Rayat Shikshan Sanstha's

Sadguru Gadage Maharaj College, Karad

(An Autonomous College)

Accredited By NAAC with A^+ Grade (CGPA 3.63)

Syllabus for

M.Sc. Part -II

Industrial Microbiology

Syllabus to be implemented from July 2023 onwards

M. Sc. INDUSTRIAL MICROBIOLOGY SYLLABUS

A. ORDINANCE AND REGULATIONS:

1. Ordinance:

As per M.Sc. Microbiology course

B. REVISED SYLLABUS FOR MASTER OF SCIENCE (M. Sc.):

1. Title: Subject: - INDUSTRIAL MICROBIOLOGY

Compulsory under the Faculty of Science

2. Year of implementation:

New syllabus will be implemented from June 2020 onwards

3. Preamble: (Applicable to University affiliated college centers)

Total number of semesters		: **04**
(Two semesters per year)		
Total No. of papers		: **16**
Total no. of practical courses		: **08**
No. of theory papers per semester		: **04**
No. of practical courses per semester		: **02**
Maximum marks per paper (Theory/Practical)		: **100**
Distribution of marks (Theory only) –		
Internal evaluation		: **20**
External evaluation		: **80**
(Semester exam)		
Total marks for M. Sc. Degree		
Theory papers	: **1600**	
Practical course		:**800**
		2400

4. General Objectives of the Course:

This two-year M. Sc. programme is designed to develop competent Industrial Microbiologists, who can progress to diverse fields of Industrial microbiological interests that include industry, research, teaching, medical science and entrepreneurship. The course is aimed at adding to the knowledge base of Industrial Microbiology as well as Microbiology graduates through significant inputs of latest information on the subject. It also envisages that the students read original research publications and develop the ability of critical evaluation of the study. Development of communication skills - written and spoken - as well as laboratory work and team work, creativity, planning and execution are also a major objective of this programme. In the core courses, the students study the basics of Industrial Microbiology along with the basics of subjects allied to and useful in Industrial Microbiology (Techniques, Biostatistics, Computer handling and Bioinformatics and Scientific writing). The specializations include topics on various fields of Industrial Microbiology, Waste Management Technology, Extremophiles and Recombinant DNA Technology.

Students are required to undertake a Research Project/ Industrial Training. In the Research Project (undertaken at the Parent Department), the student is expected to study research methodology through experimental work, literature survey and report writing following the IMRAD (Introduction, Aims and objectives, Materials and Methods, Results and Discussion) system.

In Industrial Training, the student is to take training in the Industry for a period of at

least three weeks in the vacation period. The student should study Microbiological aspects in the Industry and submit its report in the form of dissertation duly signed by the concerned authority (from the industry), concerned supervisor (in the department) and Head of the department.

Students are also required to compulsorily undertake an educational tour organized by the Department in each year (M. Sc. I and M. Sc. II) to various places of Microbiological interest and submit a `Tour Report' duly signed by the Head of the Department, practical examinations respectively failing which they will not be allowed to attend the examination.

5. Duration:

- The course shall be a fulltime course
- The course shall be of two years, consisting of four semesters

6. Fee Structure:

- **Entrance Examination fees** **:** as prescribed by Shivaji University, Kolhapur
- **Course Fee** : as prescribed by Shivaji University, Kolhapur

7. Eligibility for Admission: (as per University rule)

- As per O. M. Sc. 1.2 for graduates of this University
- As per O. M. Sc. 1.3 for graduates from other Universities
- Merit List of entrance examination result

8. Medium of instruction **:** English

7. Structure of the course:

SEMESTER – III

I22-301- Microbial Technology

I22-302- Fermentation Technology - I

I22-303- Enzymology and Enzyme Technology

I22-304- Pharmaceutical Microbiology

I22-305- Practical Course – V

I22-306- Practical Course – VI

SEMESTER – IV

I22-401- Fermentation Technology -II

I22-402- Food and Dairy Microbiology

I22-403- Microbiological Quality Control

I22-404- Industrial Waste Management

I22-405- Practical Course – VII

I22-406- Practical Course – VIII

9. Courses available in the Department:

Semester-I:

Theory courses: I22-101, I22 -102, I22 - 103, I22 -104

Practical courses: I22 - 105, I22 -106

Semester-II:

Theory courses: I22 -201, I22 -202, I22 -203 I22 -204

Practical courses: I22 -205, I22 -206

Semester-III:

Theory courses: I22 -301, I22 -302, I22 -303, I22 -304

Practical courses: I22 -305, I22 -306

Semester-IV:

Theory courses: I22 -401, I22 -402, I22 -403, I22 -404

Practical courses: I22 -405, I22 406 (Research Project)

