



SACRED HEART COLLEGE (AUTONOMOUS)

Tirupattur – 635 601, Tamil Nadu, S.India

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Ready for
Every Good Work

A Don Bosco Institution of Higher Education, Founded in 1951 * Affiliated to Thiruvalluvar University, Vellore * Autonomous since 1987

Accredited by NAAC (4th Cycle – under RAF) with CGPA of 3.31 / 4 at 'A+' Grade

M.Sc. Applied Microbiology

Sem	Part	Subject Code	Subject Title	Hrs	Credit (s)	Exam Hrs	CA	SE	Total		
I	Core Paper I	MB701	General Microbiology and Microbial Diversity	4	4	3	50	50	100		
	Core Paper II	MB702	Microbial Physiology and Metabolism	4	4	3	50	50	100		
	Core Paper III	MB703	Immunology	4	3	3	50	50	100		
	Core Paper IV	MB704	Molecular Microbiology	4	4	3	50	50	100		
	Core Practical I	PMB801	General and Medical Microbiology	5	-	-	-	-	-		
	Core Practical II	PMB802	Immunology, Hematology and Molecular Biology	5	-	-	-	-	-		
	Elective Paper I		(to choose 1 out of 3)	MB705A	1. Microbial Instrumentation	4	3	3	50	50	100
				MB705B	2. Biostatistics						
MB705C				3. Phycology and Mycology							
				30	18	-	-	-	500		
II	Core Paper V	MB801	Medical Bacteriology	6	4	3	50	50	100		
	Core Paper VI	MB802	Medical Virology	5	4	3	50	50	100		

	Core Paper VII	MB803	Medical Mycology and Parasitology	5	4	3	50	50	100
	Core Practical I	PMB801	General and Medical Microbiology	5	4	6	50	50	100
	Core Practical II	PMB802	Immunology, Hematology and Molecular Microbiology	5	4	6	50	50	100
	Elective Paper II	MB804A MB804B MB804C	(to choose 1 out of 3) 1. Pharmaceutical Microbiology 2. Bioinformatics 3. Public Health Microbiology	4	3	3	50	50	100
		PMB803J	Internship*	-	2*	-	-	-	-
				30	23+2*	-	-	-	600
III	Core Paper VIII	MB901	Research Methodology	4	4	3	50	50	100
	Core Paper IX	MB902	Bioinoculant Technology and Plant Pathology	4	4	3	50	50	100
	Core Paper X	MB903	Mushroom Technology	4	4	3	50	50	100
	Core Paper XI	MB904	Environmental Microbiology	4	4	3	50	50	100
	Core Practical III	PMB1001	Bioinoculant, Composting and Mushroom Technology	5	-	-	-	-	-
	Core Practical IV	PMB1002	Environmental and Food Microbiology	5	-	-	-	-	-
	Elective Paper III	MB905A MB905B MB905C	(to choose 1 out of 3) 1. Microbial Remediation 2. Vermitechnology 3. Microbial Nanotechnology	4	4	3	50	50	100
				30	20	-	-	-	500

IV	Core Paper XII	MB1001	Food Microbiology	4	4	3	50	50	100
	Core Paper XIII	MB1002	Industrial Microbiology	5	5	3	50	50	100
	Core Paper IX	MB1004J	Project/Dissertation with Viva voce	5	5	-	50	50	100
	Core Practical III	PMB1001	Bioinoculant, Composting and Mushroom Technology	5	5	6	50	50	100
	Core Practical IV	PMB1002	Environmental and Food Microbiology	5	5	6	50	50	100
	Elective Paper IV		(to choose 1 out of 3)						
		MB1003A	1. Microbial Biotechnology	4	4	3	50	50	100
		MB1003B	2. Microalgal Technology						
		MB1003C	3. Probiotic Microbiology						
	-	-	Human Rights	2	1	3	50	50	100
	-	-	Self Study Paper (SSP): Comprehensive Microbiology	-	2*	-	-	-	-
	-	-	NPTEL/MOOCs/Other Certificate courses*	-	2*	-	-	-	-
Total				30	29+4*	-	-	-	700
TOTAL				120	90+6*	-	-	-	2200

Sacred Heart College (Autonomous), Tirupattur District

1.2.1 List of New Courses

Department: M.Sc Applied Microbiology

S.No	Course Code	Course Name
1.	MB901	Research Methodology
2.	MB902	Bioinoculant Technology and Plant Pathology
3.	MB903	Mushroom Technology
4.	MB904	Environmental Microbiology
5.	MB905A	Microbial Remediation
6.	MB905B	Vermitechnology
7.	MB905C	Microbial Nanotechnology
8.	MB1001	Food Microbiology
9.	MB1002	Industrial Microbiology
10.	MB1003A	Microbial Biotechnology
11.	MB1003B	Microalgal Technology
12.	MB1003C	Probiotic Microbiology
13.	MB 1004J	Project/Dissertation with Viva-Voce
14.	PMB1001	Core Practical - III
15.	PMB1002	Core Practical - IV
16.	PBCD206J	Internship

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RESEARCH METHODOLOGY**Objectives**

- To learn about research designs, ethics in scientific research, data collection and analysis of scientific data using software.
- To analyze the Art of Report and Scientific writing.
- To study the basic Statistics methods used for Life science research.
- To gain the knowledge on Laboratory animals and its maintenance.
- To provide insights on importance of scientific communication, ethical issues in research, plagiarism and IPR.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Provides knowledge to collect Research paper from different Web sources.	K1, K2, K3
CO-2	Demonstrate the importance of Scientific communication, Ethical issues in research.	K2
CO-3	Identify appropriate methods for Analysis of variance and learn few Statistical packages	K4
CO-4	Provides knowledge about the maintenance and ethics related to Laboratory animals.	K1, K3
CO-5	Evaluate the students about reading the different ongoing research in area of Microbiology.	K5
CO-6	Creating an awareness on Plagiarism and IPR.	K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	2	2	3	2	2	2	2	2	3	2	2	3	3	2.3
2	3	2	2	2	2	2	3	2	2	2	2	2	2	3	3	2.2
3	2	2	2	3	1	2	3	2	1	2	3	2	3	3	2	2.2
4	2	2	3	3	2	2	3	1	3	2	3	3	1	2	2	2.2
5	2	2	3	2	2	2	2	3	2	1	2	2	1	2	2	2.0
6	2	2	1	2	2	3	2	2	2	3	3	2	3	2	2	2.2
Mean Overall Score																2.2
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Importance and need for research; Basic and Applied Research; Essential steps in Research; Ethics and Scientific research; Designing of research work; Hypothesis and Null – hypothesis; Scientific writing – Research article, Review article, Case reports and Short communication; Components of a Research report – Title, Author name & Institution details, Abstract, Introduction, Review of Literature, Materials and Methods, Results, Discussion, Summary, Conclusion, Acknowledgement and References – Harvard and Vancouver systems; Components of Thesis writing.

Unit – II

Importance of Scientific communication - Types and Modes of Scientific communications; Journals in Microbiology and Life Sciences; Impact factor of Journals; Indexing agencies for Journals; Book publication – Text books, Monographs and Edited books; Ethical issues related to Publishing; Plagiarism and Self plagiarism; Software to detect Plagiarism; Role of Computers in Biology; Useful search engines for Research; Social media related to Research

Unit - III

Collection and Classification of Data; Representation of Data - Tabulation, Frequency distribution, Diagrams and Graphs; Measurement of Central tendency; Tests of Significance - Chi-square test, Student t-test and Z score; Analysis of Variance – ANOVA (One-way classification and Two-way classification); Completely Randomized Design (CRD), Randomized Block Design (RBD), Least Significant Difference (LSD) and Duncan's multiple range test (DMR); SPSS for various applications in Biostatistical programme; R Programming Language.

Unit – IV

Laboratory animals used for Life Science Research; CPCSEA Guidelines for Laboratory Animal Facility: Veterinary care - Animal procurement, Quarantine, Stabilization & Separation and Surveillance, Diagnosis & Treatment; Animal Husbandry for Animal maintenance – Caging or Housing system, Sheltered or Outdoor housing, Social environment, Monitoring Animal activity, Food, Bedding and Water; Sanitation, Cleanliness and Waste disposal in Animal house; Record keeping in Animal house; Standard Operating Procedures for Animal Husbandry; Transport of Laboratory Animals; Anesthesia and Euthanasia.

