

**DEPARTMENT OF BOTANY**  
**SEMESTER - IV**  
**Category-I**  
**BSC (Hons.) BOTANY**

**DISCIPLINE SPECIFIC CORE COURSE - 10: Mycology**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
<b>MYCOLOGY</b> <b>DSC-10</b>	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

**Learning Objectives:**

- To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic importance
- To introduce students to the role of fungi in biotechnology, food industry, agriculture, human health and diseases etc.

**Learning Outcomes: Upon completion of this course, the students will be able to:**

- understand the world of fungi, lichens and pathogens of plants
- understand characteristics the ecological and economic significance of the fungi and lichens
- understand the application of mycology in various fields of economic and ecological significance

**Unit 1: Introduction**

**04 hours**

General characteristics; Thallus organization; Cell wall composition; Nutrition; Heterokaryosis and Parasexuality; Classification - Webster and Weber (2007) and Introduction to Phylogenetic system of classification.

**Unit 2: Chytridiomycota**

**01 hour**

General characteristics; Life cycle of *Synchytrium*, *Allomyces*

**Unit 3: Zygomycota**

**02 hours**

General characteristics; Distribution; Thallus organization; Classification; Life cycle of *Rhizopus* & *Mucor*.

**Unit 4: Ascomycota**

**05 hours**

General characteristics; Distribution; Classification, Life cycles of *Saccharomyces*, *Penicillium*, *Alternaria*, *Neurospora* and *Peziza*.

**Unit 5: Basidiomycota** **05 hours**  
General characteristics; Distribution; Classification, Life cycle of *Puccinia graministritici*, *Agaricus*; Bioluminescence, Fairy Rings, Mushroom cultivation.

**Unit 6: Oomycota** **02 hours**  
General characteristic (with emphasis on difference with fungi); Distribution; Classification, Life cycle of *Albugo*.

**Unit 7: Myxomycota** **02 hours**  
General characterises (with emphasis on difference with fungi); Distribution; Types of plasmodia; Types of fruiting bodies; Life cycle of *Stemonitis*.

**Unit 8: Symbiotic associations** **04 hours**  
Lichen - Distribution; General characteristics; Growth forms and range of thalli; Economic importance of lichens. Mycorrhiza - Ectomycorrhiza, Endomycorrhiza and their significance.

**Unit 9: Applied Mycology** **05 hours**  
Application of fungi in Food Industry- Fermentation, Organic acids, Enzymes, Mycoproteins; Introduction to Plant Pathology, Nematophagous fungi, Entomogenousfungi , Mycoparasites, Mycoremediation, Medical mycology and Mycotoxins.

**Practicals** **60 hours**

1. *Rhizopus & Mucor*: Study of asexual stage from temporary mounts and sexual stage through permanent slides.
2. *Saccharomyces*: Study of vegetative cell and buddingfrom temporary mounts.
3. *Penicillium*: Study of asexual stage from temporary mounts and sexual stage from permanent slides.
4. *Peziza*: Study of sexual stage from temporary preparation of V.S of ascocarp.
5. *Alternaria solani*: Study of symptoms of early blight of Potato. Study of asexual stages through temporary mounts.
6. *Puccinia graministritici*: Herbarium specimens of Black stem rust of wheat and barberry leaves; sections / mounts of spores (Uredospores and Teleutospores) on wheat. Permanent slides showing spore stages on both the hosts.
7. *Agaricus*: Specimens of button stage and mature basidiocarp; V.S of gills of *Agaricus*.
8. Study of Phaneroplasmodium of *Physarum* and sporangia of *Stemonitis*.
9. *Albugo candida*: Study of symptoms of white rust on *Brassica* sp.; Asexual stage study through section / temporary mounts. Sexual structures through temporary mounts / permanent slides.
10. Lichens: Study of different types of lichens - Crustose, Foliose and Fruticose. Study of Internal structure of thallus; Apothecium through permanent slides.

**Suggested Readings:**

1. Agrios, George N. (2005). Plant Pathology, 5<sup>th</sup> Edition, Academic Press / Elsevier.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition, John Wiley & Sons, Singapore.
3. Moore, David et. al. (2020). 21<sup>st</sup> Century Guidebook to Fungi, 2<sup>nd</sup> Edition, Cambridge University Press.
4. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies, Medtech Publishers.
5. Webster, J., Weber, R. (2007). Introduction to Fungi, 3rd edition. Cambridge, U.K.: Cambridge University Press, UK.

