thermophiles require a hot water environment, but some thrive in more than one extreme, such as those with high levels of sulfur or calcium carbonate, acidic water, or alkaline springs. What enables an organism to thrive in habitats where the temperature is sometimes as hot as 140 degrees C (284 degrees F)? Regardless of varying environmental conditions, the ability of thermophiles to thrive in extremely hot environments lies in extremozymes, enzymes geared to work in extremely high temperatures. The amino acids of these extremozymes have special tricks to retain their twisted and folded 3D structures in high heat, where other enzymes would unfold and no longer work.

Why are thermophiles important?

Soon after their discovery, the heat-stable enzymes of thermophiles proved to be very important to the field of biotechnology (This site may be offline.). For example, two thermophilic species *Thermusaquaticus* and *Thermococcuslitoralis* are used as sources of the enzyme DNA polymerase, for the polymerase chain reaction (PCR) in DNA fingerprinting. As thermophiles have become increasingly important in biotechnological research, the number of bioprospecting groups searching for useful organic compounds in nature have dramatically increased as well. Consequently, concerns over preservation of biodiversity and natural resources as well as profitting research results have given way to benefits-sharing agreements (more info) , such as the Cooperative Research and Development Agreement between Yellowstone National Park and the Diversa Corporation.

Scientists in the biotechnology field are among many groups of researchers taking an interest in thermophiles. Astrobiologists, including researchers from NASA, suggest that hot springs all over the world provide some of the best "doorways into early Earth." Many scientists believe that life might have begun roughly 3 billion years ago in high temperature environments and that the first organisms might therefore have been thermophiles. Not only does this give insight into the origin of life on Earth, but opens up a new realm of possibilities for life elsewhere in the universe.

Thermophile Habitats

Yellowstone National Park: With over 10,000 geothermal features all being driven by volcanism and an underlying hotspot, Yellowstone National Park is home to a wide variety of thermotolerant and thermophilic organisms.

Iceland: Situated along the mid-ocean ridge of the Atlantic Ocean, Iceland is a geologic "hot zone". Thermophiles can be found colonizing a variety of geothermal features including hot springs, mudpots, fumaroles, and geysers.

Kamchatka: The Kamchatka Penninsula, located in far east Russia, is a recent "hotspot" for thermophile research with over 30 active volcanoes, numerous geothermal features, and a constantly evolving landscape

Halophiles are organisms that thrive in high salt concentrations. They are a type of extremophile organism. The name comes from the Greek word for "salt-loving". While most halophiles are classified into the Archaea domain, there are also bacterial halophiles and some eukaryota, such as the alga *Dunaliellasalina* or fungus *Wallemiaichthyophaga*. Some well-known species give off a red color from carotenoid compounds, notably bacteriorhodopsin. Halophiles can be found anywhere with a concentration of salt five times greater than the salt concentration of the ocean, such as the Great Salt Lake in Utah, Owens Lake in California, the Dead Sea, and in evaporation ponds

Classification

Halophiles are categorized as slight, moderate, or extreme, by the extent of their halotolerance. Slight halophiles prefer 0.3 to 0.8 M (1.7 to 4.8%—seawater is 0.6 M or 3.5%), moderate halophiles 0.8 to 3.4 M (4.7 to 20%), and extreme halophiles 3.4 to 5.1 M (20 to 30%) salt content.[1] Halophiles require sodium chloride (salt) for growth, in contrast to halotolerant organisms, which do not require salt but can grow under saline conditions.

Examples

Halobacterium] is a genus of the Archaea that has a high tolerance for elevated levels of salinity. Some species of halobacteria have acidic proteins that resist the denaturing effects of salts. *Halococcus* is a specific genus of the family Halobacteriaceae.

Some hypersaline lakes are a habitat to numerous families of halophiles. For example, the Makgadikgadi Pans in Botswana form a vast, seasonal, high-salinity water body that manifests halophilic species within the diatom genus *Nitzschia* in the family Bacillariaceae, as well as species within the genus *Lovenula* in the family Diaptomidae Owens Lake in California also contains a large population of the halophilic bacterium *Halobacteriumhalobium*.

Wallemiaichthyophaga is a basidiomycetous fungus, which requires at least 1.5 M sodium chloride for *in vitro* growth, and it thrives even in media saturated with salt. Obligate requirement for salt is an exception in fungi. Even species that can tolerate salt concentrations close to saturation (for example *Hortaeawerneckii*) in almost all cases grow well in standard microbiological media without the addition of salt.[14]

The fermentation of salty foods (such as soy sauce, Chinese fermented beans, salted cod, salted anchovies, sauerkraut, etc.) often involves halobacteria, as either essential ingredients or accidental contaminants. One example is *Chromohalobacterbeijerinckii*, found in salted beans preserved in brine and in salted herring. *Tetragenococcushalophilus*is found in salted anchovies and soy sauce.

Artemia is a ubiquitous genus of small halophilic crustaceans living in salt lakes (such as Great Salt Lake) and solar salterns that can exist in water approaching the precipitation point of NaCl, 340 g L−1 and can withstand strong osmotic shocks thanks to its mitigating strategies for fluctuating salinity levels, such as its unique larval salt gland and osmoregulatory capacity

Psychrophiles or **cryophiles**

(adj. psychrophilic or cryophilic) are extremophilic organisms that are capable of growth and reproduction in low temperatures, ranging from −20 °C[1]to +10 °C. They are found in places that are permanently cold, such as the polar regions and the deep sea. They can be contrasted with thermophiles, which are organisms that thrive at unusually high temperatures. Psychrophile is Greek for 'cold-loving'.

Many such organisms are bacteria or archaea, but some eukaryotes such as lichens, snow algae, fungi, and wingless midges, are also classified as psychrophiles.

Habitat

The cold environments that psychrophiles inhabit are ubiquitous on Earth, as a large fraction of our planetary surface experiences temperatures lower than 15 °C. They are present in permafrost, polar ice, glaciers, snowfields and deep ocean waters. These organisms can also be found in pockets of sea ice with high salinity content. Microbial activity has been measured in soils frozen below −39 °C. In addition to their temperature limit, psychrophiles must also adapt to other extreme environmental constraints that may arise as a result of their habitat. These constraints include high pressure in the deep sea, and high salt concentration on some sea ice

Examples

Psychrophiles include bacteria, lichens, fungi, and insects.

Among the bacteria that can tolerate extreme cold are *Arthrobacter* sp., *Psychrobacter* sp. and members of the genera *Halomonas*, *Pseudomonas*, *Hyphomonas*, and *Sphingomonas*. Another example is *Chryseobacteriumgreenlandensis*, a psychrophile that was found in 120,000-year-old ice.

Umbilicariaantarctica and *Xanthoriaelegans* are lichens that have been recorded photosynthesizing at temperatures ranging down to −24 °C, and they can grow down to around −10 °C. Some multicellular eukaryotes can also be metabolically active at sub-zero temperatures, such as some conifers;those in the *Chironomidae* family are still active at −16 °C.

Penicillium is a genus of fungi found in a wide range of environments including extreme cold.

Among the psychrophile insects, the Grylloblattidae or icebugs, found on mountaintops, have optimal temperatures between 1-4 °C. The wingless midge (Chironomidae) *Belgicaantarctica* can tolerate salt, being frozen and strong ultraviolet, and has the smallest known genome of any insect. The small genome, of 99 million base pairs, is thought to be adaptive to extreme environments

Alkaliphiles

Alkaliphiles are a class of extremophilic microbes capable of survival in alkaline (pH roughly 8.5–11) environments, growing optimally around a pH of 10. These bacteria can be further categorized as obligate alkaliphiles (those that require high pH to survive), facultative alkaliphiles (those able to survive in high pH, but also grow under normal conditions) and haloalkaliphiles (those that require high salt content to survive)

HAbitat

Microbial growth in alkaline conditions presents several complications to normal biochemical activity and reproduction, as high pH is detrimental to normal cellular processes. For example, alkalinity can lead to denaturation of DNA, instability of the plasma membrane and inactivation of cytosolic enzymes, as well as other unfavorable physiological changes. Thus, to adequately circumvent these obstacles, alkaliphiles must either possess specific cellular machinery that works best in the alkaline range, or they must have methods of acidifying the cytosol in relation to the extracellular environment. To determine which of the above possibilities an alkaliphile uses, experimentation has demonstrated that alkaliphilic enzymes possess relatively normal pH optimums. The determination that these enzymes function most efficiently near physiologically neutral pH ranges (about 7.5–8.5) was one of the primary steps in elucidating how alkaliphiles survive intensely basic environments. Since the cytosolic pH must remain nearly neutral, alkaliphiles must have one or more mechanisms of acidifying the cytosol when in the presence of a highly alkaline environment

oligotroph

An **oligotroph** is an organism that can live in an environment that offers very low levels of nutrients. They may be contrasted with copiotrophs, which prefer nutritionally rich environments. Oligotrophs are characterized by slow growth, low rates of metabolism, and generally low population density.

The adjective *oligotrophic* may be used to refer to environments that offer little to sustain life, organisms that survive in such environments, or the adaptations that support survival. Etymologically, the word "oligotroph" is a combination of the Greek adjective *oligos* (ὀλίγος) meaning "few" and the adjective *trophikos* (τροφικός)) meaning "feeding".

Oligotrophic environments include deep oceanic sediments, caves, glacial and polar ice, deep subsurface soil, aquifers, ocean waters, and leached soils.

Examples of oligotrophic organisms are the cave-dwelling olm; the bacterium, *Pelagibacterubique*, which is the most abundant organism in the oceans with an estimated 2×10^{28}individuals in total; and the lichens with their extremely low metabolic rate.

Plant adaptations

Plant adaptations to oligotrophic soils provide for greater and more efficient nutrient uptake, reduced nutrient consumption, and efficient nutrient storage. Improvements in nutrient uptake are facilitated by root adaptations such as nitrogen-fixing root nodules, mycorrhizae and cluster roots. Consumption is reduced by very slow growth rates, and by efficient use of low-availability nutrients; for example, the use of highly available ions to maintain turgor pressure, with low-availability nutrients reserved for the building of tissues. Despite these adaptations, nutrient requirement typically exceed uptake during the growing season, so many oligotrophic plants have the ability to store nutrients, for example, in trunk tissues, when demand is low, and remobilise them when demand increases.

Oligotrophic environments

Oligotrophs occupy environments where the available nutrients offer little to sustain life. The term "**oligotrophic**" is commonly used to describe terrestrial and aquatic environments with very low concentrations of nitrates, iron, phosphates, and carbon sources.

Oligotrophs have acquired survival mechanisms that involve the expression of genes during periods of low nutrient conditions, which has allowed them to find success in various environments. Despite the capability to live in low nutrient concentrations, oligotrophs may find difficulty surviving in nutrient-rich environments

Antarctica

Antarctic life offers very little to sustain life as most organisms are not well adapted to live under nutrient-limiting conditions and cold temperatures (lower than 5 °C). As such, these environments display a large abundance of psychrophiles that are well adapted to living in an Antarctic biome. Most oligotrophs live in lakes where water helps support biochemical processes for growth and survival. Below are some documented examples of oligotrophic environments in Antarctica:

Lake Vostok, a freshwater lake which has been isolated from the world beneath 4 km (2.5 mi) of Antarctic ice is frequently held to be a primary example of an oligotrophic environment. Analysis of ice samples showed ecologically separated microenvironments. Isolation of microorganisms from each microenvironment led to the discovery of a wide range of different microorganisms present within the ice sheet. Traces of fungi have also been observed which suggests potential for unique symbiotic interactions The lake's extensive oligotrophy has led some to believe parts of lake are completely sterile. This lake is a helpful tool for simulating studies regarding extraterrestrial life on frozen planets and other celestial bodies.

Crooked Lake is an ultra-oligotrophic glacial lake with a thin distribution of heterotrophic and autotrophic microorganisms. The microbial loop plays a big role in cycling nutrients and energy within this lake, despite particularly low bacterial abundance and productivity in these environments. The little ecological diversity can be attributed to the lake's low annual temperatures. Species discovered in this lake include *Ochromonas*, *Chlamydomonas*, *Scourfeldia*, *Cryptomonas*, *Akistrodesmusfalcatus*, and *Daphniopsisstuderi* (a microcrustacean). It is proposed that low competitive selection against *Daphniopsisstuderi* has allowed the species to survive long enough to reproduce in nutrient limiting environments.

Australia

The sandplains and lateritic soils of southern Western Australia, where an extremely thick craton has precluded any geological activity since the Cambrian and there has been no glaciation to renew soils since the Carboniferous. Thus, soils are extremely nutrient-poor and most vegetation must use strategies such as cluster roots to gain even the smallest quantities of such nutrients as phosphorus and sulfur.

The vegetation in these regions, however, is remarkable for its biodiversity, which in places is as great as that of a tropical rainforest and produces some of the most spectacular wildflowers in the world. It is however, severely threatened by climate change which has moved the winter rain belt south, and also by clearing for agriculture and through use of fertilizers, which is primarily driven by low land costs which make farming economic even with yields a fraction of those in Europe or North America.

South America

An example of oligotrophic soils are those on white-sands, with soil pH lower than 5.0, on the Rio Negro basin on northern Amazonia that house very low-diversity, extremely fragile forests and savannahs drained by blackwater rivers; dark water colour due to high concentration of tannins, humic acids and other organic compounds derived from the very slow decomposition of plant matter. Similar forests are found in the oligotrophic waters of the Patía River delta on the Pacific side of the Andes.

Ocean

In the ocean, the subtropical gyres north and south of the equator are regions in which the nutrients required for phytoplankton growth (for instance, nitrate, phosphate and silicic acid) are strongly depleted all year round. These areas are described as oligotrophic and exhibit low surface chlorophyll. They are occasionally described as "ocean deserts".

Oligotrophic soil environments

The oligotrophic soil environments include agricultural soil, frozen soil etc. Various factors, such as decomposition, soil structure, fertilization and temperature, can affect the nutrient-availability in the soil environments.

Generally, the nutrient becomes less available along the depth of the soil environment, because on the surface, the organic compounds decomposed from the plant and animal debris are consumed quickly by other microbes, resulting in the lack of nutrient in the deeper level of soil. In addition, the metabolic waste produced by the microorganisms on the surface also causes the accumulation of toxic chemicals in the deeper area. Furthermore, oxygen and water are important for some metabolic pathways, but it is difficult for water and oxygen to diffuse as the depth increases. Some factors, such as soil aggregates, pores and extracellular enzymes, may help water, oxygen and other nutrients diffuse into the soi l The most abundant species in the frozen soil are Actinobacteria, Proteobacteria, Acidobacteria and Cyanobacteria, together with a small amount of archaea and fungi. Actinobacteria can maintain the activity of their metabolic enzymes and continue their biochemical reactions under a wide range of low temperature. In addition, the DNA repairing machinery in Actinobacteria protects them from lethal DNA mutation at low temperature

What is an Extremophile

An extremophile is an organism that thrives under "extreme" conditions. The term frequently refers to prokaryotes and is sometimes used interchangeably with *Archaea*. In this module, however, you will find that extremophiles come in all shapes and sizes, and that our understanding of the phylogenetic diversity of extreme habitats increases daily.

The term extremophile is relatively anthropocentric. We judge habitats based on what would be considered "extreme" for human existence. Many organisms, for example, consider oxygen to be poisonous. While oxygen is a necessity for life as we know it, some organisms flourish in anoxic environments. We call them *extremophiles*... but that is only one perspective. If they could think, what would they think of us? As you read through the list of terms below, consider how what we think of as normal may seem too *extreme* from the point of view of an extremophile.

Extremophiles environments

Most terms used to describe extremophiles are generally straightforward. They are a combination of the suffix *phile*, meaning "lover of," and a prefix specific to their environment. For example, *acidophiles* are organisms that love (*phile*) acid (*acido*).

- **Acidophile:** An organism that grows best at acidic (low) pH values.
- **Alkaliphile:** An organism that grows best at high pH values.
- **Anaerobe:** An organism that can grow in the absence of oxygen.
    - **Facultative Anaerobe:** An organism that grows in the presence or in the absence of oxygen.

  - **Obligate Anaerobe:** An organism that cannot grow in the presence of oxygen; the presence of oxygen either inhibits growth or kills the organism.
- **Endolith:** An organism that lives inside rock or in the pores between mineral grains.
- **Halophile:** An organism requiring high concentrations of salt for growth.
- **Methanogen:** An organism that produces methane from the reaction of hydrogen and carbon dioxide, member of the *Archaea*.
- **Oligotroph:** An organism with optimal growth in nutrient limited conditions.
- **Piezophile (Barophile):** An organism that lives optimally at high hydrostatic pressure.
- **Psychrophile:** An organism with optimal growth at temperature 15 °C or lower.
- **Thermophile:** An organism with optimal growth at temperature 40 °C or higher.
  - **Hyperthermophile:** An organism with optimal growth at temperature 80 °C or higher.
- **Toxitolerant:** An organism able to withstand high levels of damaging elements (e.g., pools of benzene, nuclear waste).
- **Xerophile:** An organism capable of growth at very low water activity.

XEROTOLERANT

A **xerophile** (from Greek *xēros*, meaning 'dry', and *philos*, meaning 'loving')[1] is an extremophilic organism that can grow and reproduce in conditions with a low availability of water, also known as water activity. Water activity (a_w) is measured as the humidity above a substance relative to the humidity above pure water (Aw = 1.0). Xerophiles are "xerotolerant", meaning tolerant of dry conditions. They often can survive in environments with water activity below 0.8; above which is typical for most life on Earth. Typically xerotolerance is used with respect to matric drying, where a substance has a low water concentration. These environments include arid desert soils. The term osmotolerance is typically applied to organisms that can grow in solutions with high solute concentrations (salts, sugars), such as halophiles.

The common food preservation method of reducing water activities may not prevent the growth of xerophilic organisms, often resulting in food spoilage. Some mold and yeastspecies are xerophilic. Mold growth on bread is an example of food spoilage by xerophilic organisms.

Examples of xerophiles include *Trichosporonoidesnigrescens*[2] and cacti.

endolith

An **endolith** is an organism (archaeon, bacterium, fungus, lichen, algae or amoeba) that lives inside rock, coral, animal shells, or in the pores between mineral grains of a rock. Many are extremophiles, living in places long imagined inhospitable to life. They are of particular interest to astrobiologists, who theorize that endolithic environments on Mars and other planets constitute potential refugia for extraterrestrial microbial communities

Subdefinitions[edit]

The term "endolith", which defines an organism that colonizes the interior of any kind of rock, has been further classified into three subclasses:[3]

Chasmoendolith
: colonizes fissures and cracks in the rock (*chasm* = cleft)

Cryptoendolith
: colonizes structural cavities within porous rocks, including spaces produced and vacated by euendoliths (*crypto* = hidden)

Euendolith
: penetrates actively into the interior of rocks forming tunnels that conform with the shape of its body, rock boring organism (*eu* = true)

Environment[edit]

Endoliths have been found in rock down to a depth of 3 kilometres (1.9 mi), though it is unknown if that is their limit (due to the cost involved in digging so deep). The main threat to their survival seems not to result from the pressure at such depth, but from the increased temperature. Judging from hyperthermophile organisms, the temperature limit is at about 120 °C (Strain 121 can reproduce at 121 °C), which limits the possible depth to 4-4.5 km below the continental crust, and 7 or 7.5 km below the ocean floor. Endolithic organisms have also been found in surface rocks in regions of low humidity (hypolith) and low temperature (psychrophile), including the Dry Valleys and permafrost of Antarctica,[6]the Alps, and the Rocky Mountains.

Endolithic fungi and algae in marine ecosystems

Only limited research has been done concerning the distribution of marine endolithic fungi and its diversity even though there is a probability that endolithic fungi could perhaps play an important role in the health of coral reefs.

Endolithic fungi have been discovered in shells as early as the year 1889 by EdouardBornet and Charles Flahault. These two French phycologists specifically provided descriptions for two fungi: *Ostracoblabeimplexis* and *Lithopythiumgangliiforme*. Discovery of endolithic fungi, such as *Dodgellapriscus* and *Conchyliastrum*, has also been made in the beach sand of Australia by George Zembrowski. Findings have also been made in coral reefs and have been found to be, at times, beneficial to their coral hosts.

In the wake of worldwide coral bleaching, studies have suggested that the endolithic algae located in the skeleton of the coral may be aiding the survival of coral species by providing an alternative source of energy. Although the role that endolithic Fungi play is important in coral reefs, it is often overlooked because much research is focused on the effects of coral bleaching as well as the relationships between coelenterate and endosymbioticsymbiodinia.

According to a study done by Astrid Gunther endoliths were also found in the island of Cozumel (Mexico). The endoliths found there not only included algae and fungi but also included cyanobacteria, sponges as well as many other microborers.

Endolithic fungi and the mass extinction of Cretaceous dinosaurs

Evidence of endolithic fungi were discovered within dinosaur eggshell found in central China. They were characterized as being "needle-like, ribbon-like, and silk-like."

Fungus is seldom fossilized and even when it is preserved it can be difficult to distinguish endolithic hyphae from endolithic cyanobacteria and algae. Endolithic microbes can, however, be distinguished based on their distribution, ecology, and morphology. According to a 2008 study, the endolithic fungi that formed on the eggshells would have resulted in the abnormal incubation of the eggs and may have contributed to the mass extinction of these dinosaurs. It may also have led to the preservation of dinosaur eggs, including some that contained embryos

Definition of Coral Reef:

Vaughan (1917) has defined coral reef as **"a ridge or mound of lime stone, the upper surface of which is near the surface of the sea and which is formed of calcium carbonate by the actions of organisms, chiefly corals."**
The coral reefs are, in fact, produced by corals belonging to Anthozoa, particularly by stony corals, the Madreporaria. Hence, these are supposed to be the principal builders of coral reefs though there are certain other contributors also. A coral reef, in fact, is a ridge of lime stone whose upper surface is just below the sea surface and it is exposed at low tides.

Distribution and Conditions of Coral Reef Formation:
Corals have built a thick stratum of the earth's crust, they have coral reefs in the Caribbean seas and in the Indo-Pacific region from east coast of Africa to the north-eastern coast of Australia which is known as the Great Barrier Reef. However, Fiji islands of Pacific Ocean and those situated in Bahamaislands region are the best known coral islands of the world.