Unit – V

Composition of Institutional Ethical Committee (IEC) - General Ethical Issues, Laboratory Animal Ethics, Food and Drug safety Ethics; Ethical issues in Human Gene Therapy and Human Cloning; Environmental release of Genetically Engineered Microorganisms; Intellectual Property Rights (IPR) – Protection of IPR in India, Terminology Associated with IPR and Issues Relating to IPR; Patentable and Non – patentables; World Intellectual Property Rights Organization (WIPO); Research funding agencies in India.

Text Books

- 1) Gurumani, N. 2004. Research Methodology for Biological Sciences. MJP Publishers, India.
- 2) Anderson, J. B and M. Poole. 2011. Assignment and Thesis Writing. 4th Edition, Wiley India Private Limited, UK.
- 3) Kothari, C. R and G. Garg. 2004. Research Methodology: Methods and Techniques. 2nd edition, New Age International Publishers, India.
- 4) Sateesh, M. K. 2008. Bioethics and Biosafety. I. K. International Pvt. Ltd, New Delhi, India.

References

- 1) Gupta, S. P. 2013. Fundamentals of Statistics, Sultan Chand, India.
- 2) Goel, D and S. Parashar. 2013. IPR, Biosafety and Bioethics. Pearson Education in South Asia.
- 3) Ethical guidelines for biomedical research on human subjects. ICMR, New Delhi, 2000.
- 4) Ahuja, V. K. 2017. Laws Relating to Intellectual Property Rights. Lexis Nexis.

BIOINOCULANT TECHNOLOGY AND PLANT PATHOLOGY**Objectives**

- To study about the Production, Formulation, Method of application and Quality control of Bioinoculants.
- To create an awareness on Soil microorganisms in Agriculture.
- To understand the role of Nitrogen fixers, Phosphate solubilizers, AM fungi and Algal biofertilizers.
- To give knowledge on Plant pathogen interaction and its control.
- To learn the ability of Biopesticides and Biocontrol agents in Plant growth.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Acquire knowledge on Bioinoculant technology.	K3
CO-2	Gives the knowledge to the students about Natural organic farming.	K1, K3
CO-3	Explains the details of Production, Formulation, Method of application and Quality control of Bioinoculants.	K2
CO-4	Analyzing the diseases causing ability of microorganisms in plants and its control measures.	K4
CO-5	Developing different methods for the Pest control using microbes.	K6
CO-6	Recommending the factors for good Soil quality and Agricultural output through sustainable Microbiological applications.	K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	2	3	2	2	2	2	3	3	3	3	2	3	3	2.5
2	3	2	2	3	3	2	3	2	3	2	3	3	2	2	3	2.5
3	2	2	2	3	2	2	3	3	1	2	3	2	3	2	2	2.2
4	2	2	3	3	2	2	3	2	3	2	3	3	2	2	3	2.4
5	2	2	3	2	3	3	2	2	2	1	2	2	2	2	2	2.1
6	3	3	2	2	3	3	2	3	2	2	3	3	3	2	2	2.5
Mean Overall Score															2.4	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Bioinoculants – Definition, Types and Importance; Advantages of Biofertilizers over Chemical fertilizers; Formulations of Bioinoculants; Methods and application of Bioinoculants in different crops; Quality control of different Bioinoculants; Plant – Microbe Interaction; PGPR and its role in agriculture – Direct mechanism and Indirect mechanism; Role of PGPR in Soil Bioremediation.

Unit – II

Nitrogen fixation by bacteria; Isolation, Characterization, Mass multiplication, Field application and Plant growth promoting activities of Nitrogen fixing bacteria (*Rhizobium* sp., *Frankia* sp., *Azotobacter* sp., *Azospirillum* sp. and *Gluconacetobacter* sp.). Phosphate solubilization – Phosphate solubilizing microorganisms, Screening of Phosphate solubilizing efficiency, Mechanism of Phosphate solubilization and Benefits of Phosphate solubilizing microorganisms; Algal Biofertilizers – Isolation and Mass multiplication of Blue Green Algae (BGA), Mass multiplication of *Azolla*, *Azolla* – *Anabaena* symbiosis, Heterocyst and its importance in N₂ fixation.

Unit – III

Mycorrhizal Bioinoculants – Significance, Types and Benefits; Arbuscular Mycorrhiza (AM) fungi – Taxonomy, Isolation, Assessment of AM colonization in roots, Mass inoculum production, Field applications; AM fungi and Abiotic stress; Role of AM fungi in agriculture; Biopesticides – Entomopathogenic bacteria (*Bacillus thuringiensis*); Entomopathogenic fungi (*Beauveria bassiana*, *Verticillium lecanii*, *Isaria fumosorosea*, *Lecanicillium* sp. & *Metarhizium anisopliae*); Entomopathogenic virus (Cydia pomonella granulosis virus - CpGv); Plant disease control agents (*Bacillus subtilis*, *Bacillus megaterium*, *Pseudomonas fluorescens* & *Trichoderma viride*).

Unit – IV

History of Plant Pathology; Host-parasite relationship in plants; Principles of Plant diseases; Plant Disease Triangle; Plant diseases - Symptoms and Types; Pathogenic and Non-pathogenic Plant diseases; Plant Pathology in Practice - Plant Clinic and Plant Doctor Concept; Biochemical aspects of disease development; Principle of Biotrophic, Hemibiotrophic and Perthotrophic colonization; Molecular detection of Phytopathogens.

Unit – V

Antibiosis and Biological control of Soil borne plant pathogens; Microbial pest management; Mycotoxins in plants; List of important Plant diseases; Bacterial diseases – Blight of rice, Citrus canker & Wilt of potato; Fungal diseases – Blast of rice, Late blight of potato, Rust of wheat, Smut of sugar cane, Wilt of cotton, Tikka leaf spot of ground nut, Mildews of fruits, Leaf curl disease & Little leaf disease; Viral diseases - Mosaic disease; Disease Resistance - Biochemical and Genetic aspects; Defense mechanism in Plants; Current Research Thoughts in Bioinoculant Technology and Plant Pathology.

Text Books

- 1) Saranraj, P and Sivasakthivelan, P. 2020. Text Book of Bioinoculants Technology. 1st Edition, JPS Scientific Publications, India.
- 2) Vijaya Ramesh, K. 2008. Environmental Microbiology, MJP Publishers, Chennai, India.
- 3) Subba Rao N.S. 1999. Soil Microbiology, 4th Edition, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- 4) Mehrotra, R. S. 1983. Plant Pathology, Tata McGraw Hill Publishing Company Ltd., New Delhi.

References

- 1) Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton. 2017. Prescott's Microbiology, 10th Edition, McGraw Hill Publication, United States.
- 2) Atlas, R.M and R. Bartha. 1998. Microbial Ecology. Fundamentals and Applications, 4th Edition, Red Wood City. C.A. Benjamin.
- 3) Bagyaraj, D. J and G. Rangasamy. 2002. Agricultural Microbiology, 2nd Edition, Prentice Hall, India.
- 4) Mahendra K. Rai. 2005. Hand book of Microbial Biofertilizers, The Haworth Press, Inc. New York.

MUSHROOM TECHNOLOGY*Objectives*

- To modify of the Mushroom cultivation in a scientific way for livelihood.
- To differentiate edible and poisonous mushrooms and their effects.
- To encode the importance of the Mushrooms.
- To outline the process of Mushroom cultivation.
- To obtain a good understanding of Mushroom cultivation and its disease control.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Provides the information about the Cultivation, Nutritional value and Medicinal value of Mushrooms.	K1
CO-2	Gaining knowledge about different types of Mushrooms.	K3
CO-3	Analyze the pathological damage on mushrooms and outline the post-harvest practices.	K4
CO-4	Demonstrate the methods for Disease control in Mushrooms.	K2
CO-5	Assess the nutrient and medicinal value of edible mushrooms and analyse effects of mushroom poisoning.	K5
CO-6	Develops Entrepreneurial skill on Production and Marketing of Mushroom.	K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of Cos
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	3	2	2	3	3	3	3	2	3	3	3	2	3	3	2.7
2	2	2	3	3	2	2	3	2	3	3	2	2	3	2	1	2.3
3	3	1	2	3	1	3	2	3	2	2	3	3	2	3	3	2.4
4	2	2	3	2	3	2	3	3	3	3	3	3	3	2	2	2.6
5	2	3	3	2	2	2	2	2	2	2	2	2	3	2	2	2.2
6	3	2	2	3	3	3	2	3	3	3	3	3	2	3	3	2.7
Mean Overall Score																2.5
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit - I

Mushroom – Historical development, Origin, Characteristics, Importance, Morphology and Life cycle; Classification of Mushroom; Commonly cultivated mushrooms in the world; Nutritional value of Mushroom; Medicinal value of Mushroom; Edible mushrooms and Non - edible mushroom; Medicinal and Environmental uses of Mushrooms.