**Additional Resources:**

1. Kavanagh, Kevin (2017). Fungi: Biology and Applications, 3<sup>rd</sup> Edition, Wiley-Blackwell.
2. Maheshwari, Ramesh (2012). Fungi: Experimental Methods in Biology, 2<sup>nd</sup> Edition, CRC Press.
3. Ownley, Bonnie and Trigiano, Robert N. (2017). Plant Pathology: Concepts and Laboratory Exercises, 3<sup>rd</sup> Edition, CRC Press.
4. Watkinson, Sarah et. al. (2015). The Fungi, 3<sup>rd</sup> Edition, Academic Press / Elsevier.

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**DISCIPLINE SPECIFIC CORE COURSE – 11: Ecology and Conservation**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
<b>Ecology and Conservation DSC – 11</b>	<b>4</b>	<b>2</b>	<b>0</b>	<b>2</b>	Class XII pass with Biology/ Biotechnology	Nil

**Learning Objectives:**

- To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography.
- To make them understand community patterns and processes, and ecosystem functioning.

**Learning Outcomes:**

At the end of this course, students will be able to understand:

- the interrelationship between organisms and environment.
- methods to study vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
- evolving strategies for sustainable natural resource management and biodiversity conservation.

**Unit 1: Introduction**

**01 hour**

Basic concepts, Interrelationships between the living world and the environment

**Unit 2: Soil**

**05 hours**

Origin & Formation; physical, chemical and organic components; soil profile; forms of water in soil

**Unit 3: Water**

**02 hours**

Importance; States of water in the environment; Atmospheric moisture; Water table

**Unit 4: Abiotic interactions**

**03 hours**

Abiotic factors and plant adaptations, variations in light, temperature & wind conditions.

**Unit 5: Biotic interactions**

**02 hours**

Definition; types of positive and negative biotic interactions

**Unit 6: Population ecology**

**02 hours**

Characteristics of populations; population growth models and introduction to population regulation (density-dependent and independent); ecotypes; metapopulation (history, concept and applications to conservation)

**Unit 7: Plant Communities**

**04 hours**

Community characters (General account of analytical and synthetic characters); Ecotone; Succession: processes, types (Lithosere, Hydrosere, Xerosere, Psammosere)

**Unit 8: Ecosystems**

**04 hours**

Types, components, trophic organisation; food chain & food webs, ecological pyramids. models of energy flow; production and productivity; a brief outline of biogeochemical cycles (Carbon and Nitrogen)

**Unit 9: Phytogeography**

**04 hours**

Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India

**Unit 10: Conservation**

**03 hours**

In-situ, ex-situ; gene banks, institutions - National & International; sacred groves, on-farm conservation.

**Practicals**

**60 hours**

1. Principle and operation of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH and detection of carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from atleast two soil samples by rapid field tests.
3. Determination of pH & dissolved oxygen from polluted and unpolluted water samples.
4. Determination of soil organic carbon and organic matter of different soil samples by Walkley & Black rapid titration method.
5. Study of ecological adaptations of hydrophytes and xerophytes (four each).
6. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants).
7. Determination of minimal quadrat size and number for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

9. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
10. Species distribution pattern based on A/F ratio (regular, random, clumped).
11. Field visit to familiarize students with ecology/conservation of different sites.

#### **Suggested Readings:**

1. Daubenmire, R.F. (1975). Plant and Environment. London: J. Wiley and Sons Inc.
2. Kormondy, E.J. (1996). Concepts of Ecology. New Delhi, India: PHI Learning Pvt. Ltd. 4th edition.
3. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
4. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition.
5. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.

#### **Additional Resources:**

1. Ambasht, R.S. and Ambasht, N.K. (2008). A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. R. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology. USA: An Earth Systems Approach. Oxford University Press.
5. Hanski, I.A., & Gilpin, M.E. (1997). Metapopulation biology: Ecology, genetics, and evolution. Academic Press.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

**DISCIPLINE SPECIFIC CORE COURSE – 12: Developmental Biology of Angiosperms: Form, Anatomy & Function**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
<b>Developmental Biology of Angiosperms: Form, Anatomy &amp; Function DSC-12</b>	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

**Learning Objectives:**

- To understand the basics of plant cell structure, and development, growth and organisation of the plant body.

**Learning Outcomes:**

Upon completion of the course, the students will

- become familiar with the structure and functions of various components of plant cell
- understand the process of cell growth and its regulation
- comprehend the structure and functions of tissues organising the various plant organs
- get acquainted with the reproductive processes involved in the life cycle of angiosperms
- be able to appreciate the interactions between the developmental pathways resulting in the differentiation of plant body
- recognise the importance of plant developmental biology in the improvement and conservation of plants.

