SAVITRIBAI PHULE PUNE UNIVERSITY,

PUNE

CHOICE BASED CREDIT SYSTEM

F. Y. B. Sc.

INDUSTRIAL MICROBIOLOGY

(VOCATIONAL)

Three-year degree course (Six Semesters)

(To be implemented from June 2019)

Savitribai Phule Pune University, Pune

Name of Program: Bachelor of Microbiology

(B.Sc. Industrial Microbiology)

F. Y. B. Sc. Microbiology Syllabus (CBCS)

(To be implemented from Academic year 2019-2020)

Preamble:

The 3-year B.Sc. Vocational Course in Industrial Microbiology is conducted as a part of the Savitribai Phule Pune University approved course in B.Sc. Microbiology. Industrial Microbiology is offered as one of the subjects among the four subjects at the F.Y.B.Sc. level and among the three subjects at S.Y.B.Sc. level. At the T.Y.B.Sc. level, there are two theory courses and one practical course to be offered along with four theory courses and two practical courses of T.Y.B.Sc. Microbiology.

It is therefore to be understood that this syllabus will only operate when it is offered to students who have the basic knowledge of Microbiology. It is therefore necessary that the syllabus of B.Sc. Microbiology is simultaneously considered, and that the course in Industrial Microbiology is an add-on information and practice, along with concomitant studies in Microbiology.

In keeping with the purpose of introducing vocational courses in the affiliated colleges of the Savitribai Phule Pune University, and as given in the previous statements of intent by the Board of Studies, the vocational courses are expected to be:

1. Specialized in the sense of being non-conventional.
2. They are expected to be multi-faculty as well as multidisciplinary.
3. The concerned Board of Studies is supposed to keep a holistic view and integrated approach.
4. The courses are expected to be different also because they are incorporated into conventional disciplines.
5. The courses are expected to establish a linkage with main stream disciplines, market and industry.

Introduction:

There is a continual demand for microbiologists in the work force – education, industry and research. Career opportunities for the graduate students are available in manufacturing industry and research institutes at technical level. This course focuses on training students on how microbiological techniques are carried out in industrial arena. Though the fundamentals of microbiological practices remains the same in theory and industrial practice, there are several facets of even simple microbiological practices that are exclusive to industry. For example, validation of procedures and processes are an integral part of industrial production. Also, some practices in industry, though simple and sometimes

monotonous, need to be standardized. Such standardization procedures have also not been extensively taught at the B.Sc. level.

The proposed syllabus lays more emphasis on practicals as compared to theory. This course will concentrate on experimental practice, and theoretical aspects will be oriented to explain and discuss the experimental practices. This approach justifies the term 'vocational'.

The teaching centre at the college will develop trained manpower for industry, such that employability immediately after B.Sc. is possible.

Trained and competent teachers with experience in industry would be ideal to teach the subject. Besides such teachers, persons from industry could contribute to the course.

Objectives to be achieved:

- To promote the possibility of entrepreneurship/ self employment after B.Sc.
- To bridge up the gap between knowledge based conventional education and market demands and to provide an alternative to those pursuing higher education.
- To introduce the concepts of experimental design in Industrial Microbiology
- To inculcate sense of job responsibilities, while maintaining social and environment awareness
- To help students build-up a progressive and successful career in industries with a biotechnological perspective

Course Structure:

- For First year: Student has to select 4 different subjects among the subjects offered by the College /Institute.
- For Second year: Student has to select 3 different subjects among 4 subjects chosen in first year.
- For Third year: Student has to select only 1 subject among the 3 subjects opted in second year.
- CGPA will be calculated based on core 132 credits only.
- Each theory credit is equivalent to 15 clock hours of teaching (12hrs classroom+3hrs of tutorials-active learning method) and each practical credit is equivalent to 30 clock hours of teaching in a semester.
- For the purpose of computation of workload, the following mechanism may be adopted as per UGC guidelines:
  Each theory lecture time for FY,SY and TY is of 50 min.(3Lectures per week for 2 credit courses)

i) 1 Credit = 1 Theory period of one-hour fifteen minutes duration per week
ii) 1 Credit = 1 Tutorial period of one-hour fifteen minutes duration per week
iii) 1 Credit = 1 Practical period of two-hour ten minutes duration per week