600 marks

10. System of Examination: applicable to University affiliated college centres

1. Scheme of examination:
   - Semester examination (External evaluation) will be conducted for both theory and practical courses by the University at the end of each term (Semester)
   - Theory paper of the external evaluation (Semester exam) will be of **80** marks
   - The internal evaluation test (by the Department) will be for a total of **20** marks consisting of **two** tests of **10** marks each for each course paper in the middle of the semester
   - The two practical course examinations will be external evaluation (Semester exam) only, of **100** marks each
   - Question paper will be set in view of the entire syllabus and preferably covering each unit of the syllabus
2. Standard of passing:
   As per the rules and regulations of the university for the M. Sc. course
3. Nature of question paper and scheme of marking:
   a) <u>External Evaluation (Semester exam) Theory paper:</u> Maximum marks – **80**
   - Equal weight age shall be given to all units of the theory paper

- Total number of questions – **07**
- All questions will carry equal marks.
- Out of the seven questions, five are to be attempted of which Question 1 will be compulsory
- Question No. **1** will be of an objective type
  - Total No. of bits – **16**, Total marks – **16**
  - Nature of questions - multiple choice, fill in the blanks, definitions, true or false, match the following
  - These questions will be answered along with the other questions in the same answer book.
- Remaining six questions will be divided into two sections, I and II.
- Four questions are to be attempted from these sections in such a way that not more than two questions are answered from each section.
- Both sections are to be written in the same answer book

b) Internal Evaluation Theory paper: Maximum marks – **20**

- Objective- multiple choice/True or false/ fill in the blanks/match the following
- Total number of questions will be **10** each carrying **01** mark

c) Practical Examination (External Evaluation only) Maximum marks – **100**

- Total number of questions – **06**
- All questions will be compulsory
- Questions 1 to 4 will have at least two (**02)** internal options
- Question 5 will be *viva voce* and question 6 will be for the journal, each carrying 10 marks

C. INTAKE CAPACITY:

1. 40* students every year on the basis of entrance examination
2. The above includes 10 % students from other Universities

*for S.G.M. College, Karad.

D. CREDIT SYSTEM:

1. Definition of CREDITS:

It is the workload of a student in College activities. This includes:

1. Lectures – time put in for attendance in theory class
2. Practical's – time put in performing experiments in the laboratory
3. Seminars – time put in for delivering a seminar topic in class
4. Private study work in the Library/Home – book issue, reference work (books and journals), reading magazines and relevant literature, internet access, study, preparation of notes, computations, etc.
5. Examinations - – time put in for theory and practical examinations during and at the end of each semester
6. Other activities – review writing of referred literature, taking subject related add on courses conducted by College, University or any authorized organizations.

1.1 Types of credits:

1.1.1 Credits by evaluation - examination (theory and practical)

1.1.2 Credits by non-evaluation – private study work in the Library/Home,

proficiency in state, national and international sports, social service – NSS, military service – NCC, colloquiums and debates, cultural programmes, participation in seminars, scientific symposia, workshops, conferences, etc.

2. Credits by lectures and practical's: 96

- Total instructional days as per norms of UGC = **180**
- One (**01**) credit is equivalent to **15** contact hours
- There are four (**04)** theory papers with **04** hours teaching per week
- Each theory paper consists of **04** units
- There are two (**02**) practical courses of **09** hours duration per week
- Each practical course consists of **02** units
- As there are four (**04**) semesters to the M. Sc. course, the total credits from lectures and practicals will be - **04 × 24 = 96** credits

Course type	**Contact hours**	**Credits**
Theory paper		
Unit – I	**15**	**01**
Unit – II	**15**	**01**
Unit – III	**15**	**01**
Unit – IV	**15**	**01**
	Total =	**04**
Practical course		
Unit – I		**02**
Unit – II		**02**
	Total =	**04**
Total credits per semester = 24		
Theory course -	**04 × 04 =**	**16**
Practical course -	**02 × 04 =**	**08**

3. M. Sc. Course Work (credit system) for a student:

- Total number of credits for the entire M. Sc. Course will be **100**

Theory papers : **16 × 04** **= 64** credits
Practical courses : **08 × 04** **= 32** credits

- Other activities : **= 04** credits

Total : = 100 credits

- The option of choosing credits from other departments/courses will be available only in semester – III and IV
- This choice will be restricted to **08** credits and only for theory papers i.e. two (**02**) papers in place of the elective papers
- Time course: **02** years minimum

4. Class capacity:

Theory : maximum **60** students per class
Practical courses: **12** students per batch

5. Examination:

Theory Examination:

External: 80 marks per theory paper (examination at the end of the Semester)

- This will be conducted by the University as specified in section B.10

Internal: 20 marks per theory paper (based on `objective type' question Paper)

- This will be conducted by the Department as per the norms specified in section B.10.3b above

Practical Examination:

- This will be conducted only by the University as specified in section B.10

Project/ Industrial Training evaluation:

External: 50 marks by the university examiners through observation of the oral presentation and assessment at the time of the Semester IV practical examination

Internal: 50 marks by the concerned project supervisor as the internal examiner during progress of the work.