Unit - II

Mushroom farms – Farm layout and Farm hygiene; Substrates used for Mushroom cultivation; Spawn production for Mushroom cultivation – Starter culture, Sterilization process, Clean Environmental Condition, Cultures, Preparation of Media & Slants, Spawn containers, Mother Spawn, Preparation of Final Spawn, Precautions and Storage of Spawn.

Unit - III

Genetic Improvements of Mushroom; Growth factors for Mushroom cultivation; Cultivation of Button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus sajor – caju*), Milky mushroom (*Calocybe indica*), Reizhi mushroom (*Ganoderma lucidum*) and Paddy straw mushroom (*Volvariella volvacea*);

Management of wastes generated during Mushroom cultivation; Insect pests and its management during Mushroom cultivation.

Unit - IV

Diseases of Mushrooms – Bacterial disease (Bacterial blotch, Mummy disease & Drippy gill), Viral disease (Die back disease); Fungal diseases (Dry bubble disease, Wet bubble disease, Cobweb disease, *Trichoderma* Blotch and Mildew caused by *Cladobotrym* sp. and *Aphanocladium* disease); Fungal competitors during Mushroom cultivation - Green mould, Olive Green mould, Brown plaster mould, White plaster mould, Inkcaps, Yellow mould, Sepedonium Yellow mould, Lipstick mould, Oedocephalum mold, False truffle and Cinnamon mould.

Unit - V

Post Harvest Technology of Mushroom – Harvesting, Grading, Packaging & Storage, Transportation, Preservation and Marketing (Fresh market and Drying); Environmental impact of Mushroom cultivation; Mushroom food recipes; Antimicrobial compounds from Mushroom; Economical value of Mushroom; Cost analysis for Mushroom cultivation; Challenges in Mushroom cultivation; Mushroom Research Centers in India; Current Research Thoughts in Mushroom Technology.

Text Books

- 1) Kannaiyan. 2001. Handbook of Edible Mushrooms, TNAU Publication, Coimbatore, India.
- 2) Alice, D., K. Muthusamy and M. Yesuraja. 1999. Mushroom Culture, Agricultural College, Research Institute Publications, Madurai, Tamil Nadu, India.
- 3) Russell, S. 2003. Essential Guide to Cultivating Mushrooms. 1st Edition. Storey Publishing, LLC.
- 4) Tiwari, S. C and Kapoor, P. 2018. Mushroom - The art of Cultivation. 1st Edition. Mittal Publications, India.

References

- 1) Marimuthu, T. 1991. Oster Mushroom, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
- 2) Nita Bhal. 2000. Handbook on Mushrooms, 2nd Edition, Volume - I and II, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- 3) Tripathi, D. P. 2005. Mushroom Cultivation, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- 4) Naidu, N. V. R. 2008. Management and Entrepreneurship. I.K. International Pvt. Ltd., India.

Semester – III

4 Hours/4 Credits

ENVIRONMENTAL MICROBIOLOGY

Objectives

- To describe the distribution and enumeration of air microflora and categorize the air borne diseases.
- To discuss the Terrestrial ecosystem and Aquatic ecosystem.
- To give an overview about role of microorganisms for the cycle of Carbon, Nitrogen, Phosphorus and Sulphur in the nature.
- To illustrate the process of Solid waste treatment and Sewage water treatment, and determine the role of microorganisms in water pollution and water quality.
- To gain knowledge about Bioremediation mechanisms provided by microbes.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Assess the role and importance of microorganisms in Atmosphere, Hydrosphere and Pedosphere.	K5
CO-2	Understanding the role of microorganism in recycling Soil nutrients through Biogeochemical cycles.	K2
CO-3	Provides a detailed knowledge on Solid waste and Waste water treatment technologies.	K1, K3
CO-4	Create an awareness to students with current research in environmental microbiology.	K6
CO-5	Point out the general principles and subject knowledge in the field of Environmental Microbiology.	K4
CO-6	Gain knowledge about Bioremediation and Biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability.	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	3	3	3	3	3	3	2	3	3	3	3	2	3	2.8
2	3	2	3	3	2	3	3	2	3	3	3	3	3	2	3	2.7
3	3	2	3	3	2	3	2	3	2	2	3	3	3	3	2	2.6
4	3	3	2	3	3	2	3	2	3	3	3	3	3	2	3	2.7
5	3	2	3	3	3	3	2	3	2	3	3	3	2	3	2	2.6
6	3	3	2	2	3	3	3	3	3	3	3	3	2	3	2	2.7
Mean Overall Score															2.7	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Organization of the Biosphere; Common Terminologies in Microbial Ecology; Microbiome; Ecosystem and its types; Major role of Microorganisms in Ecosystem; Atmosphere – Aeromicrobiology and Relationship between Microorganisms and Atmosphere; Sampling of Air; Aeroallergens; Air borne disease; Air pollution; Indicators of Air pollution; Green house effect; Air Sanitation; CO₂ sequestration.

Unit – II

Terrestrial Ecosystem – Importance of Soil; Formation of Soil; Composition of Soil; Soil Horizons; Soil characteristics (Physical & Chemical); Soil Microbiology – Major group of Soil microorganisms; Qualitative microflora of soil (Bacteria, Actinobacteria, Fungi, Viruses, Algae & Protozoa); Soil types and their microflora; Quantification of Soil microflora; Role of microorganisms in Soil fertility.

Unit – III

Aquatic ecosystem – Major communities of Aquatic ecosystem (Phytoplankton and Zooplankton); The Microbial Loop; Types of Aquatic ecosystem - Fresh water ecosystem, Marine ecosystem, Estuarine ecosystem and Mangrove ecosystem; Water zonations; Eutrophication; Winogradsky column; Bioluminescence; Water pollution; Bacteriological analysis of water; Water based disease transmission mechanism – Water borne, Water-washed, Water-based and Water related; Water borne diseases; Purification of water; Recycling of water.

Unit – IV

Organic matter decomposition; C:N Ratio; Formation and composition of Soil organic matter - Fluvic acid & Humic acid; Biogeochemical cycles – Carbon cycle, Nitrogen cycle, Phosphorous cycle, Sulphur cycle and Iron cycle; Microbe – Microbe Interactions; Plant – Microbe Interactions; Root exudates and Rhizosphere effects.

Unit – V

Solid waste management - Incineration, Composting & Sanitary Landfill; Sewage treatment – Small scale sewage treatment (Cesspools, Septic tank & Imhoff's tank) and Large scale sewage treatments (Primary treatment, Secondary treatment, Tertiary treatment & Anaerobic Sludge Digestion); Xenobiotics; Acid Mine Drainage; Bioremediation; – Uranium, Hydrocarbons, Pesticides, Chlorinated compounds and Plastics; Biodegradation; Bioaccumulation; Bioleaching; Biodeterioration of Paper, Leather, Wood, Textiles, Stone and Concrete; Microbially Induced Corrosion; Biofilms in Environment; Pollution control bodies and Environmental laws in India; Current Research Thoughts in Environmental Microbiology.

Text Books

- 1) Vijaya Ramesh, K. 2008. Environmental Microbiology, MJP Publishers, Chennai, India.
- 2) Saranraj, P and Sivasakthivelan, P. 2020. Text Book of Environmental Microbiology. 1st Edition, JPS Scientific Publications, India.
- 3) Subba Rao N.S. 1999. Soil Microbiology, 4th Edition, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- 4) Jeffrey C. Pommerville. 2006. Alcamo's Fundamentals of Microbiology. 4th Edition, Jones and Bartlett Publishers, Canada.
- 5) Kathleen Park Talaro and Bary Chess. 2015. Foundations in Microbiology. 9th Edition, McGraw Hill Publication, New York.
- 6) Jacquelyn G. Black. 2012. Microbiology – Principles and Explorations. 8th Edition, John Wiley and Sons, United States.