Bermuda is a coral island where houses are built of coral blocks. Around India, coral reefs are found off Port Okha and Dwarka in the gulf of Kutch and also off Rameshwaram in the gulf of Mannar between India and Sri Lanka. The coral reefs are also located at Andaman and Nicobar islands and at Lakshadweep Islands.

The coral reefs grow best at a depth of about 30 metres or less and normally in warm water up to about 20°C. Light and amount of sediment also limit the reef forming corals. They also fail to grow in dark shaded areas and they completely die in total darkness. Below 50 metres no reef building corals are found though some solitary corals exist up to 8000 metres.

Components of Coral Reefs:

In addition to stony corals, other components in the formation of coral reefs are Millepora, Tubipora, Heliopora, Alcyonaria, Gorgonians, Foraminifera, Coralline algae and branching algae, etc. The coral reefs are also inhabited by a number of sponges, anaemones, sea-urchins, starfishes, crabs, snails, bivalves, etc.

Types of Coral Reefs:

The various types of coral reefs are grouped into three major types:

1. Fringing Reefs:

The fringing reefs also referred to as the shore reefs are built from the sea bottom and extend from the shore up to 1/4 miles having no navigable channel between the shore and reef. This zone of the sea is called edge or front. However, sometimes reef beds are broken to result into irregular channels called lagoon.

Such reefs are composed largely of coral sand having living and dead corals building reefs, mud and other animals. Fringing reef is very common in East Indies.

2. Barrier Reef:

The barrier reefs are like fringing reefs but they are situated in the sea nearly 1 km to 15 km away from the shore. Therefore, navigable channel called lagoon separates these reefs from the shore. The lagoon may be 20 to 40 fathoms deep, hence, it becomes navigable. The Great Barrier Reef on the north-east coast of Australia is 1,200 miles long, about 20-70 miles wide and situated nearly 90 miles away from the shore.

3. Atoll Reef:

The atoll reef, also referred to as coral island or lagoon island, is a circular or horse-shoe-shaped reef enclosing a lagoon of water which may be small or large up to 50 miles across.

Atoll reef may be broken to form channels; some suitable for navigation and other may not be suitable for it. An interesting atoll reef example is Aldabra in the Indian Ocean, about 260 miles northeast of the Malagasy Republic and 400 miles from the coast of Africa.

Formation of Coral Reefs:

The coral reefs have great vertical thickness though reef-building corals live only up to depth of 50 metres, and those of past geological ages also lived in shallow littoral waters. How the great thickness of coral reefs has been made is explained by several theories of which two may be considered.

1. Darwin's Subsidence Theory:

This theory states that coral reefs were first formed as fringing reefs on sloping shores, they became barrier reefs when the shores sank with water channel between them and the land. If the land is an island which sinks completely, then an atoll is formed. Thus, sinking or subsidence has caused the thickness of the reefs.

2. Daly's Glacial-Control Theory:

This theory states that during the last glacial period the formation of ice caps lowered the ocean level by 60 to 70 metres below the present surface. Waves cut the shores to make flat platforms suitable for growth of corals.

As the ice caps melted and temperature rose, corals began to grow on these platforms and rose upwards with rising ocean level, and all types of reefs were formed on the pre-existing platforms. There is evidence that coral reefs are growing today on submerged land and the foundations of reefs are now at a much greater depth than they were when corals first began to grow.

Observation of living corals shows that their rate of growth is from 5 mm to 20 cm per year, thus, a 50-metre deep reef could be formed in less than 8,000 years, and all the known reefs could have been built in under 30,000 years.

Some borings made in coral reefs showed that the reef rested on level platforms, but some other borings showed that reefs had no underlying platforms but had only sand and shell below them. It appears from these facts that some reefs were laid down on pre-existing platforms, but many reefs were formed according to Darwin's subsidence theory.

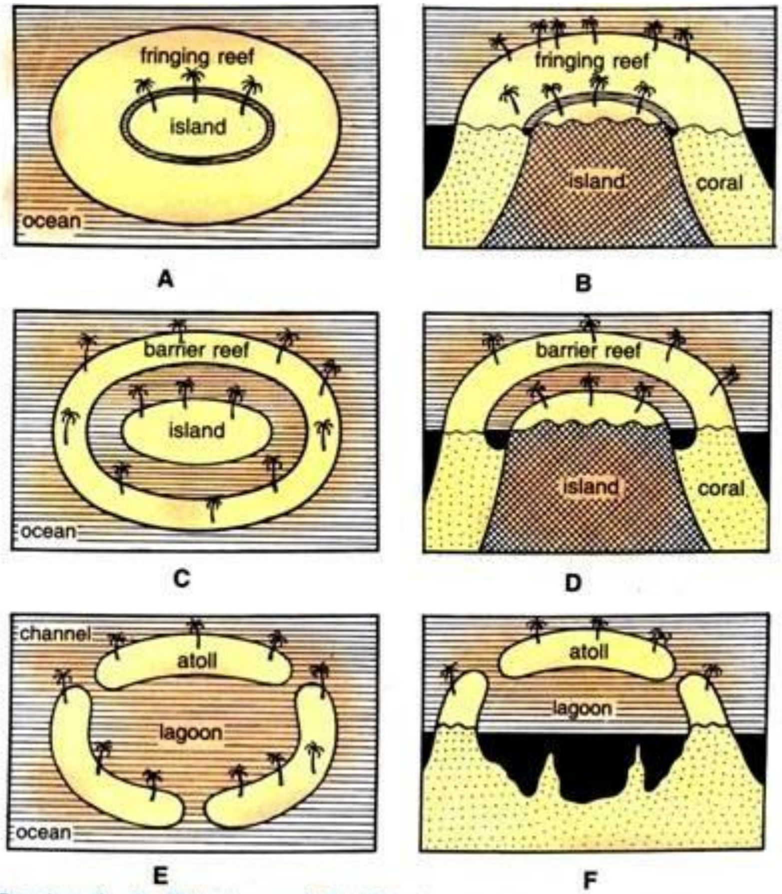


Fig. 36.2. Coral reefs. A—Fringing reef; B—Fringing reef in section; C—Barrier reef; D—Barrier reef in section; E—Atoll reef; F—Atoll reef in section.

Seagrasses

Seagrasses are flowering plants (angiosperms) which grow in marine environments. There are 60 species of fully marine seagrasses which belong to four families (Posidoniaceae, Zosteraceae, Hydrocharitaceae and Cymodoceaceae), all in the order Alismatales (in the class of monocotyledons).[1] Seagrasses evolved from terrestrial plants which migrated back into the ocean about 75 to 100 million years ago

Star Grass

Star grass (Halophilaengelmannii) is a smaller sea grass with elongated, elliptical grass blades extending just over 1 inch in height. Star grass is found in the coastal waters off Florida and the Bahamas and grows in sheltered areas with muddy substrates, up to 300 feet in depth.

Eel Grass

Eel grass (Zostera marina) is found in highly saline conditions on both coasts of the United States. Long ribbon shaped leaves extend 4 feet in height from centralized nodes, on muddy, exposed substrate surfaces. Eel grass is similar in appearance to its freshwater cousin, Wild Celery grass.

Manatee Grass

Manatee grass (Syringodiumfiliforme) has thin, cylindrical blades that form dense colonies with extensive root systems. Manatee grass grows in shallow, subtidal coastal areas, in the tropical waters of the western Atlantic ocean.

Shoal Grass

Shoal grass (Halodulebeaudettei) resembles land grass with flat, stiff blades extending up to 13 inches in height. Shoal grass is found in the temperate, subtropical and tropical waters of the western Atlantic ocean at shallow depths up to 40 feet.

Widgeon Grass

Widgeon grass (Ruppiamaritima) has narrow, multi-branching blades that are broader at the base, extending 4 inches in height. Widgeon grass is saline tolerant and found in shallow, protected, estuaries and bays, in temperate and topical climates around the world.

Turtle Grass

Turtle grass (Thalassiatestudinum) has thick, flat blades that extend 4 to 30 inches tall with an extensive root system that anchors to the substrate. Turtle grass is common in the topical waters of the western Atlantic ocean, growing in the tidal zone to depths of 30 feet or more.

Paddle Grass

Paddle grass (Halophiladecipens) is a smaller sea grass species with oval blades extending 2 inches high. Paddle grass is found in coastal tropical and subtropical climates throughout the world and is typically located between 30 to 100 feet deep.

Wild Celery Grass

Wild celery grass (Vallisneria Americana) has long, ribbon-like blades extending approximately 5 feet in height and 1/3 inch in width. This seagrass species is found in freshwater lakes and ponds in the central plains. With a low tolerance for saline water conditions, wild celery grass is rarely found in brackish water conditions

Mangroves

The word 'Mangroves" refers to a group of plants which may actually belong to several families (species that distinctly belong to their own evolutionary group). The term therefore indicates an ecological rather than a taxonomical (scientific classification) grouping - the species are not related. They are unique plants because of their ability to grow in unstable tough environments.

Mangroves are unique because they are able to thrive in areas where the water is poor in oxygen content, in salt water, in fresh water and in brackish water (a mixture of salt and fresh water). Mangroves are fast-growing trees taking several years to reach up to 25 meters when they are fully grown. Of the seven types of mangroves, three are most dominant, the red, black and white types.

Black Mangroves or 'Courida'

(*Avicenniagerminans*)

Description

Easily identified by its roots which are specialized to take in oxygen. Roots look like tubular bristles which stick out vertically and trap oxygen for its oxygen-starved root systems. These bristles are known as pneumatophores.

The Black Mangrove is tolerant of high saline conditions and the trees grow in isolated groups or woodland formations.

Individual trees are fairly large and may grow up to 20-25 meters in height and 40 centimetres in diameter at breast height.

Black mangroves produce seeds in abundance which occur throughout the year. The seeds are viviparous in nature, meaning their seeds germinate while still being attached to the parent tree. This species regenerates and coppices well and can therefore be managed under a coppice system, which is an even-agedsilvicultural system for which the main regeneration method is vegetative sprouting of either suckers (from the existing root systems of cut trees) or shoots (from cut stumps).

Uses

The Black Mangrove is the most important and dominant mangrove species in the open mud flats of Guyana . The seeds are actually edible and can be prepared into a delicious meal- but caution! Unless prepared in a certain way, your meal can be toxic!

Red Mangrove or 'Red Mango'
(*Rhizophora mangle*)

Description
This is an evergreen tree, which grows to about 25 meters inheight and 40 centimetres in diameter at breast height.
These are immediately recognized by their elaborate prop and aerial root system which stabilizes the trees. The roots contain a waxy substance that helps keep salt out. Where salt gets through, salt is deposited in older leaves and the tree then sheds them

Black Mangroves or 'Courida'
(*Avicenniagerminans*)
Description
Easily identified by its roots which are specialized to take in oxygen. Roots look like tubular bristles which stick out vertically and trap oxygen for its oxygen-starved root systems. These bristles are known as pneumatophores.
The Black Mangrove is tolerant of high saline conditions and the trees grow in isolated groups or woodland formations.
Individual trees are fairly large and may grow up to 20-25 meters in height and 40 centimetres in diameter at breast height.
The seed-like parts - the propagules - are large pre-germinated 'seedlings' knownlocally as 'monkey whistles'. A single seed germinates inside the conical fruit forming a long narrow first root (radicle), which is green except for the brown enlarged and pointed end up to 1.25 centimetres in diameter. It can grow up to 30 centimetres in length before it detaches from the mother tree and falls. They need a longer period from 16 to 30 months to mature from flower bud to mature seedlings.
Red Mangroves does not respond well to cutting, and are very sensitive. If 50% or half the leaves are removed from the tree then it will die.
Uses
The wood can be converted into good quality charcoal and the bark produces high quality tannin which is suitable for leatherwork.
White Mangrove
(*Laguncularia racemosa*)
Description
These are the shortest of the three species (reaches 5.6 meters and a diameter of 30 centimetres) and have un-buttressedroots. This species normally grows in the back portion of mangrove swamps, which remains unaffected by tidal inundation, except during spring tides. The bark is light brown to reddish dark brown, and the leaves are ovate. The leaves have adapted to their

salty environment by developing special openings (glands) that allow salt to pass from inside the tree to the outside. The leaves are then coated with speckled white salt crystals which are what gives this species its name- white mangrove.

Germination is epigeous (the cotyledons - part of the embryo of the seed- of the germinating seed expand, throw off the seedshell and become photosynthetic above the ground) and un-opened seeds are carried up to 4 - 8 centimetres on a slender green stalk. Further, the roots are fibrous, and this species coppices reasonably well. It normally grows in the back portionof mangrove swamps, which remains unaffected by tidal inundation, except during spring tides. The soil is generally clayey to silty clay.

Hydrothermal vent

A **hydrothermal vent** is a fissure on the seafloor from which geothermally heated water issues. Hydrothermal vents are commonly found near volcanically active places, areas where tectonic plates are moving apart at spreading centers, ocean basins, and hotspots.Hydrothermal deposits are rocks and mineral ore deposits formed by the action of hydrothermal vents.

Hydrothermal vents exist because the earth is both geologically active and has large amounts of water on its surface and within its crust. Under the sea, hydrothermal vents may form features called **black smokers** or **white smokers**. Relative to the majority of the deep sea, the areas around submarine hydrothermal vents are biologically more productive, often hosting complex communities fueled by the chemicals dissolved in the vent fluids. Chemosynthetic bacteria and archaea form the base of the food chain, supporting diverse organisms, including giant tube worms, clams, limpets and shrimp. Active hydrothermal vents are believed to exist on Jupiter's moon Europa, and Saturn's moon Enceladus,and it is speculated that ancient hydrothermal vents once existed on Mars

Hydrothermal vents in the deep ocean typically form along the mid-ocean ridges, such as the East Pacific Rise and the Mid-Atlantic Ridge. These are locations where two tectonic plates are diverging and new crust is being formed.

The water that issues from seafloor hydrothermal vents consists mostly of sea water drawn into the hydrothermal system close to the volcanic edifice through faults and porous sediments or volcanic strata, plus some magmatic water released by the upwelling magma. In terrestrial hydrothermal systems, the majority of water circulated within the fumarole and geyser systems is meteoric water plus ground water that has percolated down into the thermal system from the surface, but it also commonly contains some portion of metamorphic water, magmatic water, and sedimentary formational brine that is released by the magma. The proportion of each varies from location to location

Water Currents

In oceans and other water bodies, the motion of the water is defined by currents. There are two types of currents, surface currents and deep water currents, that dictate how and where water will move. Scientists study currents to learn more about how the ocean works mechanically, as well as using the speed and location of currents as a way to measure changes in large bodies of water.

Surface Currents

Surface currents occur in the upper 400 meters of the ocean. Because the ocean is so much deeper in most places, these currents only account for 10 percent of the total amount of currents in the ocean.

These currents move because of solar heating and wind. Solar heating causes water to expand. In the middle latitudes by the equator, water sits about eight centimeters higher than the rest of the water, which causes a slope that water can flow down, creating currents

Wind physically pushes the water, with faster currents occurring in shallower water. As the water gets deeper, wind-driven currents move more slowly. This phenomenon causes spiraled currents, with the tops moving faster than the bottom.

Deep Water Currents

Deep water currents make up 90 percent of the ocean currents. Unlike surface currents, which are driven by interactions with sun and wind, deep currents are caused by the interaction between temperature and water density.

The higher the salt content of water, the more dense it is. Dense water is heavier than less dense water, and thus will sink because of gravity.

The warmer water is, the more likely it is to rise towards the surface.

So, when water is both cold and very dense, it will sink to the bottom of the ocean. This motion, with heavier, colder water constantly replacing warm, less salty water, causes the deep water currents. These currents cover a lot of territory. Most start at latitudes close to the poles where it is cold and resurface as they get closer to the equator where temperatures are warmer. This long chain of currents is known as the ocean's Conveyor Belt.

Why Currents Are Important

According to the National Oceanic and Atmospheric Administration, understanding the cause and movement of ocean currents is important to utilizing the sea for human purposes. Currents are important to docking and undocking boats, speeding up shipping lanes and keeping ships safe, especially in narrow waterways. Understanding where currents are going and how quickly they are moving also aid search and rescue missions and environmental disaster clean-up.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB | COURSE NAME: MARINE MICROBIOLOGY

COURSE CODE: 19MBU105A | BATCH-2018-2021

UNIT-2

		Option A	**Option B**	**Option C**	**Option D**	**ANSWER**
1	The organisms with optimal growth temperatures between 60 and 108 degree celcius are called	Acidophiles	Thermophiles	Extremophiles	Halophiles	Thermophiles
2	Who found that organisms were growing in the boiling hot springs	Johnson	Thomas brock	Lassen	Warren	thomas brock
3	Which is used as a source of enzyme DNA polymerase	*Thermus aquatius*	*Thermococcus litiral*	Both a and b	None	both a and b
4	____are oraganisms that thrive in high salt concentrations	Thermophiles	Acidophiles	Halophiles	Alkaliphikes	Halophiles
5	Iceland is a geologic.______zone	Cold	Hot	Hotspot	Moderate	Hot
6	Which is a recent hotspot for thermophilic research	Iceland	Natinal park	Kamchatka	Utah	Kamchatka
7	Halophiles means	Cold loving	Hot loving	Salt loving	Sweet loving	Salt loving
8	Halophiles found with the conc of salt____grater than the salt conc of sea	Four times	Two times	Three times	Five times	Five times
9	____is a genus of the archea	Halobacterium	Thermobacterium	Both a and b	None of these	Halobaterium
10	Which is the famiy of bacilariacae	*Dunaliella*	*Walkemia*	*Halococcus*	*Nitzschia*	*Nitzschia*
11	Which is a basideomycetous fungus	*Artemia*	*Horteaea*	*Lovenula*	*Wallemia*	*Wallemia*

12	The fermentation of salty foods often involves	Halobacteria	Thermobacteria	Acidibacteria	None	Halobacteria
13	Which is found in salted anchoives and soy sauce	Tetraenococcus	Chromohalobacter	Artemia	Hortaea	Tetraneococcus
14	___is ubiquitous genus of small halophilc crustaceans in salt lakes	*Walkemia*	*Artemia*	*Halomonas*	*Hypomonas*	*Artemia*
15	____are capable of grow in low temperatures ranging from -20 to 10 dgree	Crypohiles	Thermophiles	Extremophiles	Halophiles	Cryophiles
16	Psycrophiles is greek for	Hot loving	Cold loving	Salt loving	Hotspot	Cold loving
17	Microbial activity has been measuredbin soils frozen below___degree	39	10	19	29	39
18	The organisms found in pockets of sea with high ___content	Salt	Cold	Acidic	None	Salt
19	_____includes bacteria,fungi,lichens,insects	Psycrophiles	Halophiles	Thermophiles	Acidophiles	Psycrophiles
20	A psycrophiles that was found 1,20,000 year old in ice	*Chryseobacterium*	*Clostridium*	*Halobacterium*	*Halomonas*	Chryseobacterium
21	Which are the lichens that have been recorded tempratures ranging down at -24 dgree celcius	Umblicaria	Xanthoria	Both a and b	None	Both a and b
22	Chironomidae family are still active at ___-dgree celcius	-16	0	10	16	-16
23	Alkaliphiles are.further.divided into___types	2	3	4	6	3
24	Alkaliphiles must have one or more mechanisms of acidyfying the_____	Enzymes	Plasma membrane	Celluose	Cytosol	Cytosol
25	Which can live in the environment of very low level of nutrients	Autotroph	Heterotroph	Oligotroph	Mixotroph	Oligotroph

26	Oligotroph organisms are the	Anaerobes	Copiotrophs	Feeding	Cave dwewling	Cave-dwewling
27	____is commonly used to describe aquatic and terretial environment with low iron,nitrates	Oligotroph	Mixotroph	Copiotroph	Psycrophiles	Oligotroph
28	Which is a freshwater lake isolated from the world beneath 4km of antartic ice	Lake vostok	Antartica	Green lake	Crooked lake	Lake vostok
29	Which is a ultra oligotrophic glacial lake	Lake vostok	Crooked lake	Green lake	None	Crooked lake
30	The organisms found in crooked lake are	*Ochromonas*	*Chlamydomonas*	*Cryptomonas*	Both a and b	Both a and b
31	Which can affect the nuteient availablity in oigotrophic environment	Decomposition	Fertilization	Decomposition	All of these	All of these
32	The most abundant species in frozen soil.are	Acidobacteria	Proteobacteria	Actinobacteria	All of these	All of these
33	Which organism protects the lethal DNA mutation at low temperature in frozen soil	Proteobacteria	Actinobacteria	Cyanobacteria	Acidobacteria	Actinobacteria
34	Prokaryores are sometimes used interchsnging with____	Algae	Archea	Bacteria	Eukarya	Archea
35	Organisms that grow best at acidic ph values	Acidophiles	Alkaliphiles	Anaerobes	Aerobes	Acidohiles
36	Organisms that grow best at high ph values	Alkalophiles	Acidophiles	Anaerobes	Aerobes	Alkanophiles
37	Organisms that grow in the presence or absence of oxygen are	Halophilic	Endolith	Facultative	Obligate	Facultative
38	Organisms that grow inside the rocks or in the pores are	Endolith	Halophilic	Methanogen	Oligotroph	Endolith
39	Organism which is able to withstand high levels of damaging element are	Oligotroph	Xerophile	Toxitolerant	Endolith	Toxitolerant

40	Organisms capable of growth at very low water activity are	Xerophilic	Thermophilic	Halophilic	Oligotroph	Xerophile
41	Example of xerophiles is	*Trichosporonoides*	*Lithopthium*	*Dodgella*	*Cinchyliastrum*	*Trichosporonoides*
42	Black mangroves are also known as	Courida	Black smokers	White smokers	Red mango	Courida
43	Example of white mangrove is	Avicennia	Laguncularia	Halophila	Ruppia	Avicennia
44	Hydrothermal vents may from features called	Black smokers	White smokers	Water currents	Both a and b	Both a and b
45	Deep water currents make up___% of the ocean currntes	90	75	80	19	90
46	Long chain of currents is known as the____conveyer belt	Sea	Ocean	Water	Wind	Ocean
47	Example of manatee grass is	Syringodium	Thalassia	Ruppia	Halodule	Syringodium
48	Example of widgeon grass is	Halodue	Ruppia	Thalassia	Halophila	Ruppia
49	Example of haddle grass is	Halodule	Ruppia	Thalasia	Halophila	Halophila
50	Example of wild celery grass is	Ruppia	Halodule	Vallisneria	Halophila	Vallisneria
51	Example of eel grass	Ruppia	Zostera	Vallisneria	Halodule	Zostera
52	Eel grass is similar in appearance to its_____cousin	Freshwater	Marine water	Waste water	Dump water	Freshwater
53	Star grass is found in coastal waters off of	Florida	Bahamas	Both a and b	None	Both a and b
54	Sea grass belong to __ families	3	4	5	6	4
55	Which is coral island where houses are built of coral blocks	Antartica	Bermuda	Crooked lake	Iceland	Bermuda
56	Coral reefs grow best at the depth of about __m	13	30	20	25	30
57	Coral reefs are grouped into__major types	5	3	4	2	3
58	Lagoon may be _____ fathoms deep	20-30	20-40	20-50	20-60	20-40

59	Thickness of coral reefs has been made by __theories	7	2	5	6	7
60	Surface currents occur in the upper___meters of the ocean	200	300	400	500	400

UNIT-3

Food pathogenic microorganisms

According to the Centers for Disease Control and Prevention, approximately 48 million Americans get sick, 128,000 are hospitalized and 3,000 die each year from food poisoning.