Semester – III

(Credit 04) I22 – 301: MICROBIAL TECHNOLOGY

UNIT – I **(12)**

1. Fermentation equipment and its use:
   - 1.1 Basic functions of a fermenter, body construction, aeration, Agitation, baffles, etc.
   - 1.2 Design of other fermentation vessels: Airlift fermenter, tower fermenter Continuous fermenter, fed batch fermenter, Waldhof type fermenter
   - 1.3 Sterilization of fermentation equipment, air and media
   - 1.4 Fermentation broth rheology and power requirements, concepts of Newtonian and non-Newtonian fluids, plastic fluids, effect of rheology on heat and oxygen transfer, Reynold's number, power number, aeration number and apparent viscosity
2. Development of industrial fermentation processes
   - 2.1 Screening
   - 2.2 Stock culture maintenance
   - 2.3 Inoculum development for yeast process, bacterial processes and mycelial process
   - 2.4 Scale up of fermentation
3. Contamination problems in fermentation industry

UNIT – II **(12)**

1. Environmental control of metabolic pathways
2. Genetic Control of Metabolic pathways
3. Growth and product formation: Concept of primary and secondary metabolites and their control, kinetics of growth and product formation (growth rate, yield coefficient, efficiency), economics
4. Computer applications in fermentation technology- General applications and specific applications

UNIT – III **(12)**

1. Fermentation media- Types of fermentation media, sources of carbon, nitrogen trace elements, growth factors, precursors, buffers, antifoam agents, sterilization of media, screening for Fermentation media.
2. Saccharification and utilization of cellulosic wastes.
3. Patents – Introduction, composition of patent, background, patent practice and problems

UNIT – IV **(12)**

1. Product recovery and purification – Precipitation, filtration, centrifugation, solvent recovery, chromatography, ultrafiltration, crystallization and whole broth processing
2. Fermentation economics – A case study, market potential for product and fermentation, product recovery cost, Entrepreneurship, plan for industry, product selection process, site selection, finance, feasibility, excise and legal aspects

REFERENCE BOOKS

1. Industrial Microbiology by L. E. Casida, John Wiley and Sons INC
2. Annual Reports on Fermentation processes Vol. I and II by D. Perlman, Academic press INC
3. Prescott and Dunn's Industrial Microbiology, 4th edition (1982) by Gerald Reed
4. Food processing: Biotechnological applications by S. S. Marwaha and J. K. Arora (2000), Asiatech publishers INC
5. Microbial technology Vol. I and II by H. J. Peppler and D. Perlman
Academic Press INC
6. Principals of Fermentation Technology by P. Stanbury and A. Whitaker, Pergamon Press
7. Essays in Applied Microbiology by J. R. Norris and M. H. Richmond, John Wiley and Sons, Chicester, New York
8. Biology of Industrial Microorganisms by A. Demain and N. Solomon Butterworths Biotechnology Series
9. Overproduction of Microbial Metabolites: Strain Improvement and Process Control strategies by Z. Vanek and Z. Hostalek Butterworths Biotechnology Series
10. Fermentation Microbiology and Biotechnology by E. M. T. El-Mansi and C. F. A. Bryce Taylor and Francis Ltd. London
11. Legal protection for Microbiological and Genetic Engineering Inventions by R. Saliwanchik Butterworths Biotechnology Series.

(Credit 04) I22 – 302: FERMENTATION TECHNOLOGY- I

UNIT – I **(12)**

1. Production of single cell protein (SCP) - Microorganisms and substrates used, techniques of production, nutritional value of SCP, economics of production, merits and demerits
2. Microbial insecticides- Candidates for development into microbial insecticides, production of insecticides, evaluating potential hazards to man and environment, effectiveness, safety, economics, advantages and disadvantages.

UNIT – II **(12)**

1. Typical Fermentation processes – industrial production of:
   - 1.1 Lactic starter culture for food fermentations
   - 1.2 Bacitracin
   - 1.3 Streptomycin
   - 1.4 β-carotene pigments
2. Typical Fermentation processes – industrial production of:
   - 2.1 Riboflavin
   - 2.2 Gluconic acid
   - 2.3 Gibberellin
   - 2.4 Itaconic acid

UNIT – III **(12)**

1. Production and applications of microbial polysaccharides- Xanthan gum and Dextran.
2. Production of mushrooms – Production steps, harvesting and preservation and nutritive value
3. Production of bacterial vaccines and antisera

UNIT – IV **(12)**

1. Industrial production of distilled alcoholic beverages – Whisky and Brandy
2. Microbial production of nucleosides and nucleotides
   a. Classification of methods for production of 5’ IMP and 5’GMP
   b. Production of 5’IMP and 5’GMP by fermentation.
3. Microbial transformations of antibiotics and steroids