References

- 1) Marjorie Kelly Cowan. 2012. Microbiology – A System Approach. 3rd Edition, MacGraw Hill Publication, United States.
- 2) Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton. 2017. Prescott's Microbiology, 10th Edition, McGraw Hill Publication, United States.
- 3) Patel, A. H. 2016. Industrial Microbiology, 2nd Edition, Laxmi Publications, New Delhi, India.
- 4) Madigan, M. T., J. M. Martinko and J. Parker. 2009. Brock's Biology of Microorganisms, 12th Edition, Pearson/Benjamin Cummings, New York.
- 5) Maier, R. M., I. L. Pepper and C. P. Gerba. 2009. Environmental Microbiology, 2nd Edition, Academic Press, United States.

Semester – III

4 Hours/3 Credits

ELECTIVE: MICROBIAL REMEDIATION

Objectives

- To motivate against environmental pollution.
- To find solution for pollution using microbes.
- To study the remediation process by plants, fungi, plants and algae.
- To develop knowledge about the environmental risk assessment and remediation.
- To gain knowledge on role of microorganisms in their environment.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Developing basic skills Environmental microbiology and Microbial remediation of wastes.	K6
CO-2	Finding solution for various pollution related problems.	K5
CO-3	Understand and explain the microbial metabolism of environmental contaminants.	K2
CO-4	Describing the principle of remediation process by various aspects.	K1
CO-5	Determining the Scientific problem related to pollution and remediation process will be explained.	K3
CO-6	Analyzing the scientific problem related to pollution and remediation process.	K4

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO 9	PSO 10	
1	3	3	2	2	3	3	3	3	2	3	3	3	2	3	3	2.7
2	2	2	3	3	2	2	3	2	3	3	2	2	3	2	1	2.3
3	3	1	2	3	1	3	2	3	2	2	3	3	2	3	3	2.4
4	2	2	3	2	3	2	3	3	3	3	3	3	3	2	2	2.6
5	2	3	3	2	2	2	2	2	2	2	2	2	3	2	2	2.2
6	3	2	2	3	3	3	2	3	3	3	3	3	2	3	3	2.7
Mean Overall Score															2.5	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Bioremediation - Process and Organisms involved; Constraints and priorities of Bioremediation; Major pollutants and Polluted sites; Bioaugmentation; Intrinsic and Engineered Bioremediation; Pollutants and associated risks; Polyaromatic hydrocarbon pollution; Organic pollutant degradation; Advantages and Disadvantages of Bioremediation.

Unit – II

Microbes involved in Aerobic and Anaerobic processes in nature - Removal of Heavy metals; Biotransformation of Heavy metals and Xenobiotics; Petroleum biodegradation; Microbial leaching of Ores - Process, Microorganisms involved and Metal recovery with special reference to Copper and Iron; Dechlorination; Biodegradable plastics and Super bug.

Unit – III

Aerobic and Anaerobic digesters - Design and Various types of Digester for Bioremediation of Industrial effluents; Pros and Cons of Anaerobic process; Dendroremediation; Composting of Solid wastes; Methane production and important factors involved; Sulphur, Iron and Nitrate reduction; Hydrocarbon degradation;

Nitroaromatic compounds degradation; Bioremediation of dyes; Bioremediation in Paper and Pulp industries.

Unit – IV

Fungi, Mushrooms and their enzymes in Bioremediation; Transformation of Industrial and Agro-industrial wastes into useful products; Characteristic of Solid and Liquid waste; Solid waste management - Incineration, Composting & Sanitary landfill; Sewage treatment – Small scale sewage treatment (Cesspools, Septic tank & Imhoff's tank) and Large scale sewage treatments (Primary treatment, Secondary treatment & Tertiary treatment).

Unit – V

Phytoremediation of polluted soil and wastewater; Advantages of Phytoremediation; Phycoremediation of Domestic and Industrial wastewater; Advantages of Phycoremediation; Potentials of Microalgae for Industrial effluents treatment; Conventional methods vs Algal technology; Novel technologies for Bioremediation of Industrial effluents; Genetic engineering in Bioremediation; Pollution control bodies and Environmental laws in India; Current Research Thoughts in Microbial Remediation.

Text Books

- 1) Singh, S. N. 2014. Biological Remediation of Explosive Residues, Springer International Publishing, Switzerland.
- 2) Vijaya Ramesh, K. 2008. Environmental Microbiology, MJP Publishers, Chennai, India.
- 3) Saranraj, P and Sivasakthivelan, P. 2020. Text Book of Environmental Microbiology. 1st Edition, JPS Scientific Publications, India.
- 4) Cheremisinoff, N. P. 2013. Biotechnology for Waste and Wastewater Treatment, Elsevier, UK.
- 5) Sathyanarayana, T., Johri, B. N and Prakash, A. 2012. Microorganisms in Environmental Management – Microbes and Environment, Springer, Heidelberg.

References

- 1) Chandrappa, R and Das, D. B. 2012. Solid Waste Management Principles and Practice, Springer-Verlag, Heidelberg.
- 2) Anjum, N. A., Pereira, M. E., Ahmad, I., Duarte, A. C., Umar, S and Khan, N. A. 2013. Phytotechnologies Remediation of Environmental Contaminants, CRC Press, Boca Raton, FL, USA.
- 3) Gupta, D. K. 2013. Plant-Based Remediation Processes, Springer-Verlag, Berlin Heidelberg.
- 4) Gupta, D. K and Sandalio, L. M. 2013. Metal Toxicity in Plants: Perception, Signaling and Remediation Springer, Berlin Heidelberg.
- 5) Khan, M. S., Zaidi, A., Goel, R and Mussarat, J. 2012. Biomangement of Metal-Contaminated Soils, Springer, Dordrecht.

Semester – III

4 Hours/3 Credits

ELECTIVE: VERMITECHNOLOGY

Objectives

- To study about the properties of soil and microbial composting.
- To classify and compare the characteristics of earthworm species and waste materials needed for Vermicomposting.
- To describe the process and benefits of Vermicomposting.
- To understand the biology of Earthworms and its role in Vermicomposting.
- To learn the ability of Earthworms in Organic farming and Solid waste reclamation.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Provide the knowledge to the students about Organic farming through Composting and Vermicomposting.	K1, K3
CO-2	Compare the difference between Microbial composting and Vermicomposting.	K2
CO-3	Observe the Biology of Earthworms and its role in Vermicomposting process.	K1
CO-4	Finding the details of Earthworms and its role in Solid waste reclamation.	K5
CO-5	Categorize the types of Earthworms and feed needed for Vermicomposting.	K4
CO-6	Develop various methods of Vermicomposting and its benefits to soil and plants.	K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	3	2	2	3	2	2	2	2	2	3	3	2	3	3	2.4
2	3	2	2	3	2	2	3	2	3	2	2	2	2	3	3	2.4
3	2	2	2	3	2	2	3	2	2	2	3	2	3	3	2	2.3
4	2	2	3	3	1	2	3	2	3	2	3	3	2	2	2	2.3
5	2	2	3	2	2	2	2	3	2	2	2	2	2	2	2	2.1
6	2	2	1	2	2	3	2	3	2	3	3	1	3	2	2	2.2
Mean Overall Score															2.3	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Vermitechnology – History and Scope; Influence of Soil microorganisms in Vermitechnology; Development and Future of Vermitechnology in India and other countries; Earthworms – Diversity, Geographical distribution, Morphology, Life cycle and Behaviour patterns.

Unit – II

Burrowing activity of Earthworms; Physical, Chemical and Biological changes caused by Earthworms in Soil; Drilospheres and Vermicasts; Effect of Earthworm is Soil structure – Carbon, Nitrogen and Phosphorous Transformation; Microclimate of Rhizosphere and Drillosphere.

Unit – III

Composting – Wastes used for Composting process; Methods of Composting; Difference between Microbial Composting and Vermicomposting; Millicomposting; Factors affecting Composting process; Analysis of Physico-chemical characteristics and Microbial quality of Compost materials; Microbial Composting - Aerobic and Anaerobic Composting.