Bacteria, viruses and parasites are the sources of many food poisoning cases, usually due to improper food handling. Some bacteria, in small amounts, are not harmful to most healthy adults because the human body is equipped to fight them off. The trouble begins when certain bacteria and other harmful pathogens multiply and spread, which can happen when food is mishandled. Foods that are contaminated may not look, taste or smell any different from foods that are safe to eat. Symptoms of food poisoning vary and develop as quickly as 30 minutes to as long as several days after eating food that's been infected.

As identified by the CDC, eight known pathogens (bacteria, viruses and parasites) account for the majority of foodborne illness, hospitalization and death in the United States.

Salmonella

Salmonella is the name of a group of bacteria that causes the infection salmonellosis. It is one of the most common bacterial causes of diarrhea and the most common cause of foodborne-related hospitalizations and deaths. *Salmonella* is more severe in pregnant women, older adults, younger children and those with a weakened immune system. Because *Salmonella* bacteria can live in the intestinal tract of humans and other animals, it can spread easily unless you use proper hygiene and appropriate cooking methods.

Sources: You can contract salmonellosis by consuming raw and undercooked eggs, undercooked poultry and meat, contaminated raw fruits and vegetables (such as sprouts and melons), as well as unpasteurized milk and other dairy products. It also can be transmitted through contact with infected animals or infected food handlers who have no washed their hands after using the bathroom.

Prevention: Cook foods such as eggs, poultry and ground beef thoroughly to recommended temperatures. Wash raw fruit and vegetables before peeling, cutting or eating. Avoid unpasteurized dairy products and raw or uncooked meats, poultry and seafood. Wash hands often, especially after handling raw meat or poultry. Clean kitchen surfaces and avoid cross-contamination.

Clostridium perfringens

Clostridium perfringens, also known as *C. perfringens*, is very common in our environment. It can multiply very quickly under ideal conditions. Infants, young children and older adults are most at risk.

Sources: Illness usually occurs by eating foods contaminated with large numbers of this bacteria that produce enough toxin to cause sickness in the form of abdominal cramping and diarrhea. *C. perfringens* is sometimes referred to as the "buffet germ" because it grows fastest in large portions of food, such as casseroles, stews and gravies that have been sitting at room temperature in the danger zone. If food isn't originally cooked, reheated or kept at the appropriate temperature, live bacteria may be consumed and cause illness.

Prevention: Cook food thoroughly and keep it out of the danger zone, above a temperature of 140°F or below 40°F. Practice leftover safety by dividing roasts and stews into smaller quantities when refrigerating for faster cooling. Leftovers should be reheated to an internal temperature of 165°F or higher before serving.

Campylobacter

Campylobacter is a common cause of diarrhea. Most cases of campylobacteriosis, the infection caused by *Campylobacter* bacteria, are associated with eating raw or undercooked poultry and meat or from cross-contamination of other foods by these items. Freezing reduces the number of *Campylobacter* bacteria on raw meat but will not kill them completely, so proper heating of foods is important. Campylobacteriosis occurs more frequently in the summer and is most common in infants and young children.

Sources: Sources include consuming raw and undercooked poultry and other meats, unpasteurized dairy products and untreated water or contaminated produce.

Prevention: Cook all foods thoroughly, prevent cross-contamination by using separate cutting boards when handling raw and cooked foods, don't drink unpasteurized milk or untreated water and wash hands frequently. Wash raw fruits and vegetables before peeling, cutting and eating.

Staphylococcus aureus

Staphylococcus aureus (staph) is commonly found on the skin, throats and nostrils of healthy people and animals. Therefore, it usually doesn't cause illness unless it is transmitted to food products where it can multiply and produce harmful toxins. Staphylococcal symptoms include nausea, stomach cramps, vomiting or diarrhea. Staphylococcal toxins are heat resistant and cannot be destroyed by cooking. Anyone can develop a staph infection but certain groups of people are at greater risk, including people with chronic conditions such as diabetes, cancer, vascular disease, eczema and lung disease.

Sources: The bacteria can be found in unpasteurized dairy products and salty foods such as ham and other sliced meats. Foods that are made or come in contact with hands and require no additional cooking are at highest risk, including:

- Salads, such as ham, egg, tuna, chicken, potato and macaroni
- Bakery products, such as cream-filled pastries, cream pies and chocolate éclairs

- Sandwiches.

Prevention: Wash hands with soap and water, do not prepare or serve food if you have a nose or eye infection or if you have wounds or skin infections on your hands or wrists. Keep the kitchen area clean and keep foods out of the danger zone.

E. coli O157:H7

Escherichia coli, better known as *E. coli*, are a large group of bacteria. Although most strains of *E. coli* are harmless, some can make you very sick. One strain, *E. Coli O157:H7* (STEC) is commonly associated with food poisoning outbreaks because its effects can be extremely severe.

Sources: These include eating raw or undercooked ground beef or drinking unpasteurized beverages or dairy products.

Prevention: Wash your hands, cook meat (especially ground meat) and poultry thoroughly; avoid unpasteurized dairy products, juices or ciders; keep cooking surfaces clean; and prevent cross-contamination. Also, don't swallow water when playing or swimming in lakes, ponds, streams or pools.

Listeria monocytogenes

Eating food contaminated with *Listeria monocytogenes* bacteria causes listeriosis — a serious infection that primarily affects individuals who are at a high risk for food poisoning: older adults, pregnant women, young children and people with weakened immune systems. *Listeria* can grow at refrigerator temperatures where most other bacteria cannot grow.

Causes: *Listeria* is found in refrigerated, ready-to-eat foods such as hot dogs, deli meats, unpasteurized milk, raw sprouts, dairy products and raw and undercooked meat, poultry and seafood.

Prevention: Cook all foods to proper temperatures and reheat precooked foods to 165°F; wash raw fruits and vegetables before peeling, cutting or eating; separate uncooked meats and poultry from foods that are already cooked or ready-to-eat; wash hands thoroughly; store foods safely; maintain a clean refrigerator and kitchen area; and wash reusable grocery totes regularly.

Norovirus

Norovirus is one of the leading causes of food poisoning and often results in symptoms similar to stomach flu such as stomach cramping, nausea, vomiting and diarrhea. Norovirus spreads easily by coming in contact with someone who is infected, especially in crowded areas. Foods, drinks and surfaces also can become contaminated with the norovirus. Anyone can get sick with norovirus, but the illness can be especially serious for young children and older adults. You can contract norovirus many times in your life.

Sources: Fresh produce, shellfish, ice, fruit and ready-to-eat foods, especially salads, sandwiches and cookies that have been prepared by someone who is infected are sources of norovirus.

Prevention: Do not cook, prepare or serve foods or beverages while you are sick. Frequently wash your hands with soap and water for at least 20 seconds. Keep foods and utensils clean by washing all fruits and vegetables, cutting boards, knives, kitchen surface areas, table linens, cloth napkins and reusable grocery bags.

Toxoplasma gondii

Toxoplasma is a parasite that causes toxoplasmosis — a disease that can result in serious health problems in individuals who are at high risk for food poisoning: pregnant women, infants, older adults and people with weakened immune systems. Symptoms can be similar to flu and include swollen lymph glands or muscle aches and pains that last for months. Other symptoms affect the eyes, causing vision to be reduced or blurred or cause pain, redness or tearing.

Sources: Sources include eating undercooked, contaminated meat or using utensils or cutting boards that have had contact with raw meat; coming into contact with feces from an infected cat when cleaning the litter box; or drinking contaminated water. *Toxoplasma* also can be spread to infants if a mother has become infected before or while pregnant.

Prevention: Cook food to safe temperatures — a food thermometer should be used to ensure food has reached a safe temperature. Also, freeze meat properly; wash fruits and vegetables before peeling, cutting and eating; avoid unpasteurized dairy products; maintain clean cutting boards; and always wash your hands with soap and water. In addition, wear gloves when cleaning a cat's litter box or touching soil in case it is contaminated with cat feces, especially if pregnant or are at a higher risk of getting sick.

One of the best things you can do to reduce your risk of food poisoning is to practice safe food handling at home. Consult a physician if you think you or someone else has been sickened by food poisoning

Role of microorganisms in nature and in foods

The food of humans which is of plant and animal origin are naturally associated with microorganisms of several kinds. Microorganisms in their natural habitat play an important role in cycling of nutrients in the ecosystem. In the process of performing their primary role in nature, the microflora associated with food cause spoilage of foods meant for human consumption. Thus, the knowledge on types of microorganisms naturally associated with plant and animal foods helps to predict the microbial types that could be present at later stages of handling, storage and preservation of food.

Depending on the nature of food and its habitat a variety of microorganisms are expected in the food and these may often affect the safety of food. Therefore, information on factors such as total number and types of microorganisms naturally present, types of microorganisms present in specific food, and ones which are not natural to the food becomes necessary. This information becomes valuable in ascertaining the safety of food during different stages of processing, handling and storage.

Microorganisms in aquatic environment

All surface waters such as ponds, lakes, rivers and oceans differ in their physical, chemical and biological characters. Depending on the nutrient status of water body, the microbial load varies with higher numbers encountering in eutrophic waters. Ground waters or subterranean waters generally have very low microbial load because of filtration effect of soil layers.

Categories of microorganisms in natural waters

The natural waters contain a variety of microorganisms. These include,

- Natural flora : Microorganisms natural to the water body and
- Transient flora : Microorganisms entering the water body from outside environment like from soil, air and through pollutants.

Microorganisms in natural aquatic environment play an important role in nutrient recycling, and as primary producers and decomposers of organic matter. All the microorganisms present in a water body can be seen as surface flora of inhabiting organisms. These not only include spoilage organisms but also human pathogenic microorganisms especially in sewage contaminated waters.

Primary source of microorganisms found in food

The foods of plants and animal origin carry several microorganisms associated with their natural habitat. Plants carry typical micro-flora on their surface and also get contaminated from outside sources. Animals carry microorganisms on their surface and intestine, and also contain contaminants from surrounding environment. Through their excretions and secretions animals release microorganisms in to surrounding environment. Besides, both plants and animals carry pathogenic microorganisms capable of causing human illness. The food associated microorganisms are influenced by the availability of specific nutritional requirements and the environmental parameters. The primary sources of entry of microorganisms in to foods are from the soil, water, air, during handling, processing transportation and storage of foods.

Soil

Soil being the rich source of several kinds of microorganisms immediately contaminates the plants and edible plant parts, and the surface of animals with the soil associated microorganisms. As the soil particles are carried in to aquatic environment through wind, rain and other means contamination of water takes place with several soil micro-flora. Therefore, it is not uncommon to find several microorganisms both in soil and water environment. These soil derived microorganisms form part of the the microbial flora involved in spoilage of foods of plant and animal source. Thus, there is a need to reduce the load of soil microorganisms in foods which can be achieved by removing the soil by washing the surface of foods with good quality water, and by avoiding contact with soil/ dust.

Water

Natural waters not only contain several microorganisms native to the aquatic environment but also from soil, raw/treated sewage and pollutants entering the water body. The microbial numbers and types vary in different water bodies depending on the nutrient status. Thus, all kinds of microorganisms found in water are likely to be associated with the aquatic organisms as surface flora. Use of such water for food processing will add microorganisms from water to food.

Sewage waters containing human pathogenic microorganisms contaminate foods when such waters are used without proper treatment. The water used in food processing should meet agreeable chemical and bacteriological characteristics.

Air

Air contains several microorganisms which may get deposited on the food being processed and handled. Though the air does not contain natural flora of microorganisms, whatever microorganisms encountered are those associated with the suspended solid material and water droplets. The sources of microorganisms to air are from dust, dry soil, and water spray from natural surface waters, droplets of moisture from coughing, sneezing and talking by food handlers, from sporulatingmoulds growing on walls, ceilings, floor, foods and food ingredients. Thus, it is likely that the microorganisms persisting in air get deposited on the food being processed and contribute for microbial load and subsequent spoilage of food.

The number of microorganisms present in air depends on factors such as extent of movement of air, sunshine, humidity, location and amount of suspended dust in air. Quiet air allows settling of microorganisms but the moving air brings in microorganisms and keeps them suspended. Thus, the number of microorganisms in air is increased by air currents caused by movement of people, by ventilation and by breeze. The rain or snow removes microorganisms from the air.

Micro-flora of food processing facility

The nature of micro-flora in a food processing facility varies depending on the nature of food being processed. Hence characteristic microbial populations are encountered in different processing units. Also variations may be observed in microbial numbers from one area of processing plant to another. The microbial types present inside the processing plant are related to quality of air out side the plant and the microbial population levels are related to the level of activity of workers.

Reducing microbial load in processing area

There is a need to reduce microbial load in the processing area. This can be achieved by by installing filtration, chemical treatment and heat or electrostatic precipitation units, and taking measures in preventing the build up after reducing the microorganisms. The build up of microorganisms in the processing area can be prevented by maintaining the positive pressure in food process area, installing filters in ventilating systems that prevent spread of microorganisms from one part of a plant to another and installing UV- irradiated air locks at doors to reduce the number of organisms carried by workers.

Handling and processing

Foods grown/cultured in natural environment containing specific groups of microorganisms are further contaminated by several microorganisms during harvesting, handling and processing. Further, addition of microorganisms to food may take place from;

- All food contact surfaces including equipments coming in contact with foods, packaging material, and from food handlers. Foods are also prone for microbial contamination during transportation and storage.
- Use of sewage contaminated water for washing foods being processed contaminates it with human pathogenic microorganisms
- All the microorganisms associated with food handlers enter the food during handling of food from hands, garments, body surface, hair etc under poor personnel hygiene practices.

Therefore, it becomes necessary to prevent/reduce contamination and microbial build-up in foods during handling and processing so as to produce safe food with good keeping quality.

Significance of microorganisms in foods

Microorganisms associated with food derive energy from food for those cell growth, maintenance and reproduction. Based on their function microorganisms associated with foods may be divided in to three general groups;

- Those causing spoilage or undesirable changes in the food
- Those producing desirable changes
- Those producing disease

Based on the extent of stability to microbial invasion foods may be classified as;

- Perishable foods Ex. Fish and meat
- Semi-perishable foods Ex. Potatoes. Tomato
- Stable foods Ex. Cereals, Flour and Sugar

The stable or semi-stable foods become unstable or perishable when the moisture content increases.

Factors affecting microorganisms in foods

The survival and activity of microorganisms in foods depends on several factors namely, numbers and types of microorganisms present, type of food, treatments to which the food has been exposed, processing or storage treatments that the food receives, whether the food is to be consumed as it is or heated.

The food associated microorganisms may have useful function, cause spoilage, cause health hazard and play no role or remain inert. The cases of spoilage, food-borne illnesses or useful activity results due to the growth and multiplication of the microorganisms. The inert microorganisms are those which do not find food environment favorable for their growth, and remain dormant without causing any changes in food.

Causes for spoilage of food

Spoilage of food usually occurs due to,

- Undesirable changes brought about by the microorganisms in the odour, colour, taste, texture and appearance of the food.
- Some microorganisms may not directly involve in spoilage but bring about changes in food that will facilitate growth of spoilage organisms. Ex. Bacteriophage attacking useful organisms and facilitating growth of undesirable organisms leading to spoilage.

Useful organisms are those which by their activity or fermentation reactions facilitated by the microbial enzymes produce desirable changes in food (Ex. bakery, dairy, wine iMicroorganisms associated with food

The presence of small numbers of microorganisms associated with foods may not cause any problem, but their unrestricted growth can result in spoilage or deterioration of the food making it unfit for consumption. The wide variety of microorganisms associated with foods is mainly saprophytic. They can not be avoided in food as these are derived from the environment in which the food is prepared or processed, and also difficult to eliminate completely. However, it is possible to reduce the number or decrease their activities by altering the environmental conditions.

A variety of bacteria, molds and yeasts are important as food spoilage organisms. Important microorganisms involved in spoilage of fish are:

Bacteria

Gram Negative Bacteria

Acinetobacter, Aeromonas, Alkaligens, Enterobacter, Flovobacterium, Moraxella, Photobacterium, Pseudomonas Vibrio etc

Gram Positive Bacteria

Bacillus, Corynebacterium, Enterococcus, Listeria, Microbacterium, Clostridium, Staphalococcus, etcndustries).

Microbial toxins

Microbial toxins are toxins produced by micro-organisms, including bacteria and fungi. Microbial toxins promote infection and disease by directly damaging host tissues and by disabling the immune system. Some bacterial toxins, such as *Botulinum* neurotoxins, are the most potent natural toxins known. However, microbial toxins also have important uses in medical science and research. Potential applications of toxin research include combating microbial virulence, the development of novel anticancer drugs and other medicines, and the use of toxins as tools in neurobiology and cellular biology

Bacterial toxin

Bacteria generate toxins[2] which can be classified as either exotoxins or endotoxins. Exotoxins are generated and actively secreted; endotoxins remain part of the bacteria. Usually, an endotoxin is part of the bacterial outer membrane, and it is not released until the bacterium is killed by the immune system. The body's response to an endotoxin can involve severe inflammation. In general, the inflammation process is usually considered beneficial to the infected host, but if the reaction is severe enough, it can lead to sepsis.

Some bacterial toxins can be used in the treatment of tumors.

Toxinosis is pathogenesis caused by the bacterial toxin alone, not necessarily involving bacterial infection (e.g. when the bacteria have died, but have already produced toxin, which are ingested). It can be caused by *Staphylococcus aureus* toxins, for example

Botulinum neurotoxin

Botulinum neurotoxins (BoNTs) are the causative agents of the deadly food poisoning disease botulism, and could pose a major biological warfare threat due to their extreme toxicity and ease of production. They also serve as powerful tools to treat an ever expanding list of medical conditions.

Tetanus toxin

Clostridium tetani produces tetanus toxin (TeNT protein), which leads to a fatal condition known as tetanus in many vertebrates (including humans) and invertebrates.

Staphylococcal toxins

Immune evasion proteins from *Staphylococcus aureus* have a significant conservation of protein structures and a range of activities that are all directed at the two key elements of host immunity, complement and neutrophils. These secreted virulence factors assist the bacterium in surviving immune response mechanisms.

Viral toxin

There is only one viral toxin that has been described so far: NSP4 from rotavirus. It inhibits the microtubule-mediated secretory pathway and alters cytoskeleton organization in polarized epithelial cells. It has been identified as the viral enterotoxin based on the observation that the protein caused diarrhea when administered intraperitoneally or intra-ileally in infant mice in an age-dependent manner. NSP4 can induce aqueous secretion in the gastrointestinal tract of neonatal mice through activation of an age- and Ca2+-dependent plasma membrane anion permeability.

Toxic effects on humans

Particularly in the tropics people are often harassed by diseases and syndroms due to consumption of seafood contaminated by algal toxins. Some of these diseases may be fatal. There is currently no international record of the number of incidents of human intoxication caused by contaminated seafood. The numbers appearing in presentations at international meetings are undoubtedly underestimates, as many cases and even fatalities can be assumed to pass undiagnosed and hence unreported in the official reports.

Five human syndroms are presently recognized to be caused by consumption of contaminated seafood:

- amnesic shellfish poisoning - ASP
- ciguatera fish poisoning - CFP
- diarrhetic shellfish poisoning - DSP
- neurotoxic shellfish poisoning - NSP
- paralytic shellfish poisoning - PSP

Other threats to human health are posed by blue-green algal toxins in drinking water which may cause severe damage or be tumor promoters.

Amnesic shellfish poisoning - ASP

This syndrome can be life-threatening. It is caused by domoic acid that accumulates in shellfish, but the disease can apparently also be fish borne, so the risk to humans may be more serious than previously believed. It is characterized by gastrointestinal and neurological disorders including loss of memory. Human ASP intoxication is presently known primarily from Canada, but the causative diatoms occur in many parts of the world, so considerable care should be exercised during blooms of species of the diatom *Pseudo-nitzschia*.

Ciguatera fish poisoning - CFP

This poisoning, transmitted by several tropical reef fish, is generally not lethal, although fatalities have been documented. Ciguatera produces gastrointestinal, neurological and cardiovascular disturbances, and recovery often takes months or even years. It is widely distributed in the tropics; thus in the period 1960-1984, there were a total of 24.000 cases of ciguatera in French Polynesia alone. Evidence is accumulating that disturbances of coral reefs by hurricanes, tourist activity etc. increase the risk of ciguatera by providing more suitable habitats for the benthic dinoflagellates (see causative organisms). There is at present no easy method to routinely measure the toxins (ciguatoxin and maitotoxin) that cause ciguatera fish poisoning.