- Each theory Lecture time for FY, SY, TY is of 50 min.(3 lectures per week for 2 credits)
- Each practical session time for FY is of 3 hour 15 minutes = 195 min
- Each practical session time for SY & TY is of 4 hour 20 minutes = 260 min
- Exam. Pattern: University assessment 70% and continuous internal assessment 30%
- For internal Examination minimum two tests per paper of which one has to written test of 10 marks
- Methods of assessment for internal exam: seminars, *viva voce*, projects, surveys, field visits, tutorials, assignments, group discussions

- Reference: Savitribai Phule University's circular on "Rules and Regulation for UG Choice Based credit system for Science Programme of Affiliated Colleges", effective from June 2019 and further amendments.

Eligibility for Admission:

First Year B.Sc.:

a. Higher Secondary School Certificate (10+2) or its equivalent Examination with English and Biology; and two of the science subjects such as Physics, Chemistry, Mathematics, Geography, Geology, etc.

OR

b. Three Years Diploma in Pharmacy Course of Board of Technical Education conducted by Government of Maharashtra or its equivalent.

OR

c. Higher Secondary School Certificate (10+2) Examination with English and vocational subject of + 2 level (MCVC) - Medical Lab. Technician (Subject Code = P1/P2/P3)

Admissions will be given as per the selection procedure / policies adopted by the respective college keeping in accordance with conditions laid down by the Savitribai Phule Pune University.

Reservation and relaxation will be as per the Government rules.

Medium of Instruction: English

Award of Credits:

- Each course having 4 credits shall be evaluated out of 100 marks and student should

secure at least 40 marks to earn full credits of that course.

- Each course having 2 credits shall be evaluated out of 50 marks and student should

secure at least 20 marks to earn full credits of that course.

- GPA shall be calculated based on the marks obtained in the respective subject

provided that student should have obtained credits for that course.

Evaluation Pattern:

- Each course carrying 100 marks shall be evaluated with Continuous Assessment (CA) and University Evaluation (UE) mechanism.
- Continuous assessment shall be of 30 marks while University Evaluation shall be of 70 marks. To pass in a course, a student has to secure minimum 40 marks provided that he should secure minimum 28 marks in University Evaluation (UE).
- Each course carrying 50 marks shall be evaluated with Continuous Assessment (CA) and University Evaluation (UE) mechanism.
- Continuous assessment shall be of 15 marks while University Evaluation shall be of 35 marks.
- To pass in a course, a student has to secure minimum 20 marks provided that he/she should secure minimum14 marks in University Evaluation (UE).
- For Internal examination minimum two tests per paper of which one has to bea written test 10 marks
- Methods of assessment for Internal exams: Seminars, Viva-voce, Projects, Surveys, Field visits, Tutorials, Assignment, Group Discussion, etc (on approval of the head of the centre)

ATKT Rules:

- Minimum number of credits required to take admission to Second Year of B. Sc.: 22
- Minimum number of credits required to take admission to Third Year of B.Sc.: 44

Completion of Degree Course:

- A student who earns 140 credits, shall be considered to have completed the requirements of the B. Sc. degree program and CGPA will be calculated for such student

Titles of Papers and Scheme of Study Evaluation

F.Y.B.Sc. Industrial Microbiology (Voc.)

Semester	Paper Code	Paper	Paper title	Credits	Lectures/Week			Evaluation		
					Th.	Tut.	Pr.	CA	UE	Total
I	IMB 111	I	Introduction to Industrial Microbiology and Microorganisms	2	2			15	35	50
	IMB 112	II	Introduction to Industrial Process and Economics	2	2			15	35	50
	IMB113	III	Practical Course based on theory paper I and II	1.5			3	15	35	50
II	IMB121	I	Quantitative Industrial Microbiology	2	2			15	35	50
	IMB122	II	Industrial Bioprocesses and Microbial Products	2	2			15	35	50
	IMB123	III	Practical Course based on theory paper I and II	1.5			3	15	35	50