REFERENCE BOOKS

1. Industrial Microbiology by L. E. Casida, John Wiley and Sons INC.
2. Annual reports on Fermentation Process Vol. I and II, by D. Perlman, Academic Press INC.
3. Prescott and Dunn’s Industrial Microbiology, 4th edition (1982) by Gerald Reed.
4. Food processing: Biotechnological applications by S. S. Marwaha and J. K. Arora (2000), Asiatech publishers INC.
5. Microbial technology vol. I and II by H. J. Peppler and D. Perlman. Academic Press INC.
6. Methods in Industrial Microbiology by B. Sikyta, Ellis Horwood Ltd. Chichester (1983)
7. Industrial Microbiology by A. H. Patel, MacMillan India Ltd.
8. Principals of fermentation technology by P. Stanbury and A. Whitaker, Pergamon Press
9. Advances in Applied Microbiology Vols. 9 and 13, by W. W. Umbreit, Academic Press, New York
10. Essays in Applied Microbiology by J. R. Norris and M. H. Richmond, John Wiley and Sons, Chicester, New York

(Credit 04) I22 – 303: ENZYMOLOGY AND ENZYME TECHNOLOGY

UNIT – I **(12)**

1. History and special properties of enzymes as catalysts
2. IUB system of nomenclature and classification of enzymes
3. Specificity of enzymes:
   - 3.1 Types: substrate and product, group or relative, absolute – stereochemical and spatial specificity
   - 3.2 Theories to explain specificity – Lock and Key and Induced Fit hypotheses
4. Structure of enzymes: monomeric and oligomeric enzymes, Ogsten's experiment and the concept of the Active Site
5. Methods employed to identify functional groups in the active site – trapping of the intermediate, use of substrate analogues, modification of amino acid side chains, some common functional groups and amino acids, chemistry of the active site
6. Co-factors in enzyme action:
   - 6.1 Organic – prosthetic groups, coenzymes and cosubstrates
   - 6.2 Inorganic – metal ions in enzyme function, metal activated enzymes and metallo-enzymes, ternary complexes

UNIT – II **(12)**

1. Kinetics of single-substrate enzyme catalysed reactions – Wilhelmy's and Brown's work, Henri and Michaelis-Menten relationships, Briggs and Haldane assumption and derivation, Lineweaver-Burk, Eadie-Hofstee, Hanes and Eisenthal and Cornish-Bowden modifications of the M-M equation to derive KM, Significance of the M-M equation and KM
2. Kinetics of multisubstrate reactions
3. Haldane's relationship for reversible reactions
4. Sigmoid kinetics – Hill and Adair equations for cooperativity
5. Enzyme inhibition: basic concepts, kinetics, examples and significance of reversible and irreversible inhibition

UNIT – III **(12)**

1. Covalent modification of enzyme structure – irreversible and reversible modification
2. Ligand induced conformational changes – basic concepts of allosterism and allosteric enzymes, models proposed to explain the mechanism of functioning (MWC and KNF); structural aspects of aspartate carbamoyl transferase, role of allosteric enzymes in metabolic regulation – feedback inhibition
3. Multienzyme systems – basic concepts, types with examples, structural and functional aspects of pyruvate dehydrogenase, fatty acid synthetase, 'Arom' complex and tryptophan synthetase
4. Membrane bound enzymes in metabolic regulation
5. Isoenzymes – basic concepts, method of detection, examples and their metabolic significance

UNIT – IV **(12)**

1. Applications of enzymes in medicine:
   1.1 In diagnosis – general principles and use of alanine amino transferase, aspartate amino transferase, lactate dehydrogenase, creatine kinase, acid and alkaline phosphatase
   1.2 In therapy – specific applications of few selected enzymes, prodrug activation with examples, enzyme replacement therapy

2. Industrial applications of enzymes – catalysts in the manufacturing and other conversion processes
   2.1 Enzymes as analytical tools
   2.2 Immobilisation of enzymes: basic concepts, methods used, properties of IME and their applications in industry, medicine, enzyme electrodes
   2.3 Newer approaches to the application of enzymes – reactions in organic solvents

REFERENCE BOOKS

1. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by T. Palmer
Affiliated East-West Press Pvt. Ltd. New Delhi
2. Fundamentals of Enzymology – N. C. Price and L. Stevens, Oxford University Press
3. Nature of Enzymology – R. L. Foster, Croom Helm Applied Biology Series, London
4. Enzyme Technology – Pandey, Webb, Soccol and Larroche. Asiatech Publishers, INC New Delhi
5. Enzyme Nomenclature by IUBMB Academic Press Inc.
6. Enzyme structure and function – A. Fuerst, Freeman, USA
7. Immobilised Enzymes – M. D. Trevan
8. Enzymes – Boyer, Academic Press
9. Advances in Enzymology – Series edited by N. O. Kaplan, Academic Press
10. Enzyme Biotechnology by G. Tripathi, Technoscience Publications
11. Enzyme Reaction Engineering by T. P. Jayadev Reddy, Biotech Books, Delhi
12. Enzymes and Immobilised Cells in Biotechnology by A. Laskin Butterworths Biotechnology Series

(Credit 04) I22- 304: Pharmaceutical Microbiology

UNIT – I **(08)**

Fundamental features of Pharmaceutical Microbiology

1. Microorganisms and Medicines.
2. Fundamental features: 2.1 Viruses, Viroids and Prions
   2.2 Prokaryotes and eukaryotes: Bacteria, Archaea, Fungi, Protozoa
   2.3 Pharmaceutical importance

UNIT – II **(16)**

Ecology of Microorganisms and spoilage in pharmaceutical processing.