**Unit 1: Introduction to diversity of plant forms**

**05 Hours**

Historical perspective, methods/tools and techniques (fixation, sectioning, macerations); terms for describing plant cells; basic plant growth-meristems and cell differentiation; Primary and Secondary plant body (introduce terms); Classification of tissues; Simple and complex tissues, Vascular system.

**Unit 2: Tissue organisation in stem**

**05 Hours**

Organization of shoot apex -Apical cell theory, Histogen theory, Tunica Corpus theory, Neuman's Theory of Continuing Meristematic Residue, Cyto-Histological Zonation Theory; Types of vascular bundles; Structure of dicot and monocot stem; Shoot Chimeras

**Unit 3: Tissue organisation in leaf** **03 Hours**

Initiation and development of leaf; leaf lamina, venation and vascular differentiation in leaf; dermal tissue system, cuticles and special epidermal cells - cuticle; epicuticular waxes; trichomes (uni- and multicellular, glandular and non-glandular, two examples of each); stomata (classification); structure of dicot and monocot leaf, Kranz anatomy

**Unit 4: Tissue organisation in root** **04 Hours**

Organisation of root apex - Apical cell theory, Histogen theory, Korper - Kappe theory; structure and function of root apex- quiescent centre; root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

**Unit 5: Vascular Cambium** **03 Hours**

Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Cambial variants in secondary growth in stem: Included phloem and Phloem wedges.

**Unit 6: Wood and Periderm** **04 Hours**

Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances; Development and composition of periderm; rhytidome and lenticels.

**Unit 7: Adaptive and Defensive Systems** **03 Hours**

Anatomical adaptations of xerophytes and hydrophytes.; Adcrustation and incrustation;

**Unit 8: Secretory System** **02 Hours**

Hydathodes, cavities, lithocysts and laticifers.

**Unit 9: Application of Plant Anatomy** **01 hour**

Applications in systematics, plant development, physiology, forensics and pharmacognosy. Dendrochronology and dendroclimatology.

**Practicals** **60 Hours**

1. Prepare temporary whole mounts/ sections to study organisation of apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma through temporary preparations / digital resources/ permanent slides.
3. Prepare temporary stained mounts (maceration, sections) to observe xylem: tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Study the types and features of wood: ring porous; diffuse porous; tyloses; heartwood and sapwood through specimens, permanent slides and digital resources.

5. Prepare temporary whole mounts/ sections to observe phloem: sieve tubes-sieve plates; companion cells; phloem fibres.
6. Study epidermal system: cell types, stomata types; trichomes: non-glandular and glandular through temporary whole mounts/peels/using enamel.
7. Prepare temporary whole mounts/ sections to study organisation of root: monocot, dicot, secondary growth in roots.
8. Prepare temporary whole mounts/ sections to study organisation of monocot, dicot - primary and secondary growth; phloem wedges in *Bignonia*, included phloem in *Leptadenia/Salvadora*; periderm; lenticels.
9. Prepare temporary whole mounts/ sections to study organisation of leaf: isobilateral, dorsiventral, Kranz anatomy.
10. Study the adaptive anatomy in xerophytes and hydrophytes (two each) through temporary preparations / digital resources/ permanent slides.
11. Study secretory tissues: cavities, lithocysts and laticifers through permanent slides / digital resources.
12. Project: submission of permanent slides

#### **Suggested Reading:**

1. Beck, C.B. (2010). Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK, New York, USA.
2. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
3. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
4. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
5. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

#### **Additional Resources:**

1. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement.
2. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants 1st ed. Springer
3. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA
4. Evert, R.F. (2017) Esau's Plant Anatomy; Meristems, Cells and Tissues Of The Plant Body- Their Structure, Function And Development. 3rd Edn Wiley India.
5. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.
6. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London

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## POOL OF DISCIPLINE SPECIFIC ELECTIVES

### DISCIPLINE SPECIFIC ELECTIVE COURSE – 03 Applied Phycology

#### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applied Phycology BOT-DSE-03	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

#### Learning Objective:

- To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

#### Learning Outcomes:

On completion of the course the students will be able to understand:

- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

#### Unit 1: Scope of phycology

**01 hour**

In emerging research areas, environment and industries.

#### Unit 2: Algae as food, feed and fodder

**03 hours**

Nutritional value of algae; Common edible algae; Algae as food, feed and fodder with suitable examples.

#### Unit 3: Algae in industry

**06 hours**

Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

#### Unit 4: Algae in agriculture

**03 hours**

Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues.

#### Unit 5: Role of Algae in environment

**06 hours**

Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

**Unit 6: Algae in biotechnology and research****05 hours**

Gene sequencing and algal systematics; Algae as a model organism (*Chlamydomonas*, *Chlorella*, *Acetabularia*, *Ectocarpus*, *Porphyra*); Bioluminescent forms; Algae in nanotechnology.