Unit – IV

Vermicompost – Morphological identification of Earthworm species used in Vermicompost production (*Eisenia fetida*, *Eisenia andrei*, *Dendrobaena veneta*, *Eudrilus eugeniae*, *Lampito mauririi* and *Perionyx excavates*); Methods for Collection and Preservation of Earthworms; Materials used for Vermicomposting; Vermicomposting methods – Small scale and Large scale; Packaging, and Marketing; Factors influencing Vermicomposting process; Cost benefit analysis of Vermicompost; Applications of Vermicomposting in Agriculture and Horticulture practices; Advantages of Vermicompost over Chemical inputs.

Unit - V

Vermiculture; Vermiculture unit – Materials required and Maintenance; Vermiwash and its applications; Feeding habits and food for Composting worms; Importance of Microorganisms as Food for Earthworms; Problems in Vermiculture units and Remedial suggestions; Problems during Vermicomposting - Pests, Parasites and Pathogens; Earthworms in recycling of various Solid wastes; Benefits of Earthworms other than Vermicomposting; Current Research Thoughts in Vermitechnology.

Text Books

- 1) Edwards, C. A., Arancon, N. Q and Sherman, R. L. 2011. Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management. 1st Edition, CRC Press, USA.
- 2) Vijaya Ramesh, K. 2008. Environmental Microbiology, MJP Publishers, Chennai, India.
- 3) Subba Rao N.S. 1999. Soil Microbiology, 4th Edition, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

References

- 1) Satyanarayana, U. 2005. Biotechnology, 1st Edition, Books and Allied (P) Ltd., Kolkata, India.
- 2) Edwards, C. A and Bohlen, P. J. 1996. Biology and Ecology of Earthworms, Chapman and Hall, London.
- 3) Ismail, S. A. 1997. Vermitechnology: The Biology Earth worm, Orient Longman, United Kingdom.
- 4) Kale Radha, D. 1998. Earthworm: Cinderella of organic farming. Prism Books Pvt. Ltd., Bangalore, India.

Semester – III

4 Hours/3 Credits

ELECTIVE – MICROBIAL NANOTECHNOLOGY

Objectives

- To assess types of nanoparticles for various medical research to find out the solution of human diseases.
- To overcome the disadvantages of nanoparticle application.
- To Physical and chemical properties of nanoparticles give idea about the biological process.
- To apply the nanoparticle research in human health sector for their healthy society.
- To motivate the researchers to carry the better advanced research on this field.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Arrange the historical events in the field of Nanotechnology and its development.	K6
CO-2	Provide knowledge on synthesis of Nanoparticles and its vast applications.	K1, K3
CO-3	Evaluate and characterize the methods for nanoparticles to know about its physical and chemical properties.	K5
CO-4	Analyze the Physical and chemical properties of nanoparticles for its Bioactivity.	K4
CO-5	Motivate the researchers to carry the better advanced research on this field.	K2
CO-6	Collect a better knowledge about targeting drug delivery by nanoparticles	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	2	2	3	2	2	2	2	2	3	2	2	3	3	2.3
2	3	2	2	2	2	2	3	2	2	2	2	2	2	3	3	2.2
3	2	2	2	3	1	2	3	2	1	2	3	2	3	3	2	2.2
4	2	2	3	3	2	2	3	1	3	2	3	3	1	2	2	2.2
5	2	2	3	2	2	2	2	3	2	1	2	2	1	2	2	2.0
6	2	2	1	2	2	3	2	2	2	3	3	2	3	2	2	2.2
Mean Overall Score																2.2
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

History of Nanotechnology; Common Terminologies – Nanotechnology, Microbial nanotechnology, Nanomedicine, Nanowires, Quantum Dots, Nanocomposite and Nanoparticles; Applications of Nanotechnology in Life Sciences; Present status and Future prospects of Microbial Nanotechnology.

Unit - II

Molecular Nanotechnology - Nanomachines and Collagen; Uses of Nanoparticles - Cancer therapy and Manipulation of cell and biomolecules; Types of Nanoparticles - Physical, Chemical and Biological; Microbial synthesis of Nanoparticles.

Unit – III

Nanoparticles - Types and functions; Physical and Chemical properties of Nanoparticles; Carbon nanotubes; Nanorobots; Characterization of Nanoparticles using UV-Vis, FTIR spectroscopy, Electron

Microscopy – HRTEM, SEM, AFM, EDS, XRD and Nanoparticle size analyzer.

Unit – IV

Advantages of Nanoparticles - Drug targeting, Protein detection and MRI; Development of Green chemistry; Commercial viability of Nanoparticles. Disadvantages – health risk associated with nanoparticles; Inadequate knowledge on nanoparticles research.

Unit – V

Drug delivery - Protein and Nanoparticle mediated; Uses of Nanoparticles in MRI, DNA and protein microarrays; Nanotechnology in Health, Agriculture and Environmental sectors; Toxicology in Nanoparticles; Current Research Thoughts in Microbial Nanotechnology.

Text Books

- 1) David, S. G. 2004. Bionanotechnology, Lessons from nature, John Wiley & Sons Inc. Publication.
- 2) Parthasarathy, B. K. 2007. Introduction to Nanotechnology, Isha Publication, India.
- 3) Elisabeth, P and Aravind, P. 2007. Bionanotechnology. Morgan & Claypool Publishers, USA.
- 4) Bernd, R. 2006. Microbial Bionanotechnology: Horizon Scientific Press, Canada.

References

- 1) David, E. R and Joseph, D. B. 2009. Bionanotechnology: Global Prospects. CRC Press, USA.
- 2) Ehud, G. 2013. Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology, World Scientific Publishers, UK.
- 3) Silva, G. A and Parpura, V. 2011. Nanotechnology for Biology and Medicine: At the building block level, Springer Science, USA.
- 1) Kingdom.

Semester – IV

4 Hours/4 Credits

FOOD MICROBIOLOGY

Objectives

- To distinguish the intrinsic and extrinsic factors of growth of microbes in food and illustrate the various food preservation techniques.
- To describe the causes of spoilage of different types of food and plan the methods for detecting the causative microbes of food spoilage.
- To obtain a good understanding of food microbiology and become qualified as microbiologist in food industries.
- To detect and interpret the food borne infections, intoxications and prevent food borne outbreaks.
- To implement quality control and represent the standards in food production.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Understand the principles of microorganisms during various food-processing and preservation steps.	K2
CO-2	Apply the role of microorganisms, various preservation techniques, and assess the growth factors of food pathogens in food industry.	K3
CO-3	Evaluate the food contamination and spoilage, detect food pathogens based on physical, chemical and immunological methods.	K5
CO-4	Adapt an appropriate preservative technique for food.	K6
CO-5	Identify the interactions between microorganisms and the food environment, and factors influencing their growth and survival.	K1
CO-6	Plan hygiene and sanitation protocol, apply Hazard analysis, Food laws and standards for good quality in food production.	K4

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	2	3	2	2	2	2	3	3	3	3	2	3	3	2.5
2	3	2	2	3	3	2	3	2	3	2	3	3	2	2	3	2.5
3	2	2	2	3	2	2	3	3	1	2	3	2	3	2	2	2.2
4	2	2	3	3	2	2	3	2	3	2	3	3	2	2	3	2.4
5	2	2	3	2	3	3	2	2	2	1	2	2	2	2	2	2.1
6	3	3	2	2	3	3	2	3	2	2	3	3	3	2	2	2.5
Mean Overall Score																2.4
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

History and Development of Food Microbiology; Importance of microorganisms in Food microbiology – Mold, Yeast and Bacteria; Microbial growth in food - Intrinsic and Extrinsic factors; Principles of Food preservation – High & Low temperature, High pressure, Drying, Radiation, Modified atmosphere, Pulsed Electric fields, Aseptic package and Manothermosonication; Food preservatives – Natural preservatives & Chemical preservatives.

Unit – II

Microbial Contamination of Foods; Sources of Microbial Contamination – Green plants, Fruits, Animals, Air and Handling & Processing practices; Classification of foods in term of potential for spoilage; Contamination, Spoilage and Preservation of Cereals and its products, Sugars and its products, Canned foods, Vegetables, Fruits, Milk products, Alcoholic products, Egg, Meat products, Seafoods and Poultry products.