1. Atmosphere
   1.1 Microbial content
   1.2 Reduction of microbial count
2. Water: 2.1 Raw or mains water
   2.2 Deionized or demineralized water
   2.3 Distilled water
   2.4 Disinfection of water
3. Skin and respiratory tract flora: 3.1 Microbial transfer from operators
   3.2 Hygiene and protective clothing
4. Raw materials
5. Packaging
6. Equipment: 6.1 Pipelines
   6.2 Cleansing

7. Spoilage—chemical and physicochemical deterioration of pharmaceuticals
   7.1 Pharmaceutical ingredients susceptible to microbial attack
   7.2 Observable effects of microbial attack on pharmaceutical products
   7.3 Factors affecting microbial spoilage of pharmaceutical products
      7.3.1 Types and size of contaminant inoculum
      7.3.2 Nutritional factors
      7.3.3 Moisture content: water activity (Aw)
      7.3.4 Redox potential
      7.3.5 Storage temperature
      7.3.6 pH
      7.3.7 Packaging design
      7.3.8 Protection of microorganisms within pharmaceutical products

UNIT – III **(12)**

Sterile pharmaceutical procedure, assurance and products

1 Sensitivity of microorganisms
   1.1 Survivor curves
   1.2 Expressions of resistance
   1.2.1 D-value and Z-value
2 Sterilization methods
3 Heat sterilization
   3.1 Sterilization process

3.2 Moist heat sterilization
3.2.1 Steam as a sterilizing agent
3.3 Dry heat sterilization
4 Gaseous sterilization
4.1 Ethylene oxide
4.2 Formaldehyde
5 Radiation sterilization
5.1 Gamma-ray sterilizers
5.2 Electron accelerators
5.3 Ultraviolet irradiation
7 Filtration sterilization
8 Sterilization control and sterility assurance
9. Sterile Products: Injectables, Non-injectable sterile fluids, Dressings. Implants, Surgical ligatures and sutures

UNIT – IV **(12)**

Drug Design and Drug Delivery

1. Rational drug design
   1.1 Lead drug and Pro-drug
   1.2 Structure based and combinatorial approach
2. Peptidomimetic and strategies for drug discovery
3. Drug delivery: Concept and approaches
4. Clinical Trials: different phases

REFERENCE BOOKS

1. Hugo, WB and Russell, AD (2003/1998) Pharmaceutical Microbiology, 6th edn, Blackwel Science, Oxford, UK (ISBN: 0-632-04196-X) Reprinted.
2. Krogsgaard-Larsen, P., Lilijefors, T. and Madsen, U. (2004) Textbook of Drug Design and Discovery, 3rd edn., Taylor and Francis, London (ISBN: 0-415-28288 PB).
3. Haider, SI (2006) Validation Standard Operating Procedures, 2nd edn., CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529-1).
4. Dutton CJ, Haxell MA, McArthur HAI and Wax RG (2002) Peptide Antibiotics, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0245-X)
5. Seth SD (2004) Textbook of Pharmacology, 2nd edn., Elsvier, New Delhi (ISBN: 81-8147-553-4).
6. Bhatia R and Ichhpujani RL (1995) Quality Assurance in Microbiology, CBS Publishers, New Delhi (ISBN: 81-239-0387-1).
7. Chakraborty C and Bhattacharya A (2004) Pharmacogenomics: An approach to New Drug Development. Biotech Books, New Delhi (ISBN: 81-7622-105-8).

I22 - 305: PRACTICAL COURSE – V

UNIT - I

1. Quantitative estimation and determination of specific activity of α-amylase
2. Salt (ammonium sulphate) precipitation of α-amylase
3. Study of the effect of Substrate concentration [S0] on α-amylase and determination of Vmax and KM
4. Study of the effect of Hydrogen Ion concentration (*p*H) and determination of optimum pH for activity of α-amylase
5. Study of the effect of Temperature – determination of optimum temperature for activity of α-amylase
6. Study of the effect of Metal ions on α-amylase
7. Immobilisation of α-amylase by entrapment in alginate gel and determination of loading efficiency
8. Assay of Invertase, Protease and Lipase

UNIT - II

1. Screening of antibiotic producers – Crowded plate technique
2. Screening of organic acid producers and amine producers
3. Screening of amylase producers and protease producers
4. Screening of vitamin producers
5. Enrichment and isolation of sulfate reducing bacteria
6. Enrichment and isolation of pesticide resistant bacteria.
7. Enrichment and isolation of phosphate solubilising microorganisms

REFERENCE BOOKS

1. Laboratory Manual in Biochemistry by J. Jayaraman. New Age International Publishers
2. An Introduction to Practical Biochemistry by D. T. Plummer TMH Publishers
3. Immobilised Enzymes – M. D. Trevan
4. Advances in Enzymology – Series edited by N. O. Kaplan, Academic Press