Diarrhetic shellfish poisoning - DSP

This is a wide spread type of shellfish poisoning which causes gastrointestinal disturbances with diarrhea, vomiting, and abdominal cramps. If is not fatal, and the patients usually recover within a few days. There are thousands of reported incidents from developed countries, e.g. 5000 in Spain in 1981 alone, but with the pathological picture of DSP, many incidents may be regarded as an ordinary stomach disorder, and therefore remain unreported. Chronic exposure to DSP is suspected to promote tumor formation in the digestive system.

Neurotoxic shellfish poisoning - NSP

Until recently this syndrome has been restricted to the Gulf of Mexico, but in 1993 it was reported also from New Zealand. It is characterized by gastrointestinal and neurological disturbances usually with recovery within a few days. Toxic aerosols formed by wave action may cause asthma-like symptoms.

Paralytic shellfish poisoning - PSP

This is a life-threatening syndrome with neurological effects. The is no known antidote to PSP. The known global distribution has increased markedly over the last few decades. Each year about 2000 cases of PSP are reported with 15 % mortality

Algal bloom

An **algal bloom** or **algae bloom** is a rapid increase or accumulation in the population of algae in freshwater or marine water systems, and is recognized by the discoloration in the water from their pigments.[2] Cyanobacteriawere mistaken for algae in the past, so cyanobacterial blooms are sometimes also called algal blooms. Blooms which can injure animals or the ecology are called "harmful algal blooms" (HAB), and can lead to fish die-offs, cities cutting off water to residents, or states having to close fisheries. A bloom can block the sunlight from reaching other organisms, deplete oxygen levels in the water, and some algae even secrete toxins into the water

Blooming

Since 'algae' is a broad term including organisms of widely varying sizes, growth rates and nutrient requirements, there is no officially recognized threshold level as to what is defined as a bloom. For some species, algae can be considered to be blooming at concentrations reaching millions of cells per milliliter, while others form blooms of tens of thousands of cells per liter. The photosynthetic pigments in the algal cells determine the color of the algal bloom, and are thus often a greenish color, but they can also be a wide variety of other colors such as yellow, brown or red, depending on the species of algae and the type of pigments contained therein.

Bright green blooms in freshwater systems are frequently a result of cyanobacteria (colloquially known as "blue-green algae" as a result of their confusing taxonomical history) such as *Microcystis*. Blooms may also consist of macroalgal (non-phytoplanktonic) species. These blooms are recognizable by large blades of algae that may wash up onto the shoreline.

Of particular note are the rare **harmful algal blooms** (HABs), which are algal bloom events involving toxic or otherwise harmful phytoplankton such as dinoflagellates of the genus *Alexandrium* and *Karenia*, or diatoms of the genus *Pseudo-nitzschia*. Such blooms often take on a red or brown hue and are known colloquially as **red tides**.

Why do HABs occur

Scientists know that environmental conditions trigger HABs, such as warmer water temperatures in the summer and excessive nutrients from fertilizers or sewage waste brought by runoff, but are still learning more about why HABs occur. As climate change gradually warms the earth's climate, scientists expect HABs to become more frequent, wide-ranging, and severe

Mechanisms of Harm

How do certain microscopic algae—that is, typesof**phytoplankton**—cause harm to fish, shellfish, marine mammals, seabirds, and people? Basically, there are four ways.

First, the physical presence of so many cells may suffocate fish byclogging or irritating the gills. Second, when the densely concentrated algal cells die off, the decay process, assisted by bacteria, can deplete the water of oxygen, which in turn can lead to the death of oxygen-dependent marine creatures. (Algae, being plants, require nutrients such as nitrogenand phosphorus to grow. When they have used up the nutrients, they tend to die off all at once.) Such oxygen-related impacts are most visible in shallow bays, inlets, or seas. Third, some algal species produce deadly toxins which directly kill the animals that ingest the poisons. Dinoflagellatetoxins have killed mussels,abalone, and fish. Airborne toxins (i.e., toxins that are aerosolized) have caused respiratory problems and eye and skin irritation to people along beaches where harmful algal blooms were present.

Fourth, shellfish such as mussels, clams, and oysters feed by filtering particles, including phytoplankton, from sea water. Toxins from certain dinoflagellateor**diatom**species accumulate in the tissues of shellfish. When people, sea mammals, or seabirds eat the shellfish, they ingest the toxins as well.

There are different kinds of toxins that cause different kinds of symptoms which, in humans, typically are neurological. Some toxins are deadly. The table above shows the categories of human poisoning; the organism associated with the toxicity; and the causative toxin (sometimes among a suite of toxins).

Types and Examples of Toxicity

The algal species that can be toxic in some circumstances are not always toxic. When they are toxic, they cause harm by being eaten by larger organisms. As a toxin is passed up the**food chain**, it becomes concentrated in larger and larger animals such as fish and shellfish, and eventually is ingested by people who eat seafood containing the toxin. In the following overview, only two examples of the various algal species known to cause toxicity are discussed.

Pfiesteria.

An exception to toxin transmission up the food chain is the dinoflagellatePfiesteria. Instead of being eaten, it does the eating—usually small organisms but also fish. It uses its toxins to make the fish lethargic and to injure the fish's skin.

Toxins can also get into the air and cause harm to people, as happened in 1991 when this peculiar organism was first discovered in a laboratory in North Carolina. Later it was found in connection with fish kills in the Albemarle–Pamlico**estuary**and other estuarine environments on the U.S. Atlantic and Gulf of Mexico coasts. Blooms of the more common dinoflagellate,*Gymnodiniumbreve*,when present in nearshore waters, can be picked up by surf and wind and carried to the seashore in the air. The microscopic organisms cause skin and eye irritation in people exposed to this toxic**aerosol**.

A red-tide dinoflagellate typically has a vegetative stage, in which it multiplies by cell division, and a cyst stage, in which two cells combine to form**gametes**enclosed in a cyst (a type of covering). The cysts sink to the seafloor until conditions are favorable for a return to the vegetative stage.

The*Pfiesteria*organism has a minimum of twenty-four stages in its life cycle, of which at least four are toxic. The life stages include flagellated cells that swim in the water, amoeboidforms both in the water and in bottom muds, and cysts that rest on the bottom. The different forms vary in size from too small to see with an ordinary microscope, to a speck visible to the naked eye.

Most of the time, the*Pfiesteria*dinoflagellate is a nontoxicpredator that feeds on small organisms such as algae, bacteria, and small animals. It becomes toxic when cyst forms detect fish excretions or secretions. Encysted cells emerge and become toxic. They damage the fish with the toxin, then feed on the epidermal tissue, blood, and other substances that leak from sores on the incapacitated fish. When the fish are dead, the cells change to the amoeboid stages and feed on the fish carcass.

Pseudo-nitzschia.

Diatoms are single-celled marine or fresh-water algae that have shell-like structures, called frustules, made of silica. Until recently, diatoms were not associated with biotoxin poisonings. But in 1987, an outbreak of domoic acid poisoning was reported in Canada. The domoic acid came from a diatom,*Pseudo-nitzschia.*Domoic acid has caused permanent memory loss and death in humans.

In 1991, examination of the stomach contents of dead seabirds found along the beaches of Monterey Bay, California revealed high levels of domoic acid. The birds had been eating anchovies which had been consuming*Pseudo-nitzschia.*In 1998, sea lion deaths on the California coast also were associated with domoic acid, which entered the food chain via toxigenic diatoms, which were eaten by anchovies that in turn were eaten by the sea lions. To prevent human illness when such toxicity is found, state health departments temporarily close beaches and federal regulatory agencies temporarily close fisheries and shellfisheries along the affected coast.

How are people exposed?

During a HAB, people can get exposed to toxins from fish they catch and eat, from swimming in or drinking the water, and from the air they breathe. In recent years, there have been numerous instances of HABs in lakes that provide drinking water, like Lake Erie. Importantly, cooking contaminated seafood or boiling contaminated water does not destroy the toxins.

People rarely get sick from HAB-related toxins in commercial seafood, however, because state regulators closely monitored fisheries for HABs and close them during blooms.

People can prevent exposure to HABs by following local health advisories regarding the safety of recreationally caught seafood and drinking water sources.

Human Impacts and Intervention

Although the economic impacts of HAB outbreaks has not been quantified on a national basis, the direct and indirect costs to even a single fishery closure can reach millions of dollars. In addition to loss of revenue to fish and shellfish industries, there are impacts on recreational fishing and tourism and their associated businesses.

Harmful algal blooms also can threaten the**aquaculture**industry. For example, unpredictable and destructive blooms of the small flagellate*Heterosigma*have threatened the commercial farmed salmonindustry in Washington state (USA) and British Columbia (Canada).*Heterosigma*blooms also have destroyed some captive populations of threatened and endangered salmon being raised in**netpens**before their release to the wild.

All of the U.S. coastal states have developed monitoring programs with regular testing of fish and shellfish from beaches. Officials and volunteers watch the shores for patches of colored water, fish kills, the beaching of marine mammals and other unusual activity, or reports of human illness following consumption of fish or shellfish. When toxins show up in laboratory analyses of samples of edible species, warnings are issued and shellfish harvesting and some kinds of fishing may be halted. Economic losses can be high when commercial fishing andaquacultureoperations (including fish and shellfish farms) are affected.

To better manage the human risk associated with HABs, scientists are continuing to research methods of rapid analysis to identify toxic phytoplankton species and to detect marine biotoxins in water, phytoplankton, and animals. Better monitoring can help decrease the incidence of overly conservative fishery closures by delineating the extent of the threat, thus reducing the need for broad-scale closures due to lack of information.

The Harmful Algal Bloom and Hypoxia Research and Control Act was enacted in 1998. The act recognizes that HABs threaten coastal ecosystems and endanger human health. A national assessment, published in early 2001, recognized the threat to human health and coastal economies, but found that management options are limited. HAB impacts can be minimized through monitoring programs that regularly sample shellfish to detect HAB toxins, and issue warnings when toxins are found. Satellite remote sensing can track offshore blooms, alerting coastal communities to potential problems as blooms come inshore.

What are the health effects of harmful algal blooms?

Depending on the type of algae, HABs can cause serious health effects and even death. For example, eating seafood contaminated by toxins from algae called *Alexandrium* can lead to paralytic shellfish poisoning, which can cause paralysis and even death. The algae *Pseudo-nitzschia* produces a toxin called domoic acid that can cause vomiting, diarrhea, confusion, seizures, permanent short term memory loss, or death, when consumed at high levels.

HABs that occur in freshwater, like the Great Lakes and other drinking water sources, are dominated by the cyanobacteria *Microcystis*. This organism produces a liver toxin that can cause gastrointestinal illness as well as liver damage.

As with many environmental exposures, children and the elderly may be especially sensitive to HAB toxins. Populations that rely heavily on seafood are also at risk of long term health effects from potentially frequent, low level exposures to HAB toxins

Other impacts from HABs

In addition to health concerns, HABs can damage the environment by depleting oxygen in the water, which can cause fish kills, or simply by blocking sunlight from reaching organisms deeper in the water. The economic impacts of HABs to fisheries and recreational areas can also be extensive. Closed fisheries can lose millions of dollars in revenue each week

harmful Algal Blooms & the Environment

A HAB can occur in fresh, marine (salt), and brackish (a mixture of fresh and salt) water bodies around the world [1-4]. HABs have occurred in every region of the United States [5]. Over 50% of states report a HAB every year in a freshwater body, and all coastal states report HABs in marine waters HABs are caused by organisms called phytoplankton, some of which can produce toxins [7,8]. Cyanobacteria, a type of phytoplankton also known as blue-green algae, are often the cause of algal blooms in fresh water and occasionally in marine water [1,2]. Dinoflagellates, a different type of phytoplankton, are the most common cause of HABs in marine waters. Diatoms, another type of phytoplankton, have also been found in marine and brackish waters, including estuaries [3]. Various factors can cause rapid growth, or blooming of these organisms, including:

- Increases in nutrient levels (for example phosphorus and nitrates) from fertilizer run-off from residences and agricultural lands, sewage discharges, and run-off from urban areas and industrial facilities
- Changes in nutrient levels associated with ocean upwelling (El Niño, El Niña)

- Low water flows, such as those associated with drought
- Changes in water temperature, particularly increases in temperature
- Changes in chemical factors such as pH or turbidity
- Changes in ocean currents
- Changes in the local ecology (how organisms interact with each other)

Climate change might increase the occurrence, severity, and impact of HABs in fresh, marine, and brackish waters. For example, warming temperatures in Lake Erie have resulted in more extensive blooms of the cyanobacteria *Microcystisaeruginosa,* that last into the early winter months. In the past several years, HABs have been observed with increasing frequency and in more locations in the United States. The National Centers for Coastal Ocean Science (NCCOS)External is working to monitor and address the impacts of climate change on HABs.External HABs have been documented and monitoredExternalregionally by the NCCOS in the Gulf of Mexico, the Great Lakes, the Northeast, the Pacific Coast, the Southeast, and the Caribbean/Pacific Islands.

Direct exposure to algae

Harmful algal blooms sometimes create toxins that are detrimental to fish and other animals. After being consumed by small fish and shellfish, these toxins move up the food chain and can impact larger animals like sea lions, turtles, dolphins, birds and manatees.

Even if algal blooms are not toxic, they can negatively impact aquatic life by blocking out sunlight and clogging fish gills

Dead zones and hypoxia

Nutrient pollution can create dead zones - areas in water with little or no oxygen - where aquatic life cannot survive. Also known as hypoxia, these areas are caused by algal blooms consuming oxygen as they die and decompose. Aquatic animals - particularly young fish and seafloor dwellers like crabs and clams - must leave the affected area to survive.

Over 166 dead zones have been documented nationwide, affecting waterbodies like the Chesapeake Bay and the Gulf of Mexico. The Gulf of Mexico dead zone is the largest in the United States, measured to be 5,840 square miles in 2013. It occurs every summer because of nutrient pollution from the Mississippi River Basin, an area that drains 31 upstream states. The Mississippi River/Gulf of Mexico Hypoxia Task Force coordinates nutrient management in this area.

Prevention and Mitigation of Harmful Algal Bloom Impacts

HABs can have a major impact on natural resources, strongly influencing utilization of those resources. The most obvious example is the occurrence of human illness and death from consumption of shellfish that have become toxic from ingestion of toxic HABs. To protect human health, state agencies are required to regulate harvesting of shellfish, but decisions are often made in the absence of information about how shellfish accumulate and depurate toxins or data about a particular toxic event. Similarly, HABs cause mortality of fish, birds, marine mammals, and turtles. Little is known about the mechanisms by which toxins cause mortality, what impacts this has on fisheries or protection of endangered species, and how the impacts can be minimized. Finfish and shellfish in mariculture facilities are particularly susceptible to HABrelated mortality, but can also promote HAB formation if nutrient effluents are not managed properly. Conversely, human resource utilization can cause or influence the occurrence and persistence of HABs. Human activities can increase nutrient inputs through changes in land-use patterns or changes in the hydrology of an area, facilitating occurrence of HABs. The cells and/or resistant resting cysts of HAB species can be transported to new areas in ballast water or in live shellfish, where they may thrive and threaten human and ecosystem health. Thus, natural resource managers, elected officials and the public must have an understanding of the causes and impacts of HABs that can be used as a basis for preventing or minimizing their adverse effects on the economy, public health, and marine systems.

Control of Harmful Algal Blooms Human efforts to control insects, diseases, and fungi are common agricultural practices on land, and control of freshwater HABs has been a significant component of public utility management of drinking, agricultural, and recreational water supplies, but similar attempts to control unwanted plants or animals in the ocean are rare or more limited in scope (Anderson 1997). Physical, chemical, and biological control measures have been used in freshwater systems for small and large-scale control of HABs due to their significant public health, economic, and ecosystem impacts (Chorus and Bartram 1999). Given that HABs in the ocean have similar impacts, these phenomena would appear to be legitimate targets for control efforts, and other countries - notably Japan and Korea - have invested heavily in research on the topic. However, research on this topic has been minimal in the United States, presumably because of over-riding concerns about costs, effectiveness, and environmental impacts. Other than one unsuccessful attempt to control a red tide bloom in Florida 45 years ago, field testing of methods to control major blooms in the marine environment has not been seriously considered in the United States. Furthermore, no federal agency has been given the responsibility for marine pest management in the way that the U.S. Department of Agriculture has been given this responsibility for agricultural pests. Approaches to direct bloom intervention can be grouped into three categories: mechanical, physical/chemical, and biological control. Mechanical control involves the use of filters, pumps, and barriers (e.g., curtains, floating booms) to remove or exclude HAB cells, dead fish, or other bloom-related materials from impacted waters. Physical/chemical control involves the use of chemical or mineral compounds to kill, inhibit, or remove HAB cells. Biological control involves the use of organisms or pathogens (e.g., viruses, bacteria, parasites, zooplankton, shellfish) that can kill, lyse, or remove HAB cells.

Bloom control efforts need not be massive and worrisome. For example, not all blooms are large in scale – many are small and localized. Where the times and places of bloom initiation can be discreetly defined, control efforts applied then and there could cover a small area but potentially have a significant impact on bloom magnitude and spatial extent. Reduction in the size of a bloom in one year might result in smaller blooms in future years due to a decrease in cysts or surviving cells that might serve as a bloom inoculum. Control efforts might also be justified in emergency situations where an endangered species or other valuable resource is threatened by a HAB, and when the benefits from prompt and effective intervention would outweigh possible negative environmental impacts. The recent discovery of the highly invasive macroalgal species Caulerpataxifolia (see photo at right) in southern California (Jousson et al., 2000) might be an example where drastic control measures are justified by the extreme threat to coastal resources, as proven in the Mediterranean where this introduced species has overgrown hundreds of kilometers of coastline.

Algae control methods

The presence of **cyanobacteria is a severe and global problem**. When it comes to lakes or bigger ponds, the current methods all have their advantages and disadvantages. While some methods are environmentally unfriendly (Algaecides), other methods are expensive (Aeration). The next chapter will also explain the new concept of combining real-time water quality monitoring, web-based software and ultrasound to monitor, predict and control algal blooms in large water surfaces. To treat and control the growth of algae, current options that are commonly used include the following four main methods:

1. Chemicals
2. Aeration
3. Mixing
4. Ultrasound

1. Chemicals

Chemical intervention involves treating the water with a variety of additives, such as alum, lanthanum, or any other products that precipitate or sequester the ionized orthophosphates. Aquatic herbicides used to treat algae are called algaecides and are often copper-based compounds, such as copper sulfate, copper chelate communes or the chemical Endothall. Care must be taken in the use of algaecides because they can cause algal cell rupture, which can result in intracellular toxins being released into the water reservoir. A rapid decay of an algal bloom may result in the release of high concentrations of algal toxins into the water. In addition, the potential long-term effect of chemicals on the ecological balance of the entire lake is a serious factor that needs to be considered.

2. Aeration

Aeration is used to increase the level of oxygen in the water. Aeration is an environmentally friendly technique to maintain and rejuvenate water bodies. To eliminate chemical use and create a healthy ecosystem, aeration systems can be used. It is important to maintain healthy levels of dissolved oxygen in your pond because the oxygen aids in the breakdown of decaying vegetation and other nutrients that find their way into the water.

This breakdown of the bottom silt is carried out by microorganisms where the water meets the soil. The decomposition is carried out by both aerobic and anaerobic bacteria. Aerobic decomposition requires a continuous supply of oxygen and proceeds more rapidly as dissolved oxygen concentrations are near saturation levels. The primary result of aerobic bacteria decomposition is carbon dioxide. Anaerobic decomposition is slower than aerobic decomposition, and the end products are organic compounds such as alcohols and foul-smelling organic acids.

The disadvantages of this technology are the high costs for maintenance (labor costs) and energy use. Since aeration does not kill the algae directly, the efficiency of this technology against algae is not always certain.

3. Mixing

The main function of mixers in a reservoir is destratification, which is a process in which the water is mixed to eliminate stratified layers (Epilimnion, Metalimnion, Hypolimnion: see figure below) and make it less favourable for algae growth in certain layers.

To control algae effectively, it is usually advised to circulate Epilimnion and Metalimnion to keep iron, manganese, and anoxic odors that commonly occur in the Hypolimnion layer away from the surface water.

The disadvantage of the mixing or circulation of water is often the high maintenance required to the systems regarding wear and tear, and the fluctuating results the systems can have on algae blooms.

4. Ultrasound

Ultrasound are sound waves with frequencies higher than the upper audible limit of human hearing (22 kHz). At specific frequencies, these **sound waves can be used to control algae growth (video)**.

Cyanobacteria use gas vesicles for buoyance and depth regulation. During the day, algae are photosynthesizing in the top layer, using carbon dioxide and dissolved nutrients from the surrounding water to produce oxygen and polysaccharides. At night, the cyanobacteria cells empty their gas vesicles (vacuole) to sink to the bottom and use oxygen and nutrients to produce biomass.

Ultrasound waves create a sound layer in the top layer of the water. The sound layer has a direct impact on the buoyancy of the algae. The algae cells will sink to the bottom and are unable to photosynthesize and eventually die due to a lack of light.