Unit – III

Fermentation and its types; Traditional Indian fermented foods; Production of Baker's Yeast; Bread production from Yeast and its spoilage; Fermented Vegetables – Olives, Pickles & Sauerkraut; Fermented Meat & Fish; Mold fermentations – Tempeh, Soy sauce & Rice wine and Mycoprotein; Genetically Modified Foods (GMF).

Unit – IV

Milk – Composition, Microflora and Prevention of Microbial contamination; Products from Milk; Lactic acid bacteria; Bacteriocin production and its health benefits; Diseases caused by Lactic acid bacteria; Concept of Probiotics & Prebiotics; Lactic starter cultures; Fermented dairy products – Cheese, Butter, Cream Yogurt and Fermented milk; Spoilage and defects of Fermented dairy products; Testing of Milk and its products; Microbiology of Ice cream and related products.

Unit – V

Food borne infection and intoxication; Seafood Toxicants; Mycotoxins in Agricultural food crops; Biosensors in Food; Food wastes and its types; Microbiology of Food products preparation; Codes of Good Manufacturing Practices; Government Regulatory Practices and Policies – FDA, EPA, HACCP, ISI, BIS and FSS; Enforcement and Control Agencies; Microbiological criteria for food; Recent trends and development in Food Technologies in India; Current Research Thoughts in Food Microbiology.

Text Books

- 1) William C. Frazier and Dennis C. Westhoff. 2013. Food Microbiology, 5th Edition, McGraw Hill, New York.
- 2) James M. Jay, Martin J. Loessner and David A. Golden. 2005. Modern Food Microbiology, 7th Edition, Springer Publications, United States.
- 3) Martin R. Adams and Maurice O. Moss. 2008. Food Microbiology, 3rd Edition, RSC Publishing, United Kingdom.
- 4) Vijaya, R. K. 2004. Food Microbiology. 1st Edition, MJP Publishers, Chennai, India.

References

- 1) Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton. 2017. Prescott's Microbiology, 10th Edition, McGraw Hill Publication, United States.
- 2) Patel, A. H. 2016. Industrial Microbiology, 2nd Edition, Laxmi Publications, New Delhi, India.
- 3) Casida, L. E. 2007. Industrial Microbiology, New Age International Publishers, New Delhi, India.
- 4) Reed, G. 2004. Prescott and Dunn's Industrial Microbiology, 4th Edition, CBS Publishers and Distributors, New Delhi, India.

Semester – IV

5 Hours/5 Credits

INDUSTRIAL MICROBIOLOGY

Objectives

- To impart theoretical knowledge of role of microbes in Industrial production of different bioproducts.
- To describe the industrial Fermentation processes.
- To explain the Construction, Design and Operation of Fermentor.
- To encompass the use of Industrially important microorganisms in the manufacture of food or industrial products.
- To study the use of microorganisms for the production of Antibiotics, Vaccines, Organic acids, Organic solvents, Amino acids, Vitamins and Industrial enzymes.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Describe different fermentation techniques, bioreactor design, inoculum development for industrial fermentations, Microbial growth and product formation kinetics.	K1
CO-2	Media formulation and sterilization, isolation, preservation and improvement of industrially important microorganisms.	K6
CO-3	Assimilate knowledge on basics and different stages in Industrial fermentation process.	K3
CO-4	Evaluate theoretical knowledge on design, construction and working of different types of fermenters and medium formulation on an industrial scale.	K3, K5
CO-5	Plan industrial production of microbial products and stages in downstream process.	K4
CO-6	Understanding the Industrial production of Antibiotics, Vaccines, Organic acids, Organic solvents, Amino acids, Vitamins and Industrial enzymes.	K2

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	3	3	3	3	2	2	3	3	3	3	3	3	2	3	2.8
2	2	2	3	3	3	3	3	3	3	3	2	3	2	2	2	2.6
3	2	3	2	3	2	3	2	3	2	3	3	2	3	3	3	2.6
4	3	3	3	2	3	2	3	2	3	3	3	3	3	2	3	2.7
5	3	2	3	2	3	3	2	3	3	3	3	1	2	2	3	2.8
6	3	3	1	3	3	3	3	2	3	3	3	3	3	3	3	2.5
Mean Overall Score																2.6
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

History of Industrial Microbiology; Industrially important microorganisms; Comparison of Bacterial and Fungal fermentation; Primary and Secondary metabolites from microorganisms; Bioproducts – Classification, Types and Advantages; Types of Fermentation process – Batch fermentation, Fedbatch fermentation & Continuous fermentation; Methods of Fermentation – Submerged fermentation & Solid state fermentation; Design of Fermentor; Factors affecting Fermentor design; Types of Fermentor; Industrial Sterilization of Fermentor and Air; Fermentation economics; Computer control of Fermentation process.

Unit – II

Difference between Wild strains and Industrial strains; Industrial strains – Characteristics, Screening techniques, Industrial strain development methods, Preservation of Industrial strains and Preparation of Inoculum; Fermentation medium – Composition and Sterilization; Downstream Processing; Foam formation and Antifoam agents.

Unit – III

Microbial production of Antibiotics (Penicillin, Streptomycin & Tetracyclines), Vaccines (Hepatitis – B Vaccine & Rabies Vaccine), Organic acids (Citric acid, Acetic acid, Lactic acid & Gluconic acid) and Amino acids (Glutamic acid & Lysine); Microbial assay of Antibiotics and Amino acids.

Unit – IV

Microbial production of Vitamins (Vitamin – B2, B12, & Vitamin – C) and Enzymes (Amylases, Proteases & Pectinases); Microbial assay of Vitamins and Enzymes; Production of SCPs – Bacterial proteins, Actinomycetous proteins, Fungal proteins and Algal proteins; Biopolymers – Classification, Properties, Applications and Industrial production of Polyhydroxyalkanoates (PHAs) and Poly-lactic acid (PLA); Production of Biodiesel, Biological Hydrogen and Biogas.

Unit – V

Yeasts and its industrial uses; Production of Baker's Yeast *Saccharomyces cerevisiae*; Factors influencing the selection of Baker's Yeast for Fermentation; Contaminants during production of Baker's Yeast; Production of Food Yeast & Fodder Yeast; Microbial production of Solvents (Bioethanol, Glycerol & Acetone – butanol) and Alcoholic beverages (Beer & Wine); Factors affecting Alcohol fermentation; Current Research Thoughts in Microbial Fermentation Technology.

Text Books

- 1) Patel, A. H. 2016. Industrial Microbiology, 2nd Edition, Laxmi Publications, New Delhi, India.
- 2) Casida, L. E. 2007. Industrial Microbiology, New Age International Publishers, New Delhi, India.
- 3) Waites, M. J. 2007. Industrial Microbiology, Blackwell Publishing Company, United Kingdom.
- 4) Stanbury, P. T and A. Whitaker. 2005. Principles of Fermentation Technology, Pergamon Press, New York.

References

- 1) Reed, G. 2004. Prescott and Dunn's Industrial Microbiology, 4th Edition, CBS Publishers and Distributors, New Delhi, India.
 - 2) Crueger, W and Crueger, A. 2000. Biotechnology: A Test Book of Industrial Microbiology, Second Edition, Panima Publishing Corporation, New Delhi, India.
 - 3) William C. Frazier and Dennis C. Westhoff. 2013. Food Microbiology, 5th Edition, McGraw Hill, New York.
- Martin R. Adams and Maurice O. Moss. 2008. Food Microbiology, 3rd Edition, RSC Publishing, United Kingdom.