I22 – 306: Practical Course –VI

UNIT-I

1. Isolation of lipolytic, proteolytic, producing microorganisms from suitable source.
2. Production of Amylase by Surface culture method
3. Production of Amylase by Submerged culture method
4. Production of Protease
5. Production of sauerkraut
6. Production of Bio fertilizers using nitrogen fixing and phosphate solubilising isolates and packaging

UNIT-II

1. Estimation of Antibiotics–Streptomycin & Tetracycline by suitable assay method.

2. Estimation of Organic Acids–Lactic Acid & Citric Acid by suitable assay method.
3. Immobilization of Amylase by using Sodium Alginate method.
4. Microbiological analysis of Butter by SPC
5. Detection for the presence of *E. coli* & *Staph. Aureus* in Butter
6. Microbial limit test for PSB market fertilizer product.

REFERENCE BOOKS

1. Experimental Microbiology–Rakesh J. Patel & Kiran R. Patel. (Vol. I&II)
2. Practical Biochemistry by Plummer
3. Microbial technology by Peppler & Periman.
4. Bacteriological Techniques- F.K. Baker
5. Bio fertilizers –Vyas & Vyas (Ekta Publication).
6. Citric acid Biotechnology–J. Achrekar.
7. Enzyme Biotechnology–G. Tripathi.
8. Bio fertilizers– Arun Sharma.
9. Industrial Microbiology–Agrawal / Parihar
10. Biotechnology–S. S. Purohit.
11. Agriculture Microbiology–G. Rangaswami & D. J. Bagyaraj

SEMESTER – IV

(Credit 04) I22-401: Fermentation Technology-II

UNIT – I **(12)**

1. Microbial Production of Vitamins:
   a. Vitamin C - Organism used production method, process, recovery and assay.
   b. Vitamin A - Organism used, production method, process, recovery and assay
2. Production of Antibiotics: Organism used, production process and recovery of Chloramphenicol
3. Production of toxoids
   a. Diphtheria
   b. Tetanus

UNIT – II **(12)**

1. Vinegar Production
   a. Introduction
   b. Production Process
   c. Quality, Grades & uses of Vinegar

2. Production of biofuels
   a. Ethanol- microorganisms used, fermentation condition, recovery, purification of Ethanol
   b. Biogas- Biomass used, Microbiology & Biochemistry of biogas production, models used, uses of biogas
   c. Biodiesel production from algae
3. Microbial Production of Amino Acids
   a. Production of lysine
4. Microbial Production of Protease, Lipase and Amylase
5. Solvents
   a. Glycerol
   b. Acetone butanol

UNIT – III **(12)**

1. Bio fertilizers:
   a. Concept & its need in organic farming

2. Rhizobium Bio fertilizer
   a. Characteristics
   b. Host Rhizobium interaction
   c. N_2 fixation in root-nodules
   d. Production
   e. Methods of application

3. Azotobacter Bio fertilizer
    a. Characteristics
    b. N_2 fixation process
    c. Production
    d. Methods of application
4. Azospirillum Bio fertilizer
    a. Characteristics
    b. Association with plants
    c. Production
    d. Methods of application

UNIT – IV **(12)**

1. VAM Bio fertilizer
    a. Characteristics & types of association
    b. Production
    c. Methods of application

2. PSB Bio fertilizer (Phosphate solubilising Bacteria)
    a. Mechanism of phosphate solubilisation
    b. Production
    c. Methods of application
3. Quality control of Bio fertilizers as per FCO (Fertilizer Control Order)
    a. Introduction of FCO specifications for bio fertilizers
    b. Sampling procedure
    c. Method of analysis
    d. Standards of bio fertilizers
    e. Biostability of product bio fertilizer
4. Azolla & BGA Bio fertilizers
    1. Azolla:
        a. Characteristics
        b. Production
        c. Methods of application
    2. BGA:
        a. Characteristics
        b. N_2 fixation process
        c. Production
        d. Methods of application

REFERENCE BOOKS:

1. Industrial Microbiology by L. E. Casida, John Wiley and Sons INC.
2. Prescott and Dunn's Industrial Microbiology, 4th edition (1982) by Gerald Reed.
3. Microbial technology Vol. I and II by H. J. Peppler and D. Perlman Academic Press INC
4. Principals of Fermentation Technology by P. Stanbury and A. Whitaker, Pergamon Press
5. Fermentation Microbiology and Biotechnology by E. M. T. El-Mansi and C. F. Bryce Taylor and Francis Ltd. London

6. Bio fertilizers– Arun Sharma.
7. Industrial Microbiology–Agrawal / Parihar
8. Fertilizer Control Order–1985 amended up to June, 2011
9. Bio fertilizers –Vyas & Vyas (Ekta Publication).
10. Agriculture Microbiology by Rangaswamy
11. Enzyme Biotechnology–G. Tripathi