S. Y. B. Sc. Industrial Microbiology

Semester	Paper Code	Paper	Paper title	credits	Lectures/Week			Evaluation		
					Th	Tut	Pr.	CA	UE	Total
III	IMB 211	I	Bioreactors: Designs and Operation	2	2			15	35	50
	IMB 212	II	Screening and Process Optimization	2	2			15	35	50
	IMB213	III	Practical based on IMB211 & IMB 212	2			4	15	35	50
IV	IMB221	I	Fermentation Processes and Downstream Processing	2	2			15	35	50
	IMB222	II	Quality Assurance Tests for fermentation products	2	2			15	35	50
	IMB223	III	Practical based on IMB221 & IMB 222	2			4	15	35	50

In addition to the compulsory credits of 132, the student has to earn additional 8 credits from following groups by taking/participating/conducting respective activities.

1. Courses in Group I are compulsory.

The student can earn maximum 04 credits from an individual group from Group 2 to Group-9. These extra credits will not be considered for GPA calculation; however these are mandatory for the completion and award of B. Sc. Degree.

Group 1: Physical Education (at F. Y.B. Sc. Sem.I)-01 credit

Physical Education (atF. Y.B. Sc. Sem.II)-01credit (Note: GroupIis compulsoryfor allthe students as stated above.)

Group 2: Sport representation at Collegelevel-01 credit

Sport representation at University/Statelevel-02 credits

Group 3: National Social Service Scheme (participation in Camp): 01 credits

N.C.C. (with participation in annual camp)-01credit

N. C. C. (with Bcertificate/C certificateaward)-02 credits

N.S.S./N.C.C. Republic day parade participation-04 credits

Group 4: Avishkar participation; Extension activity participation, Cultural activity participation– 01 credit, Avishkar selection at Universitylevel-02 credits. Avishkar winner at state level-04 credits

Group 5: Research paperpresentation at State/National level-01 credits. Research paper presentation at International level-02 credits

Group 6: Participation in Summer school/programme;Short term course(not less than 1-weekduration) -03 credit. Group 7: ScientificSurvey, Societal survey,-02credits.

Group 8: Field Visits; StudyTours;Industrial Visits; Participation in curricular/ cocurricular competitions-01 Credit.

Group 9: Online certificate Courses /MOOC Courses/ CareerAdvancementCourseup to 04 credits (Minimum10 Hrs. / credit)

Equivalence of Previous Syllabus: F. Y. B. Sc.Microbiology

Sem	Old Course (2013 Pattern)	New Course (2019 Pattern)
I	Microorganisms and Systems for Fermentation Processes	Introduction to Industrial Microbiology and Microorganisms
	Industrial Processes and Products	Introduction to Industrial Process and Economics
	Practical course	Practical Course based on theory paper I and II
II	Microorganisms and Systems for Fermentation Processes	Quantitative Industrial Microbiology
	Industrial Processes and Products	Industrial Bioprocesses and Microbial Products
	Practical Course	Practical Course based on theory paper I and II

External Students

There shall be no external students.

University Terms

Dates for commencement and conclusion for the first and second terms will be declared by the University authorities. Terms can be kept by only duly admitted students. The term shall be granted only on minimum 80 percent attendance at theory and practical course and satisfactory performance during the term.

Current curriculum orientation

The syllabus has been structured to progressively inform and discuss the concepts and working areas of the Industrial Microbiology. The training for skill sets required to perform the tasks in the industry will be concomitantly developed through the three-year course.

In the First Year of undergraduate studies, students will be given information about the spectrum of microorganisms used for production of useful metabolites and enzymes (catalysts). A typical layout of the industry, equipment and operations, and regulations governing the organisms and products are presented to the student. This information lays the foundation for detailed study of each facet in the progressive years. In the practical exercises, students will learn the basic techniques of microbiological procedures in the industrial context.

In the Second Year of undergraduate studies, methods of screening of microorganisms and media, details of operations and designs of bioreactors, processes for production of industrially important metabolites and procedures of quality assurance will be studied. The

focus of these topics is to reveal to the students the different strategies used for designing and directing the metabolism of a production strain to overproduce the metabolite, and recover it. The practical exercises use examples to explain the procedures described in the theory courses.