Semester – IV

4 Hours/3 Credits

ELECTIVE: MICROBIAL BIOTECHNOLOGY

Objectives

- To learn the basic tools in Microbial Biotechnology.
- To study the various Immobilization techniques.
- To understand the various concepts of Recombinant DNA Technology and Microbial products.
- To understand the production of Microbial Biotechnology products.
- To emphasize on IPR issues and need for knowledge in patents in Biotechnology.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Describe about different metabolites like antibiotics, organic acids, enzymes, drugs, vitamins, therapeutic peptides and pharmaceutical products, biopesticides and biofertilizers of microbial origin.	K1
CO-2	Analyze theoretical concepts of Biotechnology and their applications in Genetic engineering and Microbiology.	K4
CO-3	Assimilate knowledge on basics and different stages in Microbial fermentation process.	K3
CO-4	Evaluate the concept of Recombinant technology with special emphasis in microbial system.	K5
CO-5	Creates an awareness on the Intellectual property rights and patenting of Biotechnological processes.	K6
CO-6	Understanding the various concepts of Recombinant DNA Technology and Microbial products.	K2

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	2	3	3	3	3	3	3	2	3	3	3	3	2	3	2.8
2	3	2	3	3	2	3	3	2	3	3	3	3	3	2	3	2.7
3	3	2	3	3	2	3	2	3	2	2	3	3	3	3	2	2.6
4	3	3	2	3	3	2	3	2	3	3	3	3	3	2	3	2.7
5	3	2	3	3	3	3	2	3	2	3	3	3	2	3	2	2.6
6	3	3	2	2	3	3	3	3	3	3	3	3	2	3	2	2.7
Mean Overall Score																2.7
Result																High

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Biotechnology – Definition, Various branches and Scope; Metabolites from Microorganisms – Primary and Secondary metabolites; Microbial production of Industrial enzymes; Enzyme immobilization – Immobilization techniques and Advantages; Industrial application of Enzymes.

Unit – II

Recombinant DNA technology – Principles and applications; Cutting and joining enzymes in rDNA technology; List of Protein products from rDNA Technology; Genetic engineering of microbes for Plant improvement; Hairy root culture and their applications; Recombinant Vaccines; Microbial synthesis of Pharmaceutical products – Recombinant Vaccines, Insulin, Interferon, Hormones, Monoclonal antibodies and Polyclonal antibodies; Steroid transformations - Substrates, Typical structures, Microorganisms, Inoculum preparation, 11-hydroxylation, process and Recovery.

Unit – III

Production of Microbial biotechnology products – Xanthan, Dextran, Biosurfactants, Steroids transformation and Polyhydroxyalkanoates (PHA & PHB); Biofuels – Bioethanol, Biodiesel, Biological Hydrogen and Biogas; Microbiology of Methane production - Methanogenesis; Biopolymers –

Classification, Properties, Applications and Industrial production of Polyhydroxyalkanoates (PHAs) and Poly-lactic acid (PLA); Production of Microbial Pesticides.

Unit – IV

SCP (Algae & Yeast) – List of organisms, Cultivation Techniques, Advantages and Disadvantages; SCP cultivation from wastes; Genetically modified foods; Recombinant Microbes; Transgenic Animals; Transgenic; Organisms in Agriculture and Aquaculture; *Agrobacterium* mediated transfer; Synthetic Biology; Gene therapy; Stem cell therapy; Stem cell research – Reproductive cloning and Therapeutic cloning.

Unit – V

Animals used for laboratory experiments; Care and Maintenance for Laboratory animals; Ethics in Animal experimentation; Ethical issues in Human Gene Therapy; Protection of Biotechnological inventions – Patent protection, Trade secrets and Plant Breeder's Rights; Biowarfare and Bioterrorism; Current Research Thoughts in Microbial Biotechnology.

Text Books

- 1) Dubey, R. C. 2014. A Text Book of Biotechnology, 5th Edition, S. Chand Publishing, India.
- 2) Satyanarayana, U. 2005. Biotechnology, 1st Edition, Books and Allied (P) Ltd., Kolkata, India.
- 3) Patel, A. H. 2016. Industrial Microbiology, 2nd Edition, Laxmi Publications, New Delhi, India.
- 4) Casida, L. E. 2007. Industrial Microbiology, New Age International Publishers, New Delhi, India.

References

- 1) Old, R. S and S. B. Primrose. 2006. Principles of Gene Manipulation, 7th Edition, Blackwell Scientific Publications, London.
- 2) Jogdand, S. N. 2005. Gene Biotechnology, Himalaya Publishing House, Mumbai, India.
- 3) Singh, B. D. 2012. Biotechnology, 5th Edition, Kalyani Publishers, Chennai, Tamil Nadu, India.
- 4) Kumarasan, V. 2001. Biotechnology, Published by Saras Publication, Nagercoil, Tamil Nadu, India.

Semester – IV

4 Hours/3 Credits

ELECTIVE: MICROALGAL TECHNOLOGY

Objectives

- To learn the basic tools in Microbial Biotechnology.
- To learn about classification, characteristics of microalgae.
- To formulate algal cultures and importance of culture collections.
- To learn Upstream and Downstream techniques of microalgae.
- To analyze the benefits of Microalgae for this universe.

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Understanding the benefits of Algae to environment.	K2
CO-2	Formulate algal cultures and importance of culture collections.	K6
CO-3	Describe commercial production of fuels and microbial enzymes.	K1
CO-4	Apply knowledge on Basic cultivation technology of microalgal cultivation technique.	K3
CO-5	Develop techniques on removal of heavy metals from contaminated water using microalgae.	K6
CO-6	Focus the idea about Bioremediation using microalgae.	K4

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
	1	3	3	2	2	3	2	2	2	2	2	3	3	2	3	
2	3	2	2	3	2	2	3	2	3	2	2	2	2	3	3	2.4
3	2	2	2	3	2	2	3	2	2	2	3	2	3	3	2	2.3
4	2	2	3	3	1	2	3	2	3	2	3	3	2	2	2	2.3
5	2	2	3	2	2	2	2	3	2	2	2	2	2	2	2	2.1
6	2	2	1	2	2	3	2	3	2	3	3	1	3	2	2	2.2
Mean Overall Score															2.3	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Microalgae – Characteristics, Habitat, Distribution, Morphology, Reproduction (Asexual & Sexual) and Life cycle; Cyanobacteria; Diatoms; Algal identification (Microscopic examination) and Cultivation in Culture medium; Photosynthesis in Microalgae; Freshwater algae and Marine algae; Economical importance of Microalgae.

Unit – II

Photobioreactor based Microalgal production; Downstream processing; Heterotrophic production; Mass cultivation in Circular – Tubular column, Raceway pond and Pit method; Mass cultivation of *Chlorella*, *Spirulina* and *Dunaliella*; Algal bloom; Factor influence Algal growth – Nutrients, Temperature and Light.

Unit – III

Microalgal proteins and peptides; SCP – Advantages, Disadvantages and Pigments – Carotenoids, Phycocyanin & Phycoerythrin; Growth promoting substance from Microalgae; Extracellular polymeric Substance; Microalgal Toxins.

Unit – IV

Microalgae in Human welfare –Nutraceuticals, Pharmaceuticals, Biofertilizers and Pollution control; Biofuels – Biodiesel, Biobutanol, Biohydrogen and Bioethanol; Nanoparticles from microalgae; Algae in Transgenics; Antimicrobials from microalgae; Algal food colorants; Microalgae in CO₂ sequestration; Algae in Space.

Unit – V

Targeted Genetic Modifications: Genome shuffling and Evolutionary Engineering of Microalgae; Application of Microalgae in Synthetic biology; Bioluminescence; Quorum sensing in Microalgae – Introns, CRISPR-CAS discovery, Mode of action and Application; Current Research Thoughts in Microalgal Technology.

Text Books

- 1) Amrik, S. A. 2003. Phycology: Principles, processes and applications. Daya Publishing House, New Delhi, India.
- 2) Steve, P. 2009. Protozoans, Algae & Other Protists, Capstone Press, USA.
- 3) Hoek, C., Mann, D. G and Jahns, H. M. 1995. Algae - An Introduction to Phycology, 39; Cambridge University Press, UK.
- 4) Sharma, O. P. 2001. Textbook of Algae. Tata McGraw Hill Company, New Delhi, India.

References

- 1) Ismail, R., Sanjay K. Gupta, Amritanshu, S., Poonam, S., Sheena, K and Faizal, B. 2016. Microalgae Applications in Wastewater Treatment. 7th Edition, New India Publication, New Delhi, India.
- 2) Biris, E. S., Maria, T., Tania, M., Radu, M and Antonia, O. 2016. Applications of Microalgae in Wastewater Treatments. ProEnvironment, India.
- 3) Stephen, J. O. 1993. Bacteria, Algae, and Protozoa - Cold Spring Harbor Laboratory Press, USA.
- 4) Sarabhai, B. P and Arora, C. K. 2005. Textbook of Algae. Anmol Publishing Pvt. Ltd. New Delhi, India.