(Credit 04) I22 – 402: FOOD AND DAIRY MICROBIOLOGY

UNIT – I **(12)**

1. Food as a substrate for Microorganisms
2. General principles underlying microbial spoilage of food
3. Microbial spoilage of meat, fruits and vegetables
4. Microbial spoilage of heated canned food
5. General principles of Preservation of food: Asepsis, Removal of microorganisms, killing of microorganisms, reducing the growth rate of microorganisms
6. Methods of food preservation: Thermal processing, cold preservation, Preservation by using chemical preservatives, Food dehydration, Preservation by using Irradiation, Canning of food

UNIT – II **(12)**

1. Milk: Definition, composition, Factors affecting composition, Nutritive value of milk
2. Spoilage of milk and milk products:
   - 2.1 Milk as a substrate for microorganisms
   - 2.2 Microbial contamination of milk - sources of contamination, types of microorganisms present in milk
   - 2.3 Biochemical activities during microbial spoilage of milk
3. Fermented foods: Microbiology and biochemistry of
   - 3.1 Fermented cereal foods: Amboli, Jalebi
   - 3.2 Fermented cereal legume foods: Idli, Dhokla
   - 3.3 Fermented vegetable products: Sauerkraut, Pickles
   - 3.4 Fermented milk products: Yoghurt, Cultured butter milk

UNIT – III **(12)**

1. Food borne diseases: Food born intoxications: Botulism and staphylococcal intoxication and Food borne infections
2. Prevention and control of food borne diseases
3. Fermented dairy products and their role in controlling food borne diseases:
   - 3.1 Types of fermented dairy products, methods of preparation
   - 3.2 Therapeutic significance and their health properties - mode of action of lactic acid bacteria on enteric pathogens
   - 3.3 Fermented dairy products and their role in controlling gastro intestinal tract disorders

UNIT – IV **(12)**

1. Probiotics: probiotic microbial strains, role of probiotics in gastrointestinal disorders, probiotics in reducing risks of cancer, immunogenic effects of probiotics
2. Enzymes in food processing: Need of enzymes, sources of enzymes
3. Applications of enzymes in:
    3.1 Production of high fructose syrup
    3.2 Fruit juice industry, Baking industry, Oils and fat processing
4. Food safety and standards: Food safety issues, Food adulteration, Contaminations with harmful microbes, Metallic contamination, Food Laws and standards, Industrial food safety Laws and standards, HACCP, Indian Food Laws and standards

REFERENCE BOOKS:

1. Food processing Biotechnological application (2000) by S. S. Marwaha & K. Arora, Asiatech Publishers INC, New Delhi
2. Food science, Fifth Edition, Norman N. Potter 1996, CBS publishers and distributors
3. The technology of food preservation, Fourth Edition, Norman W. Desrosier BI Publisher and Distributors, Delhi (1987)
4. Food Microbiology - Adams & Moss
5. Dairy Microbiology by Robinson
6. Outlines of Dairy technology by Sukumar De
7. Milk and Milk Products – Clarence
8. Food Science (5th ed) Norman N. Potter, Joseph N. Hotchkiss

I22-403: MICROBIOLOGICAL QUALITY CONTROL

UNIT – I **(12)**

Safe Microbiological practices and Culture media

1. Scope and Overview**.**
2. Risk assessment
3. Sterilization, disinfection and decontamination
4. Culture Media Design
5. Good laboratory practice in culture media preparation
6. Quality control and storage of culture media.

UNIT – II **(12)**

Sampling and Enumeration of Microorganisms

1. General principles
2. Sampling approach: Single sampling, attributed sampling, reference sampling
3. HACCP approach
4. Specialized sampling

Enumeration of microorganisms: Sample preparation.

1. Counting methods: Pour Plate, Membrane filtration, Spread plate, MPN,
2. Turbidimetric methods

UNIT – III **(12)**

Endotoxin and antimicrobial preservative testing.

1. Endotoxins and pyrogens
   - 1.1 Regulatory development
   - 1.2 LAL test
   - 1.3 The gel-clot method
   - 1.4 The chromogenic end-point method
2. Preservative Efficacy Testing
   - 2.1 The requirement for a biological assessment of preservative activity
   - 2.2 Limitations of preservative efficacy tests
   - 2.3 Test procedure and factors influencing reproducibility
   - 2.4 Adaptations and alternatives to pharmacopeial tests

UNIT – IV **(12)**

Microbial Hazards analysis and Audit.

1. Objectives
2. Planning and management of audits
   - 2.1 Need of audit
   - 2.2 Planning of audit

3. Auditing the microbiology laboratory
4. Auditing the manufacturing process
4. Hazard analysis of critical control points (HACCP)

REFERENCE BOOKS:

1. Handbook of Microbiological Quality Control, Edited By Rosamund M. Baird, Norman A. Hodges, Stephen P. Denyer, Copyright 2000.

2. Pharmaceutical Microbiological Quality Assurance and Control: Practical Guide for Non-Sterile Manufacturing, Editor(s): David Roesti, Marcel Goverde.