The MPC-Buoy uses four ultrasonic transmitters for complete 360 algae control in lakes

Controlling algae with ultrasound is a well-established technology that has existed for many years. It is an environmentally-friendly technology that is harmless to fish and plants. It is, however, important for the efficiency of the technology that specific frequency programs be used, based on the type of algae that requires controlling. Due to the adaptability of algae during seasons within a lake, the ability to change these ultrasonic frequencies is of **importance for long-term algal control**.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB COURSE NAME: MARINE MICROBIOLOGY

COURSE CODE: 19MBU105A BATCH-2018-2021

UNIT-3

		Option A	**Option B**	**Option C**	**Option D**	**Answer**
1	The bacteria which causes salmonellosis is	*Salmonella*	*Clostridiun*	*Campylobacter*	*Staphylococcus*	*Salmonella*
2	Bacteria which live in intestunal tract of humans and other animals	*Salmonella*	*Clostridiun*	*Campylobacter*	*Staphylococcus*	*Salmonellla*
3	*C.perfringens is sometimes refferd to as*	Listeria	Buffet germ	Danger zone	Norovius	Buffet germ
4	*Campylobacter is a conmon cause of*_____	Ingestion	Vomiting	Nausea	Diarrhoea	Diarrhoea
5	_____reduces the number of campylobacter bacteria in sea food	Drying	Freezing	Sterilization	Boiling	Freezing
6	The bacteria which is commonly found in skin,throats,nostrilsof healthy people is	*Clostridium*	*Campylobacter*	*Staphcoccus*	*Streptococcus*	*Staph*
7	Staphylococcal toxins are heat resistant and cannot be destroyed by	Boiling	Cooking	Freezing	Drying	Cooking
8	Most strains of _____are harmless,some can make you very risk	*Clostridium*	Campylobacter	*E.coli*	Staph	*E.coli*
9	*Listeria monocytogenes bacteria causes*	Salmoneosis	Listeriosis	Toxiosis	Taxoplasmosis	Listeriosis
10	Listeria can grow at _____temperature where most other bacteria cannot grow	Hot	Low	Refrigrated	Moderate	Refrigrated
11	_____is one of the leading causes of food poisoning	Listeria	Abolavirua	Poliovirus	Norovius	Norovirus

12	_____is the parasiTe that causes txoplasmosis	Toxoplasma	Norovirus	Listeria	Campylobacter	Toxoplasma
13	____also can be spread to infants if a mother has become infected before or while pregnant	Norovirus	Toxoplasma	*Campylobacter*	Listeria	Toxoplasma
14	Which water is generaly have low microbia load because offiltration effect of soil layers	Ground	Subterraenean	Both a and b	None	Both a and b
15	Microorganism nature to the water body is called	Water body	Primary source	Transient flora	Natural.flora	Natural flora
16	Microorganism entering from the outer environment is celled	Water body	Primary source	Transient flora	Natural flora	Transient flora
17	Which removes the microorganisms.from the air	Rain	Snow	Both a and b	None	Both a and b
18	Microorganisms associated foods are divided into __grouos	2	3	4	5	3
19	Example for semiperishable foods	Potato	Tomato	Both a and b	salt	both a and b
20	Stable food become unstable when the moisture content	Increases	Decreases	High	Low	Increases
21	Example of gram negative bacteria	*Acinetobacter*	*Actinobacter*	*Bacillus*	Listeria	Actinobacter
22	Example of gram.positive bacteria	*Moraxella*	*Bacillus*	*Enterobacter*	Aeromonas	Bacillus
23	This is the most potent.natural toxin	Listeria	Botulinum	Toxoplasma	Moraxella	Botulinum
24	____is pathogenesis caused by bacterial toxin	Listeriosis	Diarrhea	Toxoplasmosis	Toxinosis	Toxinosis
25	Toxinosis is caused by	Campylobactreer	Botulinum	*Stapyhlococus aureus*	Listeris	*Staphylococcus aureus*
26	Which are the causative agents of the deadly food poisoning	Botulinum	Virus	Staph	Tetanus	Botulinum
27	*Clostridium tetanus produces_____toxin*	Botuinum	Virus	Staph	Tetanus	Tetanus
28	*Staphylococcus aureus produces____toxin*	Botulinum	Virus	Staph	Tetanus	Staph
29	Which can induce aquous secretion in gastrointestinal tract of mice	ASP	TeNT	BoNTs	NSP4	NSP4

30	Amnesic shellfish poisoning	ASP	Asp	asP	ACP	ASP
31	Ciguatera fish poisoning	Csp	csP	CFP	csp	CFP
32	Neurotoxic shellfish poisoning means	NSP	nsp	Nsp	NCP	NSP
33	Paralytic shellfish poisonong means	PSP4	Psp	psp	PSP	PSP
34	Diarrhetic shellfish poisoning means	PSP4	PSP	psp	Psp	PSP
35	The syndrome which is life threatening is	DSP	Asp	CFP	PSP	ASP
36	Toxic aerosols caused by wave action may cause	Asthma	Nausea	Vomiing	Diarhea	Asthma
37	Each year of about 2000 cases of PSP are reported with __mortality	15%	10%	28%	5%	15%
38	Cyanobacterial blooms are also known as	Harmful	Algal	Artificial	Natural	Algal
39	Blooms which can injure animals or the ecology are called harmful______bloom	Algal	Viral	Artificial	Natural	Algal
40	Bloom which often take on red or brown hue is called	Red tides	Brown tide	Both a and b	Green tide	Red tide
41	______toxins have killed mussels,abaloneand fish	Pfiesteria	Algal	Dinoflagelle	Diatoms	Dinoflagellat e
42	HABs,which are algalnbloom even involving toxic or phytoplankton such as	Dinoflagelate	Diatom	Listeria	Karenia	Dinoflagellat e
43	The pfesteria organism has a minimum of ___stages	22	23	24	25	24
44	The pfesteria dinoflagellate is a ____predator that feeds on small organisms	Harmless	Harmful	Toxic	Non toxic	Non toic
45	____acid came from a diatom,pesudo-nitzschia	Domic	Acidic	Treeric	Algic	Domic
46	Harmful algal blooms can threaten the_____industry	Sericulture	Aquaculture	Agriculture	Horticulture	Aquaculture
47	____blooms also have destroyed some captive populations of endangerred sps	Listeria	Norovitos	Pfisteria	Heterosigma	Heterosigma
48	The harmful algal bloom and hypoxia research and control act was enacted in	1918	1988	1998	1997	1998

49	The algae _____produces a toxin called domoic acid	Pseudonitzschia	Microsystis	Cyanobacteria	Alexandrium	Pesudonitzschia
50	The graet lakes and other drinking water resources are dominated by	Alexandrium	Cyanobacteria	Microcystis	Pesudofitzschia	Microcystis
51	Dinoflagelate is type of	Zooplankton	Phytoplakton	Both a and b	None	Phytoplankton
52	Diatoms are found in	Brackish water	Marine water	Both a and b	None	Both a and b
53	Watering tempratures in lake erie have resulted in blooms of cyanobacteria	Alexandrium	Pesudofitzschia	Microcystis	Diatoms	Microcystis
54	Nutrient pollution canncreate dead zones area in water	Hypoxia	Hyperemia	Mypoxia	Hypoxia	Hypoxia
55	Which is the largest dead zone in the world	Gulf of Mexico	Gulf of Mannar	Greenland	None	Gulf of Mexico
56	The presence of _____is a severe and globalproblem	Fungi	Algae	Cyanobacteria	Bacteria	Cyanobacteria
57	Aquatic herbicides used to treat algae are caled	Herbicide	Algaecides	Pesticides	Insecticides	Algaecides
58	The main function of mixers ina reserciour is	Ammonification	Nitogen fixation	Destratification	Nitrification	Destratification
59	The audible limit of human hearing is	22khz	20khz	23khz	12khz	22khz
60	The MPC-Buoy uses four ultrasonic transmitters for complete____algae control in lakes	360	320	36	32	360

UNIT-4

Microbiological Degradation of Xenobiotics

Many kinds of xenobiotics (Gk. xenos = foreign) occur in the waste effluents produced by the manufacture and consumption of all the commonly used synthetic products.

Xenobiotics that are released into the environment on a large scale are numerous different halogenated aliphatic and aromatic compounds, nitro-aromatics, phthalate esters, and polycyclic aromatic hydrocarbons.

These compounds enter the environment as components of pesticides, fertilizers, and herbicides. Many toxic xenobiotics are progressively more concentrated in each link of a food chain, a process called bio-magnification

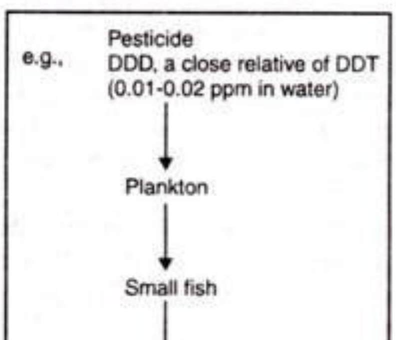


Fig. 9.3. Biomagnification of a pesticide through food chain. Organisms at the peak of food chain contain maximum amount of the pesticide.

Microbial degradation of xenobiotics has been thoroughly studied.

However, the term 'biodegradation' is widely used for:
(i) Primary degradation, in which the characteristic property of the original compound is disappeared;

(ii) Environmentally acceptable biodegradation, in which the minimum alteration of the parent compound necessary to remove properties occurs; and

(iii) Ultimate biodegradation, which involves the complete conversion of the parent compound to the inorganic end- products associated with the microorganism's normal metabolic processes.

However, many microorganisms capable of degrading unusual compounds have been isolated and tested. Detoxification of pollutants may involve as little as a single modification of structure to render a potentially hazardous chemical innocuous. The fate of xenobiotic compounds will depend upon many interacting factors, both extrinsic (pH photo-oxidation, weathering) and intrinsic (water solubility, stability, molecular size and charge, volatility).

The transformation of a xenobiotic compound that is available to the microbial community is determined by its entry into the cell and the degree of structural analogy between the synthetic compound and the natural compound for which the bio-degradative mechanism exists. Fortuitous metabolism and co-metabolism play important roles in the removal of xenobiotic compounds from the environment.

Gratuitous biodegradation occurs when an enzyme is able to transform a compound other than its natural substrate. It is done only when the unnatural substrate is able to bind to the active site of the enzyme in such a manner that the enzyme can exert its catalytic activity.

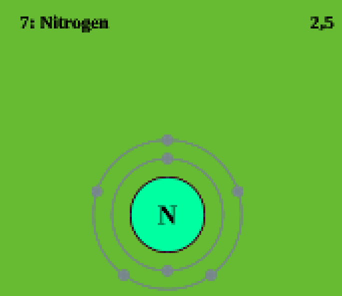
Many bacteria and fungi produce enzymes that are able to act on a wide range of organic compounds. Co-metabolism is the ability of an organism to transform a non-growth substrate as long as a growth substrate or other transformable compound is also present. A non-growth substrate is one that cannot serve as the sole source of carbon and energy for a pure culture of a bacterium and hence cannot support cell division.

F

Factors affecting Bioremediation

Microorganisms have limits of acceptance for particular environmental conditions, as well as optimal conditions for peak performance. Factors that affect efficiency of microbial biodegradation are **nutrient availability**, **moisture content**, **pH**, and **temperature of the soil matrix**.

-Nutrient availability



Inorganic nutrients such as nitrogen and phosphorus are necessary for microbial activity and cell growth. It has been shown that “treating petroleum-contaminated soil with nitrogen can increase cell growth rate, decrease the microbial lag phase, help to maintain microbial populations at high activity levels, and increase the rate of hydrocarbon degradation”. However, it has also been shown that excessive amounts of nitrogen in soil cause microbial inhibition.

-Moisture content

All soil microorganisms require moisture for cell growth and function. Availability of water affects circulation of water and soluble nutrients into and out of microorganism cells. However, excess moisture, such as in saturated soil, is undesirable because it reduces the amount of available oxygen for aerobic respiration.

-pH

pH of the soil is important because survival of most microbial species are limited to a certain pH range. In addition, soil pH can affect availability of nutrients.

-Temperature

Temperature influences rate of biodegradation by controlling rate of enzymatic reactions within microorganisms. Generally, "speed of enzymatic reactions in the cell approximately doubles for each 10^{o}C rise in temperature" (Nester et al., 2001). There is an upper limit to the temperature that microorganisms can withstand. Most bacteria found in soil, including many bacteria that degrade petroleum hydrocarbons, are mesophiles which have an optimum temperature ranging from 25 degree C to 45 degree C .Thermophilic bacteria (those which survive and thrive at relatively high temperatures) which are normally found in hot springs and compost loads exist indigenously in cool soil environments and can be activated to degrade hydrocarbons with an increase in temperature to 60 degree C.
Some contaminants can stick to soil particles and microorganisms are unable to use them for biodegradation. Therefore, under these circumstances, bioavailability of contaminants does not solely depend on the characteristics of the contaminant but also on soil type

The role of microbes in the cycles of nutrients and carbon. A historical view. 2.1 The abundance of pelagic microbes. How many are there ? In spite of the obvious nature of such a question, researchers had a hard time in finding an answer, specially for the smallest protists, viruses and bacteria. In part this was due to the fact that traditional microbiological techniques relied on cultivation, and the culture media did not seem to replicate nature very well. And because of the low concentration of bacteria detected growing on plates (four to five orders of magnitude lower than the direct bacterial counts), researchers believed that the role of bacteria in the cycling of carbon and nutrients in the ocean was very limited. A linear food web consisting of phytoplankton, zooplankton and fish (the "classical" food web) dominated carbon cycling in the ocean, and the few bacteria there simply had a role in decomposing the dying organisms (Figure

1). However, this view was at odds with the fact that most of oceanic plankton respiration occurred in size classes below 1 µm, and the fact that most of the pelagic particles had sizes below 10 µm. Could it be possible that few bacteria existed in the plankton but were extremely active, with extremely large cell-specific respiration rates

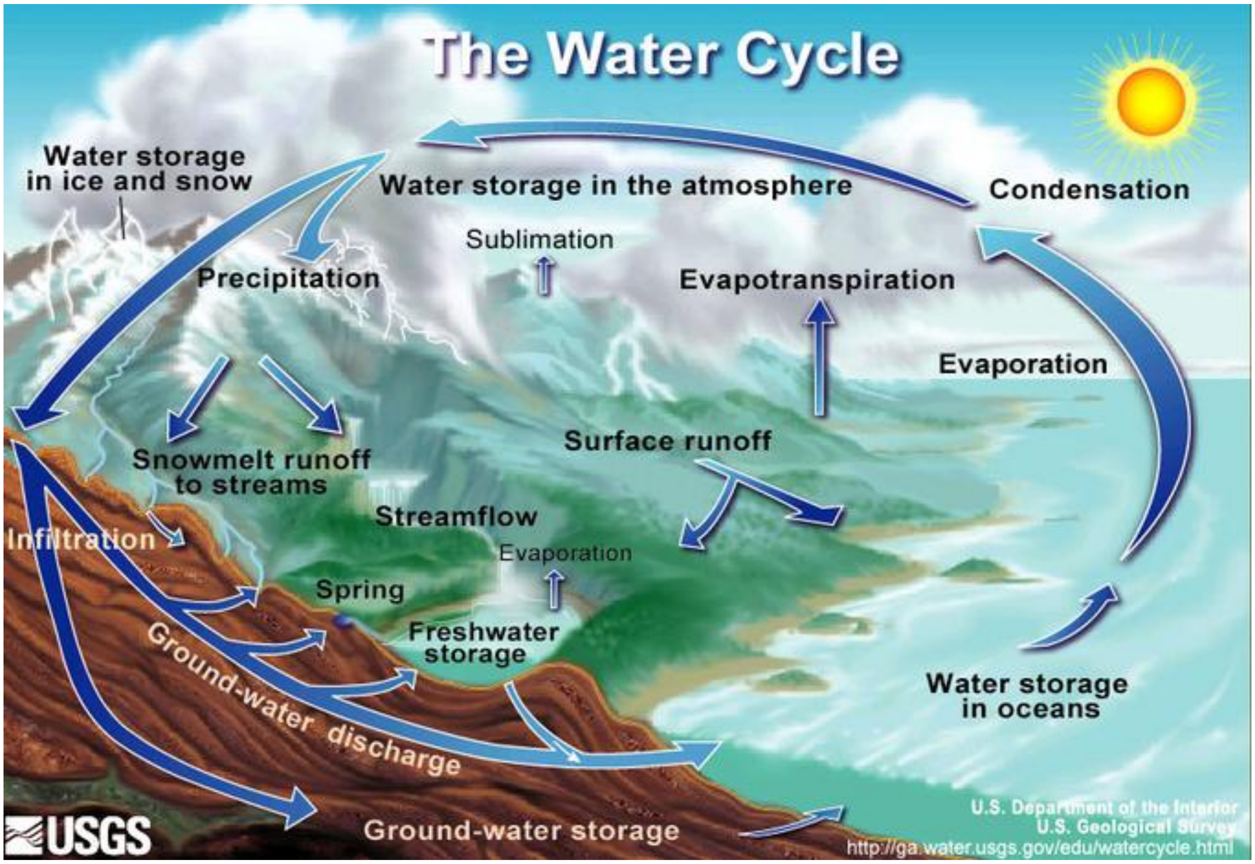
The problem was solved with the introduction of a new technique, the microscopy of cells collected in the surface of a filter and then stained with a fluorescent dye (epifluorescent microscopy) at the end of the seventies, first by Russian researchers. This new group of methods, that have been used until recently when they start to be substituted by flow cytometry, allowed the quantification of pelagic bacteria, which we now know exist inconcentrations of 105 to 106 cells ml-1 in the ocean. We could then realize that there are many bacteria in the ocean, to the point that a very important fraction of the total planktonic biomass (up to 40% in oligotrophic systems) is made up by bacteria. We also know that many pelagic ecosystems support more bacterial biomass than biomass of primary producers. A further general observation was made: while primary producers abundance can change over a large range of values (from almost 0 up to very large abundances – i.e. 105 cells ml-1), bacterial abundances seem to be relatively stable over time, ranging from a minimum of ca. 105 up to a maximum (in marine plankton) of ca. 8 x 106 cells ml-1. As in any breakthrough, not all oceanographers accepted that microbes had such an important role in the cycling of carbon in the ocean. The hypothesis that most of the detected microbial biomass was dead or inactive and thus, not a dynamic part of the pelagic community, was soon posted.

The growth and production of bacteria Answer of this question required again strong efforts in method development. The first methods that were used, like the dark incorporation of CO2, generated little uncontested data. Microbial ecologists were searching for a universal substrate that could simply and reliably provide microbe growth rate estimates with minimal experimental disturbances to natural populations. While some still think that the feasibility of achieving this goal is remote, the incorporation of nucleotide precursors of DNA (mainly thymidine) and aminoacid protein precursors (mainly leucine) are reliable methods that are currently used, not without problems, to estimate bacterial growth rates and bacterial production. The first results with these techniques, at the beginning of the 80s allowed the measurement of rates of growth of the same order than those of phytoplankton (biomass duplication times of 2-15 days for bacteria are common as are biomass duplication times of 1-6 days for phytoplankton

Microbial Role in Biogeochemical Cycling

Nutrients move through the ecosystem in biogeochemical cycles. A biogeochemical cycle is a pathway by which a chemical element (such as carbon or nitrogen) circulates through the biotic (living) and the abiotic (non-living) factors of an ecosystem. The elements that move through the factors of an ecosystem are not lost but are instead recycled or accumulated in places called reservoirs (or "sinks") where they can be held for a long period of time. Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another through these biogeochemical cycles.

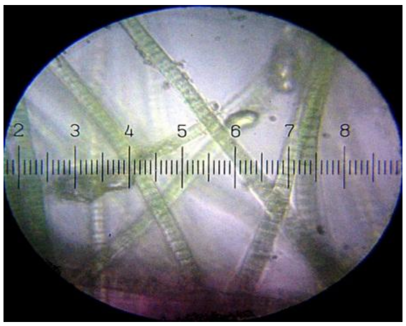
Ecosystems have many biogeochemical cycles operating as a part of the system. A good example of a molecule that is cycled within an ecosystem is water, which is always recycled through the water cycle. Water undergoes evaporation, condensation, and then falls back to Earth as rain (or other forms of precipitation). This typifies the cycling that is observed for all of the principal elements of life.



Although biogeochemical cycles in a given ecosystem are coordinated by the full complement of living organisms and abiotic factors that make up that system, microorganisms play a primary role in regulating biogeochemical systems in virtually all of our planet's environments. This includes extreme environments such as acid lakes and hydrothermal vents, and even includes living systems such as the human gut. The key collective metabolic processes of microbes (including nitrogen fixation, carbon fixation, methane metabolism, and sulfur metabolism) effectively control global biogeochemical cycling. Incredibly, production by microbes is so immense that global biogeochemistry would likely not change even if eukaryotic life were totally absent!

Microbes comprise the backbone of every ecological system, particularly those in which there is no light (i.e. systems in which energy cannot be collected through photosynthesis). Two key examples of critical biogeochemical processes carried out by microorganisms are discussed below.

The Carbon Cycle



Cyanobacteria: Cyanobacteria, also known as blue-green bacteria, blue-green algae, and Cyanophyta, is a phylum of bacteria that obtain their energy through photosynthesis

Carbon is critical for life because it is the essential building block of all organic compounds. Plants and animals utilize carbon to produce carbohydrates, fats, and proteins, which can then be used to build their internal structures or to obtain energy.

Carbon in the form of carbon dioxide (CO_2) is readily obtained from the atmosphere, but before it can be incorporated into living organisms it must be transformed into a usable organic form. The transformative process by which carbon dioxide is taken up from the atmospheric reservoir and "fixed" into organic substances is called carbon fixation. Perhaps the best known example of carbon fixation is photosynthesis, a process by which energy derived from sunlight is harnessed to form organic compounds. Photosynthesis depends on the activity of microorganisms such as cyanobacteria; indeed, the fact that there is oxygen in the Earth's atmosphere at all is a consequence of the photosynthetic activity of ancient microbes.

The Nitrogen Cycle

Nitrogen is essential for all forms of life because it is required for synthesis of the basic building blocks of life (e.g., DNA, RNA, and amino acids). The Earth's atmosphere is primarily composed of nitrogen, but atmospheric nitrogen (N_2) is relatively unusable for biological organisms. Consequently, chemical processing of nitrogen (or nitrogen fixation) is necessary to convert gaseous nitrogen into forms that living organisms can use. Almost all of the nitrogen fixation that occurs on the planet is carried out by bacteria that have the enzyme nitrogenase, which combines N_2 with hydrogen to produce a useful form of nitrogen (such as ammonia).