**Unit 7: Algae as emerging source of bioenergy****02 hours**

Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

**Unit 8: Algal culture techniques and commercial production****04 hours**

Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

**Practicals****60 hours**

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella/* any other available edible algae.
3. Study of algal symbiosis (*Azolla* fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1 (any three).
6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

**Suggested Readings:**

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2<sup>nd</sup> edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3<sup>rd</sup>edn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2<sup>nd</sup> edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4<sup>th</sup> edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean: Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

**Additional Resources:**

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2<sup>nd</sup>edn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

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**DISCIPLINE SPECIFIC ELECTIVE COURSE – 04 Industrial and Environmental Microbiology**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
<b>Industrial and Environmental Microbiology</b> <b>BOT-DSE-04</b>	<b>4</b>	<b>2</b>	<b>0</b>	<b>2</b>	Class XII pass with Biology/ Biotechnology	<b>Nil</b>

**Learning Objectives:**

- To introduce students to the concepts, principles, scope and applications of industrial and environmental microbiology.

**Learning Outcomes:**

Upon successful completion of the course, students will be able to:

- understand how microbiology is applied in manufacturing of industrial products
- know about design of bioreactors
- understand the rationale in medium formulation, design for microbial fermentation, sterilization of medium and air
- comprehend the techniques and the underlying principles in upstream and downstream processing
- learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
- understand the basic principles of environment microbiology and application of the same in solving environmental problems - waste water treatment and bioremediation
- comprehend the various methods to determine the quality of water

**Unit 1: Microbes and quality of environment**

**04 hours**

Introduction and scope of microbes in industry and environment; Distribution and isolation of microorganisms from soil, air and water.

**Unit 2: Bioreactors/Fermenters and fermentation processes**

**08 hours**

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilot

scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

**Unit 3: Microbial production of industrial products** **10 hours**

Microorganisms generally regarded as safe (GRAS); Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization; Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

**Unit 4: Microbial enzymes of industrial importance** **03 hours**

Applications of industrially important enzymes (protease, lipase, and penicillin acylase); Methods of immobilisation and its advantages.

**Unit 5: Microbial flora of water** **05 hours**

Water pollution: various sources and control measures; Role of microbes in sewage and domestic wastewater treatment systems. Microorganisms as indicators of water quality: coliforms and faecal coliforms.

**Practicals** **60 hours**

1. Principles and functioning of instruments: autoclave, laminar air flow, incubators, types of fermenters.
2. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium).
3. Hydrolysis of casein and starch by microorganisms.
4. Alcohol production by yeast using sugar/ jaggery.
5. Serial dilution method for isolation of microorganisms from water and soil and study of aero-microflora.
6. To determine the BOD of sewage water.
7. To qualitatively check the enzyme activity (phosphatase/amylase/cellulase) in soil samples.
8. To determine the microbial activity in soil by Triphenyltetrazolium chloride (TTC) assay or by measuring the CO<sub>2</sub> evolution.
9. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
10. Visit to any educational institute/ industry and a report to be submitted

**Suggested Readings:**

1. Bertrand, Jean-Claude, Caumette, P., Lebaron, P, Matheron, R., Normand, P., Sime• Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amsterdam, Netherlands, Springer.
2. Joe, S., Sukesh (2010). Industrial Microbiology. S.Chand& Company Pvt. Ltd. New Delhi, Delhi.

3. Mohapatra. P.K. (2008). Textbook of Environmental Microbiology. I.K. International Publishing House Pvt.Ltd. New Delhi, Delhi.
4. Okafer, Nduka (2007). Modern Industrial Microbiology & Biotechnology. Science Publishers, Enfield, NH, USA.
5. Pelzar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi.

**Additional Resources:**

1. Alef K, and Nannipieri P (1995). Methods in Applied Soil Microbiology and Biochemistry, First Edition Academic Press, USA.
2. Atlas, Bartha. (1997). Microbial Ecology: Fundamentals and Applications. San Fransisco, SF. Pearson.
3. Casida, J.R. (2016). Industrial Microbiology. New Delhi, Delhi, New Age International Publishers.
4. Hurst C.J., Crowford R.L., Garland J.L. and Lipson D.A. (2007). Manual of Environmental Microbiology, American Society of Microbiology, USA.
5. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited.
6. Sharma, P.D. (2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.
7. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016). Principles of Fermentation Technology. Amesterdam, ND:Elsevier Publication.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology (9<sup>th</sup> edition). San Francisco, SF: Pearson Benjamin Cummings.

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