I22 – 404: INDUSTRIAL WASTE MANAGEMENT

UNIT – I **(12)**

1. Types and Characterization of industrial wastes:
    1.1 Types of industrial wastes
    1.2 General characteristics of different industrial wastes, pH, suspended solids, volatile solids, COD, BOD and organic carbon
2. Effects of industrial wastes on aquatic life- Effects of industrial wastes of high BOD, effects of waste with toxicants
3. Self-purification in natural waters: Introduction, physical process, chemical process, biological process.

UNIT – II **(12)**

1. Microbiology and biochemistry of wastewater treatment: introduction
    1.1 Cell physiology and important microorganisms – important microorganisms, role of enzymes, principles of growth, plasmid borne metabolic activities
    1.2 Impact of pollutants on biotreatment
2. Methods of industrial waste treatment: Part-I - Physico-chemical Methods - neutralization, oxidation of cyanides, Chromium reduction, reverse osmosis, carbon adsorption, destruction of phenolic compounds

UNIT – III **(12)**

1. Methods of industrial waste treatment: Part-II - Biological methods - I
    1.1 Activated sludge process- Process, microbiology, sludge bulking
    1.2 Trickling filters- Process, Microbiology and applications
2. Methods of industrial waste treatment: Part-III - Biological methods - II
    2.1 Lagooning- Aerobic and anaerobic, applications
    2.2 Anaerobic digestion- Process, microbiology of bio-gas formation, Applications

UNIT – IV **(12)**

1. Bio management of industrial waste: technological options for treatment of liquid and solid wastes – bioaugmentation, packaged microorganisms, use of genetically engineered microorganisms in wastewater treatment
2. Industrial waste treatment: methods of treatment of wastes from Dairies, Distilleries, paper and pulp industries, fertilizer industries and Pharmaceutical industries
3. Waste disposal control and regulations: Water pollution control, Regulation and limits for disposal into lakes, rivers, oceans and land.

REFERENCE BOOKS

1. Industrial Pollution Control Vol. - I by E. J. Middlebrooks
2. The treatment of industrial wastes. (2nd ed) by E. B. Besselievre and M. Schwartz
3. Environmental Biotechnology (Industrial pollution management) by S. N.

Jogdand, Himalaya Publishing House
4. Water and water pollution Handbook Vol. – I by Leonard L. Ciaccio
5. Wastewater Treatment by M.N. Rao and A. K. Datta
6. Industrial Pollution by N. L. Sax. Van Nostrand Reinhold Company
7. Encyclopaedia of Environmental Science and Technology Vol. – II by Ram Kumar
8. Water Pollution Microbiology by R. Mitchell
9. Handbook of Water Resources and Pollution Control by H.W. Gehm and J. I. Bregman
11. Environmental Microbiology by P. D. Sharma, Narosa Publishing House, New Delhi

I22 – 405: PRACTICAL COURSE -VII

UNIT – I

1. Platform tests in dairy industry: COB, alcohol precipitation, titratable acidity, quantitative phosphatase test, mastitis test
2. Physical examination of milk: specific gravity and solids non-fat (SNF)
3. Chemical examination of milk: *p*H, fat, protein, sugar and ash
4. Production of a Lactic starter culture
5. Fermentative production of gluconic acid

UNIT - II

1. Characterization of industrial wastes: pH, Alkalinity, BOD, COD, TOC, DO, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), total volatile solids (TVS)
2. Treatability test for industrial effluents
3. Development of an activated sludge culture
4. Minimum 30 days On Job Training (Training Report with PowerPoint Presentation)

REFERENCE BOOKS

1. Official Methods of Analysis of the Association of Official analytical
2. Chemists Vols. I and II. Published by Association of Official analytical
3. Chemists, Suite 400, 2200 Wilson Boulevard, Arlington, Virginia 22201, USA
4. Laboratory Methods in Food Microbiology by D. W. Harrigan, Academic Press
5. Handbook of Techniques in Microbiology by A. S. Karwa, M. K. Rai and H. B. Singh Scientific Publishers, Jodhpur
6. Dairy Microbiology by Robinson
7. Outlines of Dairy technology by Sukumar De
8. Standard Methods in Water and Wastewater Analysis by APHA, AWWA and WPCF
9. Analysis of Plants, Irrigation water and Soils by R. B. Somawanshi and
10. others. Mahatma Phule Agricultural University, Rahuri
11. Microbiological aspects of Anaerobic Digestion – Laboratory Manual by

12. D. R. Ranade and R. V. Gadre, MACS Agharkar Research Institute, Pune
13. Pollution Microbiology: A Laboratory Manual by Melvin S. Finstein, Marcel Dekker Inc.
14. Molecular Cloning – A Laboratory Manual, Vol. 1,2,3 by J. Sambrook, E. F.
15. Fritsch and T. Maniatis
16. Molecular Biology and Biotechnology by J. M. Walker and R. Rapley,
17. Panima Publishing Corp. New Delhi
18. Principles and Techniques of Practical Biochemistry by K. Wilson and J.
19. Walker, Cambridge University Press
20. Molecular Biology Laboratory Manual by Denny R. Randall
21. Plant Tissue Culture by H. D. Kumar

I22 – 406: PRACTICAL COURSE – VIII

Project work