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB COURSE NAME: MARINE MICROBIOLOGY

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UNIT-4

	Questions	**Option A**	**Option B**	**Option C**	**Option D**	**Answer**
1	Cyanobacteria also known as	Blue green algae	Cyanophyta	Alage	Bacteria	Bluegreen algae
2	Which is the phylum of bacteria that obtainnenergy from photosynthesis	Archaea	Cyanophyta	Phyophyta	Bryophyta	Cyanophyta
3	Carbom is in the form of ___	Co2	O2	H2O	Glucose	Co2
4	The process by which co2 is taken from the atm and fied into organic substances is called	Evaporation	Sublimation	Carbonfixation	Assimilation	Carbonfixation
5	Known example of carbon fixation is	Photosynthesis	Evaporation	Sublimation	Condensation	Photosynthesis
6	Which is esential for all forms of life	Water	Oxygen	Carbon	Nitrogen	Nitrogen
7	Which is primarily unusal.for biological organisms	N2	AtmN2	O2	Co2	Atm N2
8	Nitrigenfixation occes in the palnet is carried out by	Water	Algae	Bacteria	Fungi	Bacteria
9	A good example of molecule that is cycled within a ecosystwm is	Water	Co2	O2	H2O	Water
10	Water undergoes	Evaporation	Condensation	Precipitation	All of these	All of these

11	Which is the backbone of every ecological system	Microbes	Warer	Co2	O2	Microbes
12	The role of bacteria in cycling of ___and ___in the ocena was very limited	Nutrients	Carnob	Both a and b	Water	Both a and b
13	A linear food web consist of	Zooplankton	Phytoplankton	Fish	All	All of these
14	The role of microbes in the cycles is	Nutrients	Carbon	Water	Both b and c	Both b and c
15	The most of the oceanic palnkton respiration occurd in size. class	Below 1	Above 1	1	Below 2	Below 1
16	Which move tonough the ecosystem in biogeochemical cycles	O2	Nitrogen	Carbon	Nutrients	Nutrients
17	A biogeochemical cycle is a pathway by which a chemical element circulates through	Biotic	Abiotic	Growth	Both a and b	Both a and b
18	Elements move through the factors of an ecosystem are recycled in places caled	Waste treatment	Oceans	Dams	Reserviors	Reservoirs
19	Example of extreme environment	Acidlakes	Hydrothermal vents	Both	none	both a and b
20	The key collective metabolic process of microbes effectively control	Lakes	Reservior	Global biocemical cycling	None	Global biochemical cycling
21	Factors that affect the efficiency of microbes are	Nutrient	Moisture	Ph	All	All
22	Inorganic nutrients are	Carbon	Nitrogen	Phosphorous	Both b and c	Both b and c
23	The excessive ammount of nitrogen in soil cause	Microbial inhibition	Degradation	Soil infertility	Soil erosion	Microbial inhibition
24	Soil microbes require moisture for	Function	Cell growth	Growth	Both a and b	Both a and b

25	Soil ph affect availability of	Oxygen	Nutrients	Moisture	Growth	Nutrients
26	Which influences the rate of biodegradation	Co2	Water	Temperature	Ph	Temperature
27	Mesophiles have the optimum temperature of	25-45	20-40	30-45	16-18	25-45
28	The bacteria which thrive at high temperatures	Thermophilic	Basiphilic	Cyrophilic	Mesophilic	Thermophilic
29	Optimum temperatures of thermophilc bacteia are	Below69	Below 85	Above 60	None	Above 60
30	Which is important for survival of most microbes	Carbon	Nutrients	Temperature	Ph	Ph
31	Xenobiotics is derived from	Latin	Greek	Italic	None	Greek
32	Which is released into the environment on large scale	Plankton	Microbes	Toxic	Xenobiotics	Xenobiotics
33	Which is more concentrated each link of a food chain	Xenobiotics	Pesticide	Microbes	Food	Xenobiotics
34	Xenobiotics are more concentrated in each link of food chain is called	Bacteria	Xenobiotics	Biomagnification	Biodegradation	Biomagnification
35	In which the characteristic of property of the original cpd is disappeared	Primary	Environmental	Ultimate	None	Primary
36	In which the minimum alteration of the parent cpd necessary to remove property	Primary	Environmental	Ultimate	None	Environmental
37	Which involves the complete conversion of the parent cpd to inorganic end pdts	Primary	Environmental	Ultimatree	None	Ultimatree
38	What are play important role in the removal of xenobiotic compound	Xenobiotics	Biodegradation	Detoxification	Transformation	Detoxification
39	Which play ikportant role in the removal of xenobiotic compound	Fortious metabolism	Cometabolism	Both a and b	None	Both a and b
40	Which biodegradation occurs when anbenzyme is able to transform a cpd	Ultimate	Secondary	Gratuitous	Primary	Gratuitous

41	Conjugation is:	Process of drug reduction by special enzymes	Process of drug oxidation by special oxidases	Coupling of a drug with an endogenous substrate	Solubilization in lipids	Coupling of a drug with an endogenous substrate
42	What is implied by “active transport”?	Transport of drugs trough a membrane by means of diffusion	Transport without energy consumption	Engulf of drug by a cell membrane with a new vesicle formation	Transport against concentration gradient	Transport against concentration gradient
43	What kind of substances can’t permeate membranes by passive diffusion?	Lipid-soluble	Non-ionized substances	Hydrophobic substances	Hydrophilic substances	Hydrophilic substances
44	The reasons determining bioavailability are:	Rheological parameters of blood	Amount of a substance obtained orally and quantity of intakes	Extent of absorption and hepatic first-pass effect	Glomerular filtration rate	Extent of absorption and hepatic first-pass effect
45	For the calculation of the volume of distribution (Vd) one must take into account:	Concentration of a substance in plasma	Concentration of substance in urine	Therapeutical width of drug action	A daily dose of drug	Concentration of a substance in plasma
46	Biotransformation of a medicinal substance results in:	Faster urinary excretion	Slower urinary excretion	Easier distribution in organism	Higher binding to membranes	Faster urinary excretion

47	The organelle that carry Cytochorome p450 MO is	Endoplasmic reticulam	Golgi complex	Mitochondria	Mitochondria	Endoplasmic reticulam
48	Bioluminescene is formed when the oxygen combines with	Luciferin	Lucifease	Galactase	None of the above	Luciferin
49	The phase II reaction which produce a compound with greater pharmocological actvity	Glucoronic acid conjugation	Conjugation with amino acid	Methylation	Glutathione conjugation	Methylation
50	Elimination is expressed as follows:	Rate of renal tubular reabsorption	Clearance speed of some volume of blood from substance	Time required to decrease the amount of drug in plasma by one-half	Clearance of an organism from a xenobiotic	Clearance of an organism from a xenobiotic
51	Acidic drug rapidly absorbed at	Stomach	GI tract	Large intestine	Mouth	Stomach
52	Coenzyme required by Cytochorome p450 MO is	NADH	NADPH	Lipoic acid	TPP	NADPH
53	Basic drugs are absorbed in	Small intestine	Stomach	Large intestine	Pancreas	Small intestine
54	Which effect may lead to toxic reactions when a drug is taken continuously or repeatedly?	Refractoriness	Cumulative effect	Tolerance	Tachyphylaxis	Cumulative effect
55	What term is used to describe a more gradual decrease in responsiveness to a drug, taking days or weeks to develop?	Refractoriness	Cumulative effect	Tolerance	Tachyphylaxis	Tolerance
56	What term is used to describe a decrease in responsiveness to a drug which develops in a few minutes?	Refractoriness	Cumulative effect	Tolerance	Tachyphylaxis	Tachyphylaxis
57	Which drug that cross the lipid bilayer easily	Water soluble drug	Lipid soluble drug	Ionsoluble drug	Non ionsoluble drug	Lipid soluble drug

58	Science that deals with drug	Pharmacy	Pharmacognosy	Pharmacodynamics	Pharmacology	Pharmacology
59	Luciferin is made up of	Reduced Riboflavin Phosphate	Riboflavin Sulphate	Phospholipase	None of the above	Reduced Riboflavin Phosphate
60	Biopigment are also known as	Biochromes	Bioluminescence	Biocolors	All of the above	Biochromes

UNIT-5

Microalgae or microphytes are microscopic algae, typically found in freshwater and marine systems, living in both the water column and sediment. They are unicellular species which exist individually, or in chains or groups. Depending on the species, their sizes can range from a few micrometers (μm) to a few hundred micrometers. Unlike higher plants, microalgae do not have roots, stems, or leaves. They are specially adapted to an environment dominated by viscous forces. Microalgae, capable of performing photosynthesis, are important for life on earth; they produce approximately half of the atmospheric oxygen and use simultaneously the greenhouse gas carbon dioxide to grow photoautotrophically. Microalgae, together with bacteria, form the base of the food web and provide energy for all the trophic levels above them. Microalgae biomass is often measured with chlorophyll a concentrations and can provide a useful index of potential production. The standing stock of microphytes is closely related to that of its predators. Without grazing pressures the standing stock of microphytes dramatically decreases.

The biodiversity of microalgae is enormous and they represent an almost untapped resource. It has been estimated that about 200,000-800,000 species in many different genera exist of which about 50,000 species are described. Over 15,000 novel compounds originating from algal biomass have been chemically determined. Most of these microalgae species produce unique products like carotenoids, antioxidants, fatty acids, enzymes, polymers, peptides, toxins and sterols.

Seaweed, or **macroalgae**, refers to several species of macroscopic, multicellular, marine algae. The term includes some types of *Rhodophyta* (red), *Phaeophyta* (brown) and *Chlorophyta* (green) macroalgae. Seaweed species such as kelps provide essential nursery habitat for fisheries and other marine species and thus protect food sources; other species, such as planktonic algae, play a vital role in capturing carbon, producing up to 90 percent of earth's oxygen. Understanding these roles offers principles for conservation and sustainable use. Mechanical dredging of kelp, for instance, destroys the resource and dependent fisheries.

Seaweed are a source of biologically active compounds including proteins and polysaccharides with promising uses in nutrition, biomedicine, bioremediation and other uses.

What are the benefits of seaweed?

1. Benefits

2. Side effects and risks

3. How to eat seaweed

4. Takeaway

Seaweed grows in or near salty waters. There are several types, and they generally contain many healthful minerals that are easy for the body to break down. Adding seaweed to the diet may help with thyroid function, digestive health, and weight loss.

Types of seaweed include:

- nori
- kelp
- wakame
- kombu
- dulse
- blue-green algae, such as spirulina and chlorella

This variety can make it easy to incorporate seaweed into different recipes. It is possible to eat too much seaweed, however, and some people should avoid it.

The benefits of seaweed

The following are the best health benefits of seaweed:

1. It is highly nutritious

Seaweed is a rich source of iron and iodine.

Each type of seaweed may contain slightly different nutrients and minerals.

In general, however, eating this marine algae is a simple way to boost a person's intake of vitamins and minerals without adding many calories.

As a study in *Marine Drugs* notes, seaweed is generally a good supply of:

- protein
- carbohydrates
- fiber
- minerals
- polyunsaturated fatty acids

A study in the *Journal of Applied Phycology* points out that the various types of seaweed contain helpful nutrients, including:

- vitamin C
- vitamin B
- vitamin A
- vitamin E
- iron
- iodine

Seaweed also contains antioxidants, which may protect the body from oxidative stress and reduce inflammation at the cellular level.

2. It may help with thyroid function

The thyroid gland controls and releases hormones for energy production, growth, and cellular repair.

The thyroid needs iodine to function correctly, but the amount that a person requires depends on the state of the thyroid.

Iodine deficiency is one cause of hypothyroidism (underactive thyroid). It may result in the development of a goiter, a visible enlargement of the thyroid gland.

People may be able to prevent or improve hypothyroidism by ensuring that their diet contains sufficient iodine.

Hyperthyroidism occurs when the thyroid gland is overactive and produces excessive amounts of hormones. An excessive iodine intake may worsen symptoms of hyperthyroidism.

Seaweed is very rich in iodine. According to a study in the *Journal of Food and Drug Analysis*, kombu is the richest source of iodine, followed by wakame and nori. Kelp powder is also a significant source.

The type of seaweed and location in which it was grown can alter the iodine contents.

3. It may help with diabetes

Seaweed may help in the management of diabetes.

Fiber-rich foods may help with diabetes. This is because high amounts of fiber help regulateblood glucose levels and insulin levels. Adding seaweed to the diet may help increase a person's fiber intake without a large increase in calories.

A 2018 study in rats found that compounds in one type of seaweed may directly reduce markers of type 2 diabetes, such as high blood sugar.

Compounds in seaweed may also reduce diabetes risk factors, such as inflammation, high fat levels, and insulin sensitivity. Further research in humans may help provide stronger evidence for the use of these compounds.

4. It may support gut health

Bacteria in the intestines play an important role in breaking down food and supporting digestion and overall health.

Algae may be an ideal food for the gut. Authors of a study in the *Journal of Applied Phycology*report that algae tend to contain high amounts of fiber, which may make up 23–64 percent of the algae's dry weight.

This fiber can help feed the gut's bacteria. Intestinal bacteria break fiber into compounds that improve gut health and the health of the immune system.

Adding algae to the diet may be a simple way to provide the body with plenty of gut-healthy prebiotic fiber, which in turn can help with issues such as constipation or diarrhea.

5. It may help with weight loss

The fiber in seaweed may benefit people who are trying to lose weight.

Fiber helps a person feel full, but it contains very few or no calories itself.

According to the study in *Marine Drugs*, a high amount of dietary fiber delays stomach emptying. As a result, the stomach may not send signals of hunger to the brain for a longer time, which may help prevent overeating.

6. May protect the heart

As the same study notes, high-fiber foods such as algae may also reduce levels of cholesterol in the blood. These soluble fibers bind to bile acids or salts in the body.

The body then uses cholesterol to replace these elements, which may result in a decrease of total cholesterol by up to 18 percent.

Many types of algae also have high levels of antioxidants, which may also support heart health over time.

Side effects and risks

There are a few things to be aware of when adding seaweed to the diet, including:

Excess iodine

Excess iodine consumption can cause tightness around the neck.

A primary concern is the risk of consuming too much iodine.

Most seaweed contains high levels, and a person may consume too much if they eat a lot of seaweed over an extended period.

While many people can handle high levels of iodine, some are more vulnerable to its effects, which can include thyroid dysfunction.

A resulting condition could cause symptoms such as weight gain or swelling and tightness around the neck.

Anyone experiencing these symptoms should stop consuming iodine and see their doctor for a full evaluation.

Heavy metals

Another common concern involves heavy metals. Seaweed absorbs minerals and nutrients from the sea. If the surrounding water contains these metals, the seaweed will absorb them as well.

A study in *Chemosphere* found that in edible seaweed, levels of the toxic metals aluminum, cadmium, and lead are generally very low.

Also, a study in *Scientific Reports* investigated 10 potentially dangerous metals in seaweed and came to a similar conclusion, though the authors called for more research into other metals.

While levels may be low, toxic metals may build up over time in a person who eats seaweed every day. Though the general risk is low, it may be a good idea to ensure that seaweed is organic and derived from a high-quality source.

How to eat seaweed

Adding seaweed to the diet can be very simple. The big sheets of dried nori used in sushi also make a great substitution for tortillas or bread, and they can make delicious wraps.

Flavoring bean soups with kombu can reduce the risk of gas thanks to kombu's healthful enzymes.

Also, many companies produce roasted seaweed with a little oil and salt, which can be a perfect way to satisfy a salty craving.

Toasted seaweed or seaweed flakes can be a great topping for grains such as rice or quinoa and may help reduce the amount of salt or soy sauce a person needs.

For those who are not fans of seaweed's flavor, a person can slip it into a hearty vegetable soup.

Demand for food is increasing rapidly – the global population is expected to reach 11.2 billion by 2100. To keep up with the additional mouths to feed, intensive farming practices have maximised production, but often at the expense of the environment and human health.

Livestock is reared to maximise economic returns, which often means animals are kept in close confinement with each other, increasing the risk of disease. As a result, antibiotics are often used to treat animals destined for human consumption, but relying on them can cause bacteria to develop resistance in the long run. A recent review found 100 academic studies on antimicrobial resistance had detected a link between antibiotic consumption in animals and antimicrobial resistance in humans.

This means that using antibiotics in animal rearing can cause resistant bacteria that may also affect humans down the food chain. Antibiotics have been phased out of livestock rearing in the EU and in their place zinc has been introduced into the diet of animals to help kill bacteria which cause Salmonella and E. coli.

High levels of zinc in the diets of pigs and cows can help them grow bigger and kill E. coli, but it's starting to become an environmental issue in its own right. Most of the zinc fed to the animals is excreted and washed into waterways and soils where it can harm aquatic life and acidify the soil. As a result, European legislation will phase out the use of zinc by 2022.

This leaves the producers of livestock feed and farmers in a difficult position. New products are needed to prevent infection in livestock which don't harm the environment or human health by contributing to antimicrobial resistance, but where could they come from?

eat seaweed

Brown seaweeds synthesise a unique class of compound called phlorotannins as they grow. These compounds can kill bacteria that emerge among farm animals. How effectively these compounds can kill bacteria depends on the species of seaweed being used, with different species producing more potent bactericides.

The flock of North Ronaldsay sheep in Scotland have grazed on nothing but seaweed for generations. Animals raised on such diets which are rich in Omega-3 fatty acids produce healthier – and arguably tastier – meat.

Seaweed can be grown in the ocean and harvested from natural stocks in a rotational manner, ensuring natural habitats don't have to be plunderedto supply livestock farmers. Seaweed farming also doesn't have to compete for land space like traditional feed crops and could reduce pressure on agricultural land – allowing space for habitat restoration and rewilding which helps fight climate change.

Seaweed farms in the ocean draw in a lot of carbon dioxide – which helps de-acidify the seawater around them – and release oxygen. This improves the health of sea life nearby and helps organisms such as coral or sea snails to grow stronger exoskeletons of calcium carbonate.

Modern farming uses huge quantities of fertiliser which run off the land and into rivers and the ocean. There, these nutrients stimulate algae which grow and multiply. When algal blooms die and decay, they're decomposed by bacteria which absorb oxygen from the water, creating vast dead zones where fish and other aquatic life suffocate. Luckily, growing seaweed requires no fertiliser and only uses nutrients which already exist in seawater.

Global seaweed production rose from 10.5 to 28.4 million tonnes between 2000 and 2014, but 95% of this was in Asia. There's therefore huge growth potential for seaweed agriculture in the rest of the world. The brown seaweeds which produce the helpful antibacterial compounds are widespread on temperate shores, and by converting them into supplements for livestock feed, a vibrant industry that's good for humans and the environment could flourish.

Use of microalgae for food feed and bioproducts

The indigenous use of algae as food sources is an ancient practice. Many species of green algae have been utilized as food from ancient times. Cultivation of microalgae started only a few decades ago, when it became clear that the fast-growing world population was likely to suffer a lack of protein-rich food stuffs. Microalgae are an excellent source of food and other important bioproducts, such as natural antibiotics . The world energy crisis in the 1970s led to the identification of algae as renewable and sustainable sources for biofuels production, prompting the exploration of microalgae as a new field of research for fuels and other valuable products . The first large-scale culture of the microalga Chlorella for commercial purposes was reported in Japan, in the 1960s . Over the last few decades, algae culturing expanded to new fields, such as food and feed, biofuels, and biopharmaceuticals. Natural products in algal extracts are used in cosmetics and medicinal products . According to one estimate, about 5000 metric tons of dry algal biomass processed for bioproducts generates US$ 1.25 × 109 each year.

Microalgae produce a wide range of other commercially important and valuable products. They produce vitamins, which elevates their importance as a nutritional food for people and animals .They also produce different types of medicinally important polysaccharides. Various species produce bioactive and commercially important pigments, such as chlorophyll, β-carotene and other carotenoids, phycobiliproteins, and astaxanthin. These pigments are crucial in therapies for tumorigenesis, neuronal disorders, and optical diseases. Microalgae are also rich sources of protein. Their production of essential amino acids increases their potential for use as protein-rich foods .Microalgae synthesize starch, cellulose, hemicelluloses, and other polysaccharides from simple monomeric sugars: basically, glucose. The higher amounts of carbohydrates in algal cells make them an important food source . Microalgae also produce and accumulate large amounts of lipids, which vary among species and are affected by various factors . Lipids in algal cells are present mainly in the form of glycerol, esterified sugars to different types of fatty acids (12–22 carbon atoms). Algal fatty acids have nutritional and medicinal applications. Most of the substances produced by microalgae have therapeutic effects. Therefore, a new area of research is extracting and identifying substances from microalgae and determining their biological and medicinal activities. Microalgae are becoming economical sources of natural substances for use as food and in cosmetics .

Pharmaceuticals on the market mainly consist of tablets or liquid forms of health-promoting substances, but several microalgae species are available as a supplement of various active substances in extract form, a new trend in the market. The microalgae market is growing due to the increasing demand for beneficial algal food and health products . Polyunsaturated fatty acids produced by microalgae are important commercial products of high therapeutic value for cardiac diseases, asthma, and arthritis . Many important microalgae products, such as eicosapentaenoic acid and docosahexaenoic acid (DHA), have been marketed by various biotechnological companies. Some species of microalgae produce protective substances against free radicals to prevent oxidative stress. These compounds are utilized as antioxidants in nutraceuticals and foods.

Researchers are taking a keen interest in algal substances with antioxidant properties that may be used in beverages and functional foods. These natural substances are highly important in pharmaceutical formulations for the treatment of free radicals and oxidative stress–associated diseases and complications. Blue-green microalgae (cyanobacteria) are rich in various pigment compounds that enhance the efficiency of light energy utilization (phycobiliproteins) and protect photosynthetic pigments from photo-oxidation (carotenoids). Currently, microalgae products with high nutritional value are available both in pure form as extracts, tablets, or capsules and as additives to several food products, such as candy bars, gums, pastas, and beverages. These products are either used as nutrients or food coloring agents. Many microalgae strains, such as *Aphanizomenonflos-aquae, Chlorella, and Arthrospira*, are being cultured at a commercial scale for their high protein content and other health-promoting substances. These products reportedly have important biological effects, such as anti-hyperglycemia and antihyperlipidemia, which are helpful in diabetes and obesity control because they affect the elevated serum glucose level.