In the Third Year of undergraduate studies, the students of Industrial Microbiology share four theory courses (per semester) and one practical course with Third Year Microbiology undergraduate students. The four theory courses they share are Medical Microbiology, Microbial Physiology, Microbial (prokaryotic and eukaryotic) Genetics and Immunology. The practical courses they share are 'Biochemistry and Molecular Biology' (Practical Course II) and 'Diagnostic Microbiology and Immunology' (Practical Course III) as per the existing version of the T.Y.B.Sc. Microbiology syllabus.

The courses for T.Y.B.Sc. Industrial Microbiology are structured to describe, explain and perform experiments related to Pollution Control Methods, Animal and Plant Tissue Culture, Validation of processes and methods and areas of Process Management and Economics.

Qualification of Teachers:

With minimum undergraduate and postgraduate degree in Microbiology (B. Sc. and M. Sc. Microbiology) and qualified as per UGC regulations.

F. Y. B. Sc. Industrial Microbiology Syllabus CBCS Pattern
Paper I: Introduction to Industrial Microbiology and Microorganism
Semester I

Sr. No.	Topic	No. of Hours
Credit One	**Scope of Industrial Microbiology:***(Discussion should address atypical nature of Industrial microbiology to that with Chemical/any other industry, emphasis on functioning of fermentation industry by quoting examples of product and microbes)* • Definition and use of the term 'fermentation' • Industrial Microbiology Vs Biotechnology • History(An Art from the Past, a Skill for the Future) • Multidisciplinary nature • A Typical Bioprocess: introduction, advantages and limitations. • Types of fermentations: Aseptic and non-aseptic fermentations • Fermentation types according to the organization of the biological system :Suspended and support culture • Organizational set-up in an industrial microbiology establishment • Upstream processing (USP) and downstream processing (DSP), unit downstream processing • Process flow diagrams • Industrial fermentation products and their producer microorganisms(List) • Obsolescence of procedures and methods • Patents and Intellectual Property Rights Activity Based Learning methodology	**(15)**
Credit Two	**Industrial Microorganisms:** • Taxonomic diversity of industrially useful bacteria and Fungi*(Discussion on groups, their general feature and taxonomic position and uses)* • Important characteristics of microbes used in Industrial Microbiology • Isolation of suitable producer microorganisms from the environment (Discuss approach for isolation) • Concept and examples of Microorganisms classified as Generally Regarded As Safe (GRAS) • Culture Collections of industrially important microorganisms • Use of mutants / Genetically Modified Microorganisms (GMM) as against Wild type isolates for production. **Development of a pharmaceutical product** Product development, regulation and safety (emphasis should be on the health care product development process and it's peculiarities in context with GMP,GMM, GLISP, QC,FDA, SOPs and validation) • Development of a pharmaceutical product • Product quality and safety(Quality assurance components) • Manufacturing and environmental safety(World Health Organization's classification of microorganisms on the basis of hazard, Safety precautions required for different levels of containment)	**(15)**

F. Y. B. Sc. Industrial Microbiology (Vocational) Syllabus CBCS Pattern
Paper I: Quantitative Industrial Microbiology
Semester II

Sr. No.	Topic	No. of Hours
Credit One	**Introduction to Engineering Calculations** • Physical Variables, Dimensions and Units(Substantial Variables, Natural Variables, Dimensional Homogeneity in Equations, Equations Without Dimensional Homogeneity) • Units • Force and Weight • Measurement Conventions(Density, Specific Gravity, Specific Volume, Mole, Chemical compositions, Temperature and Pressure) • Physical and Chemical Property Data • Stoichiometry Modeling the Kinetics of Biological Activity in Fermentation Systems *(It is expected to emphasize skillful use of mathematics to address problems in fermentation)* • Basics of Modeling. • Need of Models. • Cyclic processes of model construction, verification and applications. • The Components of Modeling. • The Control Region (Volume), Variables, Parameters, Equations	**15**
Credit Two	**Presentation and Analysis of Bioprocess Data:** *(It is expected to deliver the topic using numerical problems and exercises based on fermentation)* • Errors in data calculation(Significant figures, Absolute and relative uncertainty, types of error, statistical analysis,) • Presentation of experimental data(Tables, graphs and equations) • Data Analysis(Trends, Testing mathematical models, Goodness of fit: Least Square Analysis, Linear and Non-linear models) • Graph paper with logarithmic coordinates(Log-log plots, Semi-log plots) • General procedures for plotting data	**15**