ELECTIVE: PROBIOTIC MICROBIOLOGY**Objectives**

- To acquire the knowledge and utilization of Probiotics and Prebiotics in our daily life.
- To develop the Entrepreneurial Skill production and assessment of Probiotic microbes.
- To list out the Commercial probiotic strains.
- To explain the definition and types of Probiotics.
- To characterize the limitation and dosage of Probiotics

Course Outcomes

Course Outcome (CO)	Description	Cognitive level (K level)
CO-1	Understand the basic knowledge of Gastrointestinal Ecosystem.	K2, K3
CO-2	Learn the Gastrointestinal microbiota and regulation of the Immune system.	K1
CO-3	Develop the Entrepreneurial Skill production and assessment of Probiotic microbes.	K6
CO-4	Knowledge about the Genetically modified probiotics.	K3
CO-5	Evaluate the <i>In vitro</i> assessment of probiotic microbes.	K5
CO-6	Analyze and explore the Genetic tools used for the identification of adaptation and probiotic factors.	K4

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)										Mean Scores of COs
	PO 1	PO 2	PO 3	PO 4	PO 5	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8	PSO9	PSO 10	
1	3	3	2	2	3	3	3	3	2	3	3	3	2	3	3	2.7
2	2	2	3	3	2	2	3	2	3	3	2	2	3	2	1	2.3
3	3	1	2	3	1	3	2	3	2	2	3	3	2	3	3	2.4
4	2	2	3	2	3	2	3	3	3	3	3	3	3	2	2	2.6
5	2	3	3	2	2	2	2	2	2	2	2	2	3	2	2	2.2
6	3	2	2	3	3	3	2	3	3	3	3	3	2	3	3	2.7
Mean Overall Score															2.5	
Result															High	

Assessment Pattern

Bloom's Category	CA Tests (Marks Allotment)		Term End Exam (100) Marks Allotment
	I CA (50)	II CA (50)	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	10
Analyze	10	10	10
Evaluate	5	5	10
Create	5	5	20

Unit – I

Gastrointestinal tract architecture; Intestinal microbiota; Functions of Endogenous microflora; Gastrointestinal microbiota and regulation of the immune system; Factors affecting the Gut microbial balance; Role of enteric pathogens in Gastrointestinal diseases; Treatment and prevention of Gastrointestinal disease - Antibiotics, Probiotics, Prebiotics, Synbiotics.

Unit – II

History of Probiotics; Features of Probiotics; Types of Probiotics - Human probiotics and Animal probiotics; Forms of Probiotics; Probiotic territorial colonization; Physiological effects and Mechanism of action of Probiotics; Side effects and safety profile of Probiotics; Limitations of Probiotics; Dosage of Probiotics; Prebiotics – Definition and Prebiotics vs. Probiotics; Prebiotics in Diet and Health benefits.

Unit – III

Probiotic strains - Lactic acid bacteria (LAB): *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Lactococcus*; Actinobacteria: *Bifidobacteria*, *Streptomyces* and *Oerskovia*; Fungi - *Saccharomyces*, *Candida* and *Aspergillus*. Others Probiotic strains: *Escherichia coli*, *Bacillus* and *Enterococcus*; Commercial Probiotic strains; Genetically Modified Probiotics (GMP).

Unit – IV

In vitro assessment of Probiotic microbes – Survivability, Acid resistance, Bile salt resistance, Pepsin resistance and Pancreatin resistance; Colonization properties - Aggregation, Hydrophobicity, Adhesion with intestinal epithelial cell lines, Mucin adhesion assay, Biofilm forming ability, Hemolytic activity and Antibiotic resistance; Functional properties - Antimicrobial activity, Bacteriocin production, Bile salt hydrolase activity and Production of digestive enzymes; *In vivo* assessment of probiotic microbes in chicken model.

Unit – V

Adaptation factors - Stress resistance, Cell envelope integrity, DNA repair and Protein repair; Transport and Hydrolysis of bile (*bsh* gene); Adhesion factors - S layer and Mucus binding proteins (*mub* gene), LTA, EPS and PG; Health promoting factors - Microbe - Microbe interaction, Production of Antimicrobial peptides and Competitive exclusion; Genetic tools used for the identification of Adaptation and Probiotic factors; Current Research Thoughts in Probiotic Microbiology.

Text Books

- 1) William C. Frazier and Dennis C. Westhoff. 2013. Food Microbiology, 5th Edition, McGraw Hill, New York.
- 2) Kenji Sonomoto and Atsushi Yokota. 2011. Lactic acid bacteria and *Bifidobacteria*, Caister Academic Press Publisher, China.

- 3) Charalampopoulos, Dimitris, Rastall and Robert. 2009. Prebiotics and Probiotics. Science and Technology, Springer Publication, USA.
- 4) Nicholas Joseph Talley and Christopher J. Martin. 2006. Clinical Gastroenterology: A practical problem-based approach, Elsevier Publication, USA.
- 5) Gary B. Huffnagle and Mairi Catherine Noverr. 2008. GI microbiota and regulation of the immune system, Springer Publication, USA.

References

- 1) Malago. 2011. Probiotic Bacteria and Enteric Infections: Cytoprotection by Probiotic Bacteria, Springer Publication, USA.
- 2) Wolfgang Kneifel and Seppo Salminen. 2011. Probiotics and Health Claims, John Wiley and Sons Publication, UK.
- 3) Natasha Trenev, 1998. Probiotics: Nature's Internal Healers, Penguin Publication, India.
- 4) Dash, Allan N. Spreen and Beth M. Ley. 2000. Health Benefits of Probiotics. BL Publications, India.
- 5) Yuan Kun Lee and Seppo Salminen. 2008. Handbook of Probiotics and Prebiotics, Wiley-Interscience Publication, UK.

Semester – III & IV

5 Hours/5 Credits

PRACTICAL – III: BIOINOCULANT, COMPOSTING AND MUSHROOM TECHNOLOGY

- 1) Isolation, Purification, Mass production and Formulation of Nitrogen fixing bacteria – *Rhizobium* sp., *Azotobacter* sp. and *Azospirillum* sp.
- 2) Isolation, Purification, Mass production and Formulation – *Bacillus subtilis* and *Pseudomonas fluorescens*, *Trichoderma viride* and *Beauveria bassiana*.
- 3) Isolation of Phosphate solubilizers from Soil.
- 4) Study of Phylloplane microflora by Leaf impression method.
- 5) Estimation of Plant growth promoting substance produced by PGPR.
- 6) Antagonistic activity of Biocontrol agents.
- 7) Assessment of AM colonization in roots.
- 8) Different formulations of Bioinoculants.
- 9) Method of application and Quality control.
- 10) Mass cultivation of *Azolla* and BGA.
- 11) Preparation of Microbial Compost and Vermicompost.
- 12) Analysis of Physical, Chemical and Microbial characteristics of Microbial Compost and Vermicompost.
- 13) Substrates preparation for Mushroom cultivation.
- 14) Spawn production for Mushroom cultivation.
- 15) Sterilization process and Media preparation for Mushroom cultivation
- 16) Cultivation of Milky mushroom and Oyster mushroom

Semester – III & IV

5 Hours/5 Credits

PRACTICAL – IV: ENVIRONMENTAL AND FOOD MICROBIOLOGY

- 1) Assessment of Milk quality by MBRT and Resazurin method.
- 2) Enumeration of microorganisms in Milk by Direct Microscopic Count and SPC Method.
- 3) Enumeration of microorganisms in Water by SPC Method.

- 4) Estimation of Physical parameters of Waste water.
- 5) Bacteriological examination of water by MPN test.
- 6) Isolation and enumeration of microorganisms from Air.
- 7) Isolation and enumeration of microorganisms from Fruits and Vegetables.
- 8) Isolation and enumeration of Antibiotic producing fungi from soil.
- 9) Estimation of Soil enzymes - Urease and Phosphatase.
- 10) Extracellular enzyme activities – Amylase, Cellulase, Protease and Lipase.
- 11) Preparation of Immobilized Sodium alginate beads.
- 12) Isolation of Fungi from spoiled Bread.
- 13) Isolation of Cellulose, Phenol and Pesticide degrading bacteria.
- 14) Determination of inhibitory effect of Food preservatives.
- 15) Isolation and Microscopic examination of Yeast from Grapes.
- 16) Media formulation and Cultivation of *Spirulina platensis*
- 17) Microscopic examination, Growth analysis and Extraction of *Spirulina platensis*.
- 18) Extraction of Pigments from microorganisms.