Microalgae used as live food

Chaetoceros sp.[7]	Aquaculture[7]
Chlorella vulgaris[8]	Source of natural antioxidants[8]
Dunaliellasalina[9]	Produce carotenoids (β-carotene)[9]
Haematococcus sp.[10]	Produce carotenoids (β-carotene), astaxanthin, canthaxanthin[10]
Phaeodactylumtricornutum[8]	Source of antioxidants[8]
Porphyridiumcruentum[8]	Source of antioxidants[8]
Rhodella sp.[7]	Colourant for cosmetics[7]
Skeletonemasp[7]	Aquaculture[7]
Arthrospira maxima[11]	High protein content – Nutritional supplement[11]
Arthrospira platensis[11]	High protein content – Nutritional supplement
In formulated feed ingredient	Arthrospiraplatensis (Cyanophyceae); Chlorella vulgaris, C.minutissima, C.virginica, Dunaliellatertiolecta, D. salina,

	Haematococcuspluvialis (Chlorophyceae)
Feed for bivalve mollusks	Thalassiosirapseudonana (Bacillariophyta); Pavlovalutheri (Haptophyta); Isochrysisgalbana Chlorella minutissima, Gomphonemasp, Isochrysisgalbana, Nitzschiasp, Phaeodactylumtricornutum, Tetraselmissubcordiformis. Tetraselmissuecica, T.chui (Chlorophyceae); Chaetoceroscalcitrans,C. gracilis; Skeletonemacostatum.
Rotifer and Artemia live prey	Crypthecodiniumcohnii (dinoflagellates); Schizochytrium sp.; Ulkenia sp. Chlorella sp, Chlamydomonassp, Nannochlorisoculata, Tetraselmistetrathele and T. chuii.
Feed for crustacean larvae ((shrimps, lobsters))	Tetraselmissuecica, T.chui (Chlorophyceae); Chaetoceroscalcitrans, gracilis; Skeletonemacostatum; Thalassiosirapseudonana (Bacillariophyta).
Feed for gastropod molluscs and sea urchins	Nitzschia sp. ; Navicula sp.; Amphora sp.
Green water" for finfish larvae	Isochrysisgalbana; Nannochloropsisoculata

Microalgae for Zooplanktonic Live Prey Microalgae have an important role in aquaculture as a means of enriching zooplankton for feeding to fish and larvae (Chakraborty et al., 2007).The predatory finfish larvae and decapod crustacean larvae is to feed with zooplanktonic live prey rather than formulated inert diets.This reflects the technological challenge and high costs of providing nutritionally balanced feeds in the correct physical form for small planktonic larvae, whose digestive capacity is only partially developed. Prior to 1960's aquaculture hatcheries use rotifers (Brachionus sp.) followed by brine shrimp (Artemia sp.) extensively as the key zooplanktonic live prey for larval finfish and decapods (Bengtson, 2003). These zooplankton have deficient nutritional composition are not the natural prey of the aquaculture species. Neverthless their rapid reproduction rates with high densities are more significant than their nutritional shortcomings in most cases (Lubzens and Zmora 2003; Dhont and Stappen, 2003). The nutritional quality of rotifer and brine shrimp were improved by manipulating their diet particularly to enhance n-3 highly unsaturated fatty acids (HUFA, e.g., docosahexaenoic acid and eicosapentaenoic acid) by microalgal strain selection or by incorporating dried microalgal biomass into formulated inert diets. Hatchery production of rotifers was initially based on feeding with live microalgae (Nannochloropsis sp., Tetraselmis sp., Pavlovalutheri and Isochrysisgalbana) or baker's yeast (Conceicao et al., 2010). For instance rotifers fed with microalgae become rapidly enriched with ascorbic acid. After 24 h, rotifers fed on Isochrysis sp. and Nannochloropsisoculata contained 2.5 and 1.7 mg/g dry wt respectively, whereas rotifers fed on baker's yeast alone are deficient in ascorbate and contained only 0.6 mg/g dry wt Commercial feed formulations have been developed and are now widely used as alternatives to live microalgae and yeast. These products are intended to optimise growth and reproduction of the rotifers and to enhance their final nutritional composition before feeding to larvae. Hatcheries when adopted such artificial feeds for mass rotifer cultivation, it is easy to retain rotifer master cultures on live microalgae, and this simplifies hygiene maintenance. Live microalgae remain the preferred diet for planktonic groups (orders Calanoida and Cyclopoida), whereas benthic copepods (order Harpacticoida) are more manageable to cultivate on inert feeds Among the products used as feed for aquaculture live prey are several marine microorganismsThedinoflagellate, Crypthecodiniumcohnii, has been exploited due to its high docosahexaenoic acid (DHA) content.

SOURCES OF FISH FEED

i) Microalgae as fish feed :-The largest current application of microalgae feeds is in aquaculture. Microalgae are used fresh (e.g. live, or at least not dried) in bivalve, shrimp and fish fry and fingerling production (in the latter case via an intermediate food source, such as zooplankton or brineshrimp) (Benemann, 1992, Spolaore *et al*, 2006). Several companies produce aquaculture feeds using *Chlorella* and *Spirulina*, or a mixture there of. Some examples of the use of microalgae for aquaculture:- Microalgae species *Hypneacervicornis* and *Cryptonemiacrenulata* particularly rich in protein were tested in shrimp diets (da Silva et al, 2008). Algae were collected, rinsed, dried and ground up for the feed formulations. Larvae shrimps were fed daily with one of four diets prepare
with different percentages of seaweed powder: 39%, 26%, 13%, 0%. The results suggest that there is an increase in feed conversion when the levels of algae are increased. Amount of algae in fish feed resulted in significant increase in shrimp growth rates.

- A large number of marine nitrogen-fixing cyanobacteria have been tested for their nutritional value with the hybrid Tilapia fish fry; a majority were acceptable as single ingredient feeds. Very high growth rates of Tilapia fish using marine cyanobacteria with in-door and out-door cultures have been reported. The marine cyanobacterium *Phormidiumvalderianum* was shown to serve as a complete aquaculture feed source, based on the nutritional qualities and non-toxic nature with animal model experiments (Thajuddin et al., 2005).

Initially, the colour-enhancing effects of phycocyanin-containing *Spirulina* biomass or carotenoides from *Dunaliella* were exploited in ornamental fish. In recent years, questions of feed utilization and health status in the dense aquacultural fish populations became more important. Here, the addition of microalgae can, depending on concentration, directly enhance the immune system of fish, as investigations on carp have shown (Schreckenbach et al. 2001).

The addition of microalga-derived astaxanthin to feed formulations enhances the colour of the muscles of salmonids. This has a high biotechnological potential and culture techniques for *Haematococcuspluvialis* are well developed for this purpose (Piccardi et al. 1999). On the Hawaiian Islands and in China, *Haematococcus* is cultivated in open ponds (Pulz and Gross, 2004).

More than 40 species of microalgae are used in aquaculture worldwide, depending on the special requirements of local seafood production. In 1999, the production of microalgae for aquaculture reached 1000 ton (62% for molluscs, 21% for shrimps and 16% for fish) for a global world aquaculture production of 43 x 106 ton of plants and animals (Muller-Feuga, 2004).

ii) Macroalgae as fish feed : *Spirulina* is a blue-green plant plankton rich in raw protein, vitamins A, B_1, B_2, B_6, B_{12}, C and E, beta-carotene, color enhancing pigments, a whole range of minerals, essential fatty acids and eight amino acids required for complete nutrition.

The filamentous green alga (*Cladophoraglomerata*) meal was used as the sole source of protein for Nile tilapia. Similarly, Appler (1985) recorded ***Specific growth rates*** of 44 % and 56 % of control diets when the filamentous green alga (*Hydrodictyonreticulatum*) meal was used as the sole source of protein for *O. niloticus*and *T. zillii*.

Catla catla

finngerlings: *Anabanea sp.; Microcystis sp.; Oscillatoria sp.; spirulina sp. Botryococcusbraunii; chlamydomonas sp.; Closterium sp.; Coelastrummicroporum; Eudorinaelegan; Pandorinamorum; Pediastrum simplex; Tetrahedron minimum;*

Adult: *Anabaena sp.; Microcystissp; Oscillatoria sp.; Spirulinasp .;*

Chlamydomonus.;Closterium sp.; Coelastrum sp.; Eudorina sp.; Pandorina.; Pediastrum.; Volvox sp.;

Cyclotella sp.; Navicula sp.; Pinnularia sp.;

Ceratium.;Peridinum sp.;

rohita

Fingerlings: *Carteria sp.; Chlamydomonas sp.; Chlorogonium sp.; Eudorina sp.; Pandorina sp.; Pleodorina sp.; Volvox sp.;*

Closterium sp.; Staurastrum sp.; Xanthidium sp.;

adult: *Chlorogonium sp.; Closterium sp.; Eudorina sp.; Gonium sp.; Pandorina sp.; Volvox sp.; Xanthidium sp.;*

Botryococcus sp.;

Mallomonus sp.; Synura sp.;

Ceratium sp.; Peridinium sp.;

Anabaena sp.; Microcystis sp.; Oscillatoria sp.; Spirulina sp.;

2. Algae as feed additives

The main applications of microalgae for aquaculture are associated with nutrition, being used fresh (as sole component or as food additive to basic nutrients) for colouring the flesh of salmonids and for inducing other biological activities (Muller- Feuga, 2004). Several investigations have been carried out on the use of algae as additives in fish feed. Feeding trials were carried out with many fish species, most commonly red sea bream (*Pagrus major*), ayu (*Plecoglossusaltivelis*), nibbler (*Girellapunctata*), striped jack (*Pseudoceranxdentex*), cherry salmon (*Oncorhynchusmasou*), yellowtail (*Seriolaquinqueradiata*), black sea bream (*Acanthopagrusschlegeli*), rainbow trout (*Oncorhynchusmykiss*), rockfish (*Sebastesschlegeli*) and Japanese flounder (*Paralichthys olivaceus*). Various types of algae were used; the most extensively studied ones have been the blue-green algae *Spirulina* and *Chlorella*; the brown algae *Ascophyllum*, *Laminaria* and *Undaria*; the red alga *Porphyra*; and the green alga *Ulva*. Fagbenro (1990) predicted that the incidence of cellulase activity could be responsible for the capacity of the catfish *Clariasisherencies* to digest large quantities of Cyanophyceae

Seaweed pellet

Until recently the value of **seaweed** as a biomass product was not fully realized. Lately both fresh water and salt water plants have been utilized for animal feed and as a bio fuel.

It is possible (dependent on the type of **seaweed**) to use it for human consumption (for example in sushi) but even more so as feed for horses, cows and other farm animals. It is also possible to use **seaweed** as green energy fuel.

In order to **produce seaweed** into a feed mix or fuel you will need to get a **granulating machine** (a **pellet mill**).

Seaweed is a general term for any simple photosynthesising organism that grows in a body of water. Some of these plants are dangerous to eat, so if you are not sure about the types of seaweed your area (and their suitability for feed or as a fuel), please consult a professional. We can give you the technological know-how to make **pellets**from almost all known weeds

Microalgae as feed Processes

Preservation

As marine invertebrates depend on microalgae for their whole life cycle, mollusc or fish hatcheries need to include a microalgae production system in parallel to their fish production. However, handling live microalgae is not without problems and various attempts have been made to replace living algae by processed algae-based diets with a longer shelf life

Spray-drying

Spray-drying is probably the most common technique used to preserve microalgae as a sole feed or supplement to the diet in). The shelf life is up to 2 years if stored at a low temperature. Spray-dried *Chlorella vulgaris* and *Nannochloropsis* sp. are available as intact cells or broken cell walls.

Freeze-drying

Freeze-drying is a good method for producing an algal feed with a shelf life similar to that obtained with spray-drying, resulting in diets that are almost identical to fresh diets regarding size, shape, and biochemical composition

Low temperatures

Refrigerated (0-4°C) concentrated pastes of 90-300 g/L (DM) have a shelf life ranging from 4 weeks to 1 year. All algal pastes are nonviable cells except for *Chlorella vulgaris* (130 g/L). Frozen paste kept at -20°C may have a shelf life of up to 2 years. Cultures of *Nannochloropsisoculata* have been kept alive at 8°C for over 100 days, or at 5°C for 18 months when provided with light and nitrogen).

Microencapsulation

The encapsulation of microalgae in digestible microcapsules allows the delivery to suspension feeders without loss of nutrients to the aqueous medium. The stabilization of the capsule was best when microalgae were cultivated in 2% $CaCl_2$ concentration.

Cell walls disruption

Most microalgae contain cell walls that are detrimental to digestion in monogastric species. Treatment is necessary to disrupt the cell walls: physical methods include boiling and various types of high temperature drying, if necessary simply sun drying; chemical methods include autolysis or breaking of hydrogen bonds by phenol, formic acid, or urea (which requires later detoxification) (Becker, 2013a).

Live *vs.* dried microalgae

Dried microalgae are often less efficient than live microalgae for feeding marine larvae. The oxidation of microalgae that occurs during drying causes a loss of highly unsaturated fatty acids essential for larval growth. Dried cells tend to disintegrate when kept in suspension. Due to the broken cell walls, water-solubles components are lost in the culture media and are no longer available to the host species. Dried microalgae are also more susceptible to pathogenic bacterial contamination. Algae paste exhibit similar issues. These problems can be alleviated by proper preparation (centrifugation, flocculation, or filtration) and/or preservation techniques (additives and freezing) that preserve cell wall integrity

Applications of Spirulina (Arthrospiraplatensis)

Spirulina is well known for its phycobiliproteins which can serve as an active free-radical scavenger and also an excellent source of vitamin B1, an antitumor and anticancer drug .The single cell protein, Spirulina is called as a super food and it grows naturally in the hypersaline lakes in the subtropical climates and can easily tolerate even the pH of 10 to 11. Due to the culture shift from chemical-based products to organic products, algae and its derivatives find a niche segment in the industry of organic product (Table 3). It is confirmed that Spirulina is having a high amount of γ-linolenic acid (GLA) and it serves as an essential polyunsaturated fatty acids (PUFA) and as a potential nutraceuticalproduct .Investigations have also revealed that GLA can kill tumor cells without damaging the normal ones. GLA is also applied into schizophrenia, dermatitis, multiple sclerosis, diabetes and rheumatoid arthritis

Applications of Chlorella

Chlorella was digested much more easily while it is in the form of paste up to 5% in the daily animal diet and their protein digestibility for pigs was 56% . Similarly, trials have found that the usage of Chlorella resulted in the weight gain in sheep. In the aquaculture industries, microalgae strains are most appropriate for fish feed. Algae companies such as, Allma and Necton based at Portugal are commercially supplying Spirulina and Chlorella for human consumption in the form of soups, millets, juices, crunches, biscuits, ice creams, smoothies, natural coloring agent and dietary supplements (antioxidant, vitamins, minerals, protein sources, immunostimulantetc). In addition, they are also sApplications of Dunaliella

The halotolerant alga, Dunaliella is well known for its natural β-carotene isomers, it can serve as an essential nutrient, antioxidant and anticancer compounds and has high demand in the market. Dunaliellasalina contains a potent mixture of important carotenoids including β-carotene, α-carotene, lutein, zeaxanthin, and cryptoxanthin .In addition to other medicinal properties, β-carotene occurs naturally with its isomers namely all-trans, 9-cis, 13-cis and 15-cis forms. Dunaliella powder has also been widely used in pharmaceutical and nutraceutical applications. The applications include human health dietary supplements as tablets, capsules, fortified nutritional blends, animal feed, natural pigments and dyes and in cosmetics. The red to orange colored Dunaliella powder contains 1–3% of β-carotene. The oil based extract of β-carotene is used in coloring margarine (Hemaiswarya and Raja, 2010) and the water-soluble extract is used for coloring beverages.

Applications of Haematococcus

Haematococcus produces astaxanthin and it has beneficial effects on the metabolism especially in humans are recorded. Astaxanthin belongs to xanthophyll type and it has a potent antioxidant to prevent the intracellular oxidative stress, proved in different tests to be the strongest (Ranga Rao et al., 2014). Natural astaxanthin is more protective due to its safe and higher antioxidant properties which makes useful nutraceutical product for humans also (Ranga Rao et al., 2014). Astaxanthin used as a nutritional supplement, anti-inflammatory and anticancer agent, cardiovascular diseases and recently recorded that it prevents diabetes, neurodegenerative disorders and stimulates immunization (Walker et al., 2005). It also has anti-inflammatory properties and is used for various commercial applications in the dosage forms as biomass, capsules, creams, granulated powders, oils, soft gels, syrups and tablets Astaxanthin is sold under different brand names (i.e.) BioAstin by Cyanotech Corp., Hawaii.

In a free radical elimination experiment at Creighton University, natural astaxanthin proved to be 20 times stronger than synthetic astaxanthin. In Brunswick Laboratories, natural astaxanthin was 55 times stronger in singlet oxygen quenching than synthetic astaxanthin. ORAC testing showed that natural astaxanthin is 14 times more potent as an antioxidant than synthetic astaxanthin Neurodegenerative diseases are increasing faster nowadays than any other illness, so protecting your brain is one of the most important things. Several animal trials have shown neuroprotective effects of natural astaxanthin; human clinical trials have also been recorded (*).

Microalgal applications in aquaculture industries

Microalgae are also an important food source in all stages of marine bivalve mollusks (oysters, clams and scallops), the larvae of few marine gastropods (abalone and conch), some marine fish and shrimp and zooplanktons. Thus, microalgae were cultivated and concentrated to produce algae pastes (concentrated microalgae cells dispersed in liquid media) or freeze-dried cubes. These forms can be stored under refrigeration and used directly by the aquaculture industrialists (Hemaiswarya et al., 2011). The aquaculture live feed diet formulations are predominantly in paste form. The formulations contain one or more species of algae in order to provide a balanced nutrition. Algae paste is produced by batch cultivation of microalgae and subsequent dewatering using high volume continuous flow centrifuges. Food grade preservatives such as glycerin are added to the dewatered algae slurry to increase their shelf life. The wet slurry is then packed and stored at 32-35°F to preserve the feed from decay. Microalgae live feed provides a source of essential fatty acid to fish. It is well known that Omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are extracted and sold as fish oil for human consumption. DHA and EPA are not synthesized by the fish but accumulated and stored from the microalgae which they feed on.

Algae paste can also be freeze dried into small ice cubes of a pre-measured quantity for ready usage. Storage in the form of ice cubes extends the shelf life of the particular algae. These ice cubes can be added directly to the water tank or diluted with water and then added into the tank. Important eukaryotic classes being used for the aquaculture feed productions are Bacillariophyceae and Chlorophyceae. Green algae are especially abundant in freshwater and within this group of microalgae, some of them are commercially very important. Three different marine algae (Chaetoceros sp., Phaeodactylumtricornutum and Nannochloropsisoculata) were used commercially for making this kind of pastes (Chini-Zittelli et al., 1999). They were mixed with seawater to form 10% algal solution then frozen into ice cubes for uniform feedings in the aquaculture industries. There are few ice cube products and their brand names which are commercialized, they are: Mega Marine Algae Cubes-Hikari Bio Pure (brand name); Spirulina Formula Cubes-Ocean Nutrition and Formula Two Cubes-Ocean Nutrition.upplying feed for chicken, fish, cattle, pet and high performance animals

Algae Products

Algae is used as a key ingredient in various food products. The substance can either be used as an additive or can act as a thickener in many types of food products. Algae can also be found in household products, such as toothpaste and various pharmaceuticals. A type of algae, known as carrageenan, is often added to dairy products such as cheese and sour cream in order to give them a denser texture. Alginic acid, which can be found in algae, is used to stabilize foods such as milkshakes, malts, and mayonnaise. Consumers might also be familiar with the green paper-like sheets used to wrap sushi. This product, called nori, is actually a leafy form of algae which was traditionally grown in Japan and contains plenty of healthy nutrients and assorted vitamins.

Gelatin is used in the production of numerous edible products. In fact, this substance is made up of a type of algae known as agar. Purportedly first used in 17th century China, gelatin acts to solidify liquids found in such popular products such as pie crusts and fillings.

Purple-colored algae, also known as Porphyra, is commonly used in Japan and is known as nori, which is used to wrap up sushi rolls. In Korea, this same substance is known as gim. In **Wales**, this type of algae is referred to as laverbread, which is traditionally served for breakfast along with bacon and cockles (a type of mollusk). In Ireland, residents stew or boil the algae, thus making it into a pink colored jelly.

In the manufacturing of toothpaste, algae is used in order to thicken what would otherwise be a runny substance and transform it into a partially solid form. This particular form of algae is safe to consume and dissolves during the tooth brushing process.

Fertilizer

The two most common varieties of algae used in the manufacture of fertilizer are large red and brown. In particular, these two types of algae are utilized in areas located near the ocean. Liquid fertilizer can also be produced using a concentrated seaweed extract. The reasons why this type of fertilizer is so popular involves the organism’s ability to repair levels of nitrogen already present in the soil. For example, rice producers in **India** typically employ blue-green algae in order to fertilize their agricultural fields.

Reclaiming Alkaline

In many countries, such as India, fields that once produced large agricultural yields can no longer be used due to high concentrations of alkalinity in the soil. In order for crops to eventually be grown in these lands, often referred to as "Usar" lands, the ph level must be lowered and the ability of the soil to hold onto water must be increased. This process can be achieved using blue-green algae

Biologically active compounds

Seaweed extracts act as biostimulants mainly due to the presence of plant hormones. Main phytohormones identified in seaweed extracts are: auxins, cytokinins, gibberelins, abscisic acid and ethylene. Auxins are responsible for elongational growth of plant tissues and apical dominance, cell division, plant movements and plant aging. Cytokinins are involved in cell division regulation affecting plant growth and rest period. Moreover, they inhibit aging of plant tissues and play crucial role in transport of nutrients. One of the basic functions of gibberellins are initiation of seed germination, growth regulation, braking bud dormancy, florescence and fruits development. Abscisic acid and ethylene are responsible for response to stress factors, inhibition of cell growth, acceleration of plant aging. Furthermore, abscisic acid participates in regulation of seed germination. Seaweeds the most widely used in agriculture due to their good biostimulant activity are red algae: Corralinamediterranea, Janiarubens, Pterocladiapinnata, green algae: Cladophoradalmatica, Enteromorphaintestinalis, Ulvalactuca and brown algae: Ascophyllumnodosum, Ecklonia maxima, Saragassumspp

Seaweed extracts in plant cultivation Some research show that the application of seaweed extracts in plant cultivation exhibits positive effect on cultivated plants. Algae extracts improve plant resistance to frost and drought and increase crop yields. Plants sprayed with the use of seaweed extracts are also characterized by higher resistance to pests and pathogens and more efficient consumption of nutrients from soil. Seaweed extracts contribute to the recovery of damages caused by insects and bacterial or fungal diseases. Formulations basing on algal extracts are rich in phytohormones (gibberelins, auxins, cytikinins), amino acids and fatty acids which are responsible for plant growth, development and resistance to pathogens. Biostimulant activity of extracts obtained from marine algae is connected with the presence of plant growth regulators, particularly cytokinins mainly responsible for plant aging delay, mitosis induction, stimulation of chloroplast maturation, growth of shoot and lateral buds . The ammount of cytokinins changes and their ratio to other plant growth hormones depends on the species of algae resulting in different effects of seaweed extracts on plantcultivation . Seaweed extracts can be delievered to plants in many ways. Soaking of seeds in algal extracts is one of the methods. This way of treatment can affect seeds germination. Foliar and classical soil application can be used as well . In addition to application methods, also the concentration of seaweed extract, species of algae, plant variety affects the efficiency of seaweed extracts as plant biostimulants. Seaweed extracts are well-known biostimulants. They are characterized by high efficiency in plants cultivation what was proved by many papers, besides they are environmentaly friendly due to biological origin of material. The use of extracts from marine algae gives an opportunity to choose any metod of application suitable for a particular plant and expected effects.

Nutritional composition of edible seaweeds

Proximate composition (moisture, ash, protein and oil content), total dietary fibre content and physicochemical properties of three brown and two red edible Spanish seaweeds, namely: Himanthaliaelongata (sea spaghetti), Bifurcariabifurcata, Laminariasaccharina (sweet kombu), Mastocarpusstellatus and Gigartinapistillata were studied. Ashes (24.9–36.4%) were high in all samples. Protein content ranged from 10.9 to 25.7%, being much higher for Laminaria (25.7%) followed by the red seaweeds (15.5–21.3%). Minor components were lipids (0.3–0.9%) in all samples except for Bifurcaria (5.6%).In conclusion, these seaweeds can be estimated as a good source of food fibre, protein and minerals for human consumption (Gómez-Ordóñez et al., 2010). Mineral content was determined in several brown (Fucusvesiculosus, Laminariadigitata, Undariapinnatifida) and red (Chondruscrispus, Porphyratenera)edible marine sea vegetables. Seaweeds contained high proportions of ash (21.1–39.3%) and sulphate (1.3–5.9%). In brown algae, ash content (30.1–39.3%) was higher than in red algae (20.6–21.1%). Edible brown and redseaweeds could be used as a food supplement to help meet the recommended daily intake of some essential minerals and trace elements (Rupérez, 2002). Sea spaghetti (Himanthaliaelongata), Wakame (Undariapinnatifida), and Nori (Porphyraumbilicalis), on fatty acid composition, amino acid profile, protein score, mineral content and antioxidant capacity in low-salt meat emulsion model systems. The addition of seaweeds caused an increase in ω-3 polyunsaturated fatty acids (PUFA) and a decrease in the ω-6/ ω-3 PUFA ratio. In general, addition of seaweeds to products increased the concentrations of K, Ca, Mg and Mn. The presence of Nori caused an increase in levels of serine, glycine, alanine, valine, tyrosine, phenylalanine and arginine, whereas Wakame and Sea Spaghetti produced no significant changes in amino acid profiles in the model systems. López-Lópezet.al., 2009). The nutritional compositions of 34 edible seaweed products of the Laminariasp.,Undariapinnatifida, Hizikiafusiforme and Porphyra sp. varieties were analyzed.The marine macroalgae varieties tested demonstrated low lipid contents with 2.3 ± 1.6 g/100 g semi-dry sample weight(s.w.) and proved to be a rich source of dietary fibre (46.2 ± 8.0 g/100 g s.w). The pure protein content of seaweed products varied widely (26.6 ± 6.3 g/100 g s.w. in red algae varieties and 12.9 ± 6.2

g/100 g s.w. in brown algae varieties). All essential amino acids were detected in the seaweed species tested and red algae species featured uniquely high concentrations of taurine when compared to brown algae varieties (Dawczynski et al., 2007). The total lipid, protein, ash and individual fatty acid contents of edible seaweeds that had been canned (Saccorhizapolyschides and Himanthaliaelongata) or dried (H. elongata, Laminariaochroleuca, Undariapinnatifida, Palmaria sp. and Porphyra sp.) Total lipid content ranged from 0.70±0.09 to 1.80±0.14 g/(100 g dry weight). The four most abundant fatty acids were C16:0, C18:1ω9, C20:46 and C20:5ω3. Unsaturated fatty acids predominated in all the Brown seaweeds studied, and saturated fatty acids in the red seaweeds, but both groups are balanced sources of ω3 and ω6 acids. Ash content ranged from 19.07±0.61 to 34.00±0.11 g/(100 g dry weight), and protein content from 5.46±0.16 to 24.11±1.03 g/(100 g dry weight) (Sanchez-Machado, et. al.,2004).

Edible seaweed in foods

Red macro-algae (Gracilaria spp.) are used as a fresh food in Hawaii. Species commonly marketed include G. coronopifolia, G. parvispora, G. salicornia and G. tikvahiae, however, these seaweeds have a short postharvest life of about 4 days (Paul and Chen, 2008). Seaweeds are a rich source of phytochemicals having anti-oxidant and antimicrobial properties. Presence of fibres and minerals helps in improving the mineral content reduce the salt content. The adding of seaweeds or their extracts to food products will help in reducing the utilization of chemical preservatives (Gupta and Abu-Ghannam, 2011). Edible seaweeds contain various bioactive compounds with potential health benefits and their use as functional ingredients opens up new prospects for food processing, meat product formulations included. Seaweeds basically contain high proportions of polysaccharides along with various other potentially beneficial compounds such as good-quality protein and essential fatty acids, particularly long-chain n-3 polyunsaturated fatty acids (PUFAs). Alginates are the most abundant ionicpolysaccharides present in brown seaweeds (Fernández-Martín et al., 2009). Some seaweed polysaccharides are used by food industry as texture modifiers because of their high viscosity and gelling properties. In Asia seaweeds have been used for centuries in salads, soups and as low calorie dietetic foods. The diateryfibre which constitutes 25-75 % of the dry weight of marine algae and represents their major component, is primarily soublefibre.(Jiménez-Escrig and Sánchez-Muniz, 2000). In particular, miyeok (Undariapinnatifida) is often served in soup,salad, and sidedishes. Gamma irradiation at 10 kGy is sufficient to sterilizefreeze-dried miyeokguk without significant deterioration in the sensory quality,andthus,the freeze-dried and irradiated miyeokguk at 10 kGy fulfills themicrobiological requirements as spacefood (Song et al., 2012). The sausages were produced with two types of carrageenan (i- and j-) in four levels (0%, 1%, 2% and 3%). Carrageenan had a better effect on such characteristics as pH, weight loss and lipid oxidation of the sausages, as well as, on sensory attributes. The carrageenan level of 3% negatively affected the firmness of the sausages.Carrageenan added at levels up to 2% had a positive effect on the physicochemical and microbiological characteristics of the lowfat fermented sausages. (Koutsopoulos et al., 2008). Cultivated Ulvarigida was utilized by using marination technology. Fresh and boiled (at 100˚C for 2 min.) Ulvarigida were marinated with two different formulations by using 2 % lemon salt and 2 % vinegar. The marination of Ulvarigida were made at room temperature for 20 days. Marinated fresh and boiled ulvarigida by using lemon salt and vinegar can be an alternative for human foods (Kılınç et al., 2011). Breads were made by using Lemna minor (Tekogul et al., 2011) and Ulvarigida (Turan et al., 2011). The shelf-life of breads by using Ulvarigida were determined as unacceptable on day 5 at room temperature whereas on day 10 at 4˚C. When compared with control groups, the shelf-life of breads containing Ulvarigida were determined longer shelf-life. Breads prepared with Ulvarigida extended the shelf-life of breads for 2 days in two different storage period. Lemna minor extended the shelf-life of breads. The shelf-life of breads with Lemna minor were extended the acceptable limit on day 8 at room temperature whereas on day 12 at 4 ˚C. But control group extended this acceptable limit on day 3 at room temperature, on day 8 at 4 ˚C.

Fermented seaweed

Brown edible seaweeds as a sole source of nutrition for the growth of lactic acid bacteria. Growth kinetics of lactic acid bacteria (LAB; Lactobacillus plantarum) was studied using three species of edible Irish brown seaweeds Himanthaliaelongata, Laminariadigitata and Laminariasaccharina. The results of this study present an indication of the potential of fermentation of seaweeds using LAB with a possibility towards the development of a range of functional foods (Gupta et al., 2011). Low molecular weight polysaccharides from seaweed as prebiotics. Gelidium seaweed showed significant increase in bifidobacterial populations. Agar and alginate bearing seaweeds indicate prebiotic potential. Brown macroalgae contain high concentration of mannitol and laminarian. Clostriumacetobutylicum ferments these seaweed extract substrates to butanol. Seaweed fermentation exhibited triauxic growth: glucose-mannitol-laminarin.Butanol yields in seaweed and pure glucose fermentations were comparable.

Seaweeds used as fertilizer and biogas production

Seaweed are used as a fertilizer which is suitable for use in organic agriculture . Energy-rich methane can be harnessed from seaweed deposits by anaerobic digestion. However, the high heavy metal content in the seaweed and its digestates limits their use as fertilisers. The efficient utilisation of seaweed for biogas production, and the partial heavy metals mobilisation to enable the metal removal for improved fertiliserquality . The red alga Chondracanthussquarrulosus was cultured under semi-controlled conditions to valuate growth (biomass production) with agricultural fertilizers (ammonium nitrate, ammonium sulphate and urea) vs. analytical grade inorganic salts; sodium nitrate (analytical grade) and seawater were used as controls .

Industrial uses

But as the carbohydrates in algae and seaweeds are far more complex than the starch in plants, the processes required to convert them into ethanol are complicated and have not been perfected on an industrial scale. In many instances, there is not yet any detailed knowledge of the biochemical principles involved in the breakdown of complex carbohydrates. Further studies are needed to elaborate effective, biotechnological production systems to bridge this gap. A number of research projects have shown that on a small scale one can use both microalgae and seaweeds to produce biofuels, but commercial viability has been achieved in only a single instance on small, family-run seaweed farms in the Philippines. In general, it has proven to be exceptionally difficult to scale up the results obtained in experimental pilot projects. At first glance it would appear that the cultivation of microalgae would be most practical for the production of biofuels. They are probably better suited for conversion into biodiesel on account of their lipid content, which might be increased by growing genetically modified varieties. A drawback, however, is that their growth rate is often vastly overestimated. Just the same, there is optimism in some quarters, an optimism fueled by goverment grants. A small Florida company, Algenol, is developing a method for capturing ethanol directly from the microalgae without killing or fermenting them. Particular strains of algae, kept in special bioreactors containing seawater and added nutrients, are exposed to sunlight and carbon dioxide from the atmosphere or power plant emissions. The algae photosynthesize, leading to the formation of sugars inside the cells and these sugars, still in the cells, are turned f Experimental cultivation of sea lettuce (Ulvalactuca) for bioethanol production. 216 Seaweeds for industrial uses Food or fuel? The global demand for energy is unlikely to decline, regardless of the degree of energy efficiency that it is possible to achieve in the developed countries. Robust, new economies in Asia are expanding by leaps and bounds and the Third World has a large, unmet demand for energy sources. At the same time, a hungry world needs more food. It is, therefore, quite possible that our deliberations about the industrial utilization of algae will be confronted by the same dilemma as the one that has arisen with respect to the growing exploitation of plants, such as corn, soya, and rapeseed, which are often the dietary staples of poor people, for the extraction of ethanol. There are indications that rising prices and the looming global food crisis are partly due to the diversion of agricultural output from foods to energy production. This raises the fundamental question of the extent to which we should aim to dedicate marine resources to increasing the food supply or to trying to fill the world’s insatiable demand for more energy. Another basic question is whether the exploitation of seaweeds and algae for energy production can be carried out in a sustainable manner, so that their capacity to fix carbon dioxide, with its inherent positive impact on the Earth's atmosphere and climate, is not diminished.

Seaweeds in medicine, health care, and cosmetics

Seaweeds in medicine

A variety of seaweed species have been incorporated into traditional Chinese and Japanese herbal medical practice in the treatment of tuberculosis, rheumatism, colds, influenza, wounds, worm infestations, and cancer. Just as it is difficult to dismiss several thousand years of experience with naturopathic medicine, it is equally difficult to establish a firm scientific basis for its beneficial effects, to say nothing of trying to shed some light on precisely which substances in the seaweeds are the biologically active ingredients and what determines their bioavailability. Over and above this, advocates of macrobiotic approaches to wellness will probably maintain that the determining factors are not the individual chemical substances, but the seaweed in its entirety and the synergy between it and the patient in a particular treatment situation. Nevertheless, many bona fide researchers have come to the conclusion that various seaweed species may well contain substances that are biologically 219 Seaweeds in medicine, health care, and cosmetics of its precursor bacteria, Helicobacter pylori, to colonize the stomach lining. In addition, brown seaweeds contain a long list of terpenes, an umbrella term for a large and varied class of organochemicals.

Some of these terpenes exhibit anti-viral and anti-cancer properties and possibly have the potential to counteract malaria. As described earlier, some of the fats (certain glycolipids) and some of the polysaccharides (especially fucoidan) that have already been discovered have the ability to suppress the growth of tumors. As the search for new antibiotics has intensified in the last few years due to the rapid proliferation of drug-resistant bacteria, attention is increasingly being paid to the substances found in seaweeds and algae that are natural defenses against attacking microorganisms and herbivorous marine fish. The brown algae contain specific tannins and the green and red algae have, for example, acrylic acid and bromophenols. These compounds exhibit antibacterial activity and, furthermore, discourage herbivores from eating the algae. It has been proposed that using a combination of extracts of such bioactive substances from a variety of seaweed species in connection with the aquaculture of fish, would make it possible to dispense with conventional antibiotics in the fish fodder. A number of reports in the scientific literature suggest that extracts derived from various seaweeds can counteract fungi and mosquito larvae and, therefore, may have potential as insecticides. Currently, research is being undertaken into the use of special algae, for example, transgenic algae, which produce different substances that can serve as a type of vaccine against skin infections and sea lice on farmed salmon.

Microalgae and Biofuel

Microalgae have long been recognized as potentially good sources for biofuel production because of their high oil content and rapid biomass production. In recent years, use of microalgae as an alternative biodiesel feedstock has gained renewed interest from researchers, entrepreneurs, and the general public. Algae offer many potential advantages: ● algae can potentially produce 1 000-4 000 gallon/ acre/yr significantly higher than soybeans and other oil crops. ● they do not compete with traditional agriculture because they are not traditional foods and feeds and they can be cultivated in large open ponds or in closed photobioreactors located on non-arable land ● they can grow in a wide variety of climate and water conditions; they can utilize and sequester CO_2 from many sources

finally, they can be processed into a broad spectrum of products including biodiesel via trans-esterification, green diesel and gasoline replacements via direct catalytic hydrothermal conversion, and catalytic upgrading, and bioethanol via fermentation, methane via anaerobic digestion, heat via combustion, bio-oil and biochar via thermochemical conversion, and high protein animal feed. There are several ways to convert microalgal biomass to energy sources, which can be classified into biochemical conversion, chemical reaction, direct combustion, and thermochemical conversion . Thus, microalgae can provide feedstock for renewable liquid fuels such as biodiesel and bioethanol.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB COURSE NAME: MARINE MICROBIOLOGY

COURSE CODE: 19MBU105A BATCH-2018-2021

UNIT-5

s.no	question	opp a	opp b	opp c	opp d	answer
1	Which showed that natural astaxanthinn is 14times more potent	ORAC testing	biosastin	ranga rao	DHA	ORAC testing
2	which produces astaxanthininand its beneficsl effests on the metabolism to humans	marginine	haematococcus	carotene	astaxantinin	Haematococcus
3	__contains abpotent mixture of important carotenoids	gla	duanaliella sailing	chlorela	puga	dunalella sailing
4	which is well known for its natural betacarotene	necton	duanaliella	chlorella	gla	duanaliella
5	what is based at portugal are comercially supplying spirulina and chlorella	necton	minerlas	vitamims	chlorella	necton
6	which was digested much more easily while it is in thevform of paste up 5% in animal	necton	duaneliella	chlorella	pufa	chlorella
7	which is also applied into diabetes,,dermatitis,schizophermia and rheumatoid arthritis	nectoj	gla	necton	linolenicnacid	gla
8	which is having high amount of linolenic acid	chlorella	spjrulina	necton	gla	spirulina
9	___is tend to disintegrate whennkept in suspension	linolenic acid	dried cells	necton	gla	dried cells

10	microalgae were cultivated in __%of cacl2 concentration	2	5	6	9	2
11	nannochlroporosis oculata have beennkept alive at __deg celcius	2	4	8	6	8
12	which is a good method for producing an algal feed with a self life	freeze drying	spray drying	aquoes medim	gas	freeze drying
13	which in intestines play an importsnt role in breaking down of food	bacteria	eukaryotes	prokaryotes	fungi	bacterisa
14	Algae may be ideal food for	stomach	intestine	gut	body	gut
15	algae tend to contain high amount of fiber which contains __%of algal dry weight	23-64	68-96	25-72	24	23-64
16	inestinal baceria break fiber into compounds that improve gut and ___	face	gut	stomach	immune system	immune system
17	prebiotic fiber,which in turn can help with issues such as	vomiting	nausea	infection	diarrhoea	diarrhoea
18	what contains high amount of dietary fibers delyas stomach emptying	prebiotic	probiotic	marine drugs	fiber	marine drugs
19	algae may also reduce the ___in foods	mineral	vitamin	choestrol	fat	cholestrol
20	many types of algae have high levels of	antifungal	antioxidant	antimicrobials	antiviral	antioxidant
21	excess____cinsumption canncause tidhtness around the back	enzyme	iodine	fibers	vlycerol	iodine
22	A study in ___found that in edible seasweed	syratosohere	chemospher	hydrosphere	biosphere	chemosphere

23	sceibtifc reports investigated__%pontentially dangerous in seaweed	6	8	10	12	10
24	the big sheets o__used in sushi and also use tortillas or bread	dried potato	dried cells	dried nori	kombu	dried nori
25	___-with kombu can reduce the risk of gas	nori	seaweed	bean soups	kombu	bean soups
26	toasted seaweed flakes can be a great topping for grains suc as rice or	grain	oil	orquiona	gas	orquiona
27	the global population is expected to be___billion in 2100	9.2	8.7	11.2	22.4	11.2
28	which is raeres to maximise economic returns which often means animals	livestock	animal	plant	sauce	livestock
29	a recent view of found 100 academic studies is on	antiviral	antibacterial	antimicrobials	antifungal	antimicrobiall
30	which have been phased out of livestock raeing in the EV	antigen	antibiotic	antibodies	alage	antibodies
31	high levdls of __in diet of pig and cow made them grow bigger	tin	zin	copper	aluminum	zinc
32	European legislation will phasebout the usd of zinc by	2033	2022	copper	2045	2022
33	Brown seeds synthesize a unique class of compound called___	xanthin	xanthophyll	phlorotannins	pycomblin	phlorotannins
34	The flock of north ronaldsy sheep in ____have grazed on seaweed for generations	nstherland	norway	scotkand	france	scotland
35	___ are a source of biologically active compounds including proteins and polysaccharides	Seaweed	kombu	kelp	iron	seaweed
36	___ grows in or near salty waters	Seaweed	dulse	wakame	nori	seaweed

37	Adding seaweed to the diet may help with ___,___,___	thyroid function,digestive & weight loss	bp	doabetes	cough	thyroid function,diegtive&weight loss
38	Types of seaweed include:	(nori,kelp, wakame,kombu,dulse,	iodone	algae	bacteria	noei,kwlp,wkame,kombu, dulse
39	Seaweed is a rich source of	iron & iodine	lead	nickel	tin	iron&iodine
40	eating this ______is a simple way to boost a person's intake of vitamins Etc.,	marine algae	fungi	bacteria	vieus	marine algae
41	Seaweed is generally a good supply of:	Carbohydrates	mineral	protein	vitamin	carbohydrares
42	A study in the _________ points out that the various types of seaweed	Journal of Applied Phycology	ntaa	mycology	biology	jounal of applied phycolgy
43	Seaweed also contains ________	Antioxidants,	antifungal	antimicrobial	antibiotic	antioxidants
44	which may protect the body from oxidative____ and reduce ________ at the cellular level	Stress, inflammation	diabetes	goiter	gut	stress,inflamation
45	iodine deficiency is one cause of ________	hypothyroidism	goiter	diabetes	hyperthyrodism	hypothyrodism
46	Thyroid may result in the development of a _____,a visible enlargement of the thyriod gland	goiter	diabetes	stress	inflamation	goiter
47	____________occurs when the thyroid gland is overactive and produces excessive amounts of hormones	Hyperthyroidism	bp	hypothyrodism	diabetes	hypwrthyrodism
48	_____is the richest source of iodine	Kombu	nori	kelp	dulse	kombu
49	______is also a significant source of iodine	kelp powder	dulse	kombu	nori	kwlp powder

50	Seaweed may help in the management of ______	diabetes	stress	inflamtion	weight loss	diabetes
51	________ may help with diabetes	Fiber-rich foods	protein	vitamin	minerl	fiber rich foods
52	one type of seaweed may directly reduce markers of type 2diabetes,such as _________	high blood sugar	low blood sugar	diabetes	mineral	high blood sugar
53	______in the intenstines play an important role in breaking down food and supporting	Bacteria	algae	fungi	virus	bacteria
54	Algae may be an ideal food for the ___	gut	intestine	stomach	mouth	gut
55	algae tend to contain high amounts of fiber, which may make up _____percent of the algae's dry weight	23-64	15-45	35-69	22-75	23-64
56	the guts bacteri.Intestinal bacteria break fiber into compounds that improve gut health and the	health of the immune system	digwstive system	mouth	nevous system	health of immune system