Recommended books:

1. Modern Industrial Microbiology and Biotechnology (2007) by Nduka Okafor. Published by Science Publishers, Enfield, NH, USA
2. Practical Fermentation Technology Edited by Brian McNeil and Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9
3. Industrial Microbiology: An Introduction (2001); Michael J. Waites, Neil L. Morgan, John S. Rockey& Gary Higton
4. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books , ISBN: 0122208552

5. Basic Biotechnology 2nd Ed. (2001); Colin Ratledge and Bjorn Kristiansen. Cambridge University Press.
6. Bioreaction Engineering Principles 3rd Ed. (2011); John Villadsen, Jens Nielsen, Gunnar Lide´n, Springer
7. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
8. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
9. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
10. Batch Fermentation Modeling: Monitoring, and Control. Authors: Ali Cinar; Satish J. Parulekar; CenkUndey

F. Y. B. Sc. Industrial Microbiology (Voc.) Syllabus CBCS Pattern
Paper II: Introduction to Industrial Process and Economics
Semester I

Serial No.	Topic	No. of Hours
Credit One	Entrepreneurial overview of Biotechnology companies *(It is expected to discuss configuration and functioning of biotechnology companies with special emphasis on the factors that contribute to the success and failure of the companies.)* • Concept of a biotechnology company • Applications of biotechnology companies (Food, Agriculture, Medicine, etc.) • Scientific creativity • Market need • The basic components of the companies (Infrastructure, Manpower, Hierarchical structure for overall management) • How are the facilities integrated? • Strategy to establish and run the company • Competitive advantages • Success • Business plan • Investment in biotechnology	**15**
Credit II	**I Designing Biotech Processes for commercial success** a. Strain Design and Selection b. Strain Improvement **II Criteria for Design and Optimization of a Fermentation Process** **III Process economics** a. Cost estimates b. Process design optimization c. Design exercise d. Capital costs estimates e. Operating costs estimates, The costs case – to build or not to build	**15**

F. Y. B. Sc. Industrial Microbiology (Voc.) Syllabus CBCS Pattern
Paper II: Industrial Bioprocesses and Microbial Products
Semester II

Serial No.	Topic	No. of Hours
Credit One	**I Bioprocessing** a. Overall characterization of industrially important microorganisms b. Fermentation media and raw materials • Carbon sources • Nitrogen sources • Minerals, Vitamins and growth factors • Precursors • Inducers and elicitors • Inhibitors • Antifoams Overview of fermentation systems **II Microbial enzymes** a. Commercial microbial enzyme production b. Detergent enzymes c. Starch processing enzymes d. Enzymes in cheese production e. Enzymes in plant juice production f. Enzymes in textile manufacture g. Enzymes in leather manufacture h. Enzymes used in the treatment of wood pulps i Enzymes as catalysts in organic synthesis **III Fuels and industrial chemicals** a. Butanol b. Industrial ethanol c. Hydrogen d. Electricity e. Amino acids Organic acids	**15**
Credit Two	**I Health care products** a. Antibiotics b. Bacterial vaccines c. Recombinant therapeutic peptides and proteins d. Bacteriophages as therapeutic agents e. Probiotics, Prebiotics and Synbiotics **II Health care products** a Food and beverage fermentations Alcoholic beverages a. Vinegar production b. Dairy fermentations Other traditional fermented foods **III Food additives and supplements**	**15**

	a. Flavors b. Lipids c. Natural food preservative d. Vitamins and Polysaccharides **IV Microbial biomass production** a. Manufacture of baker's yeast b. Single cell protein production **c.** Mushrooms	

Recommended books :

1. Basic Biotechnology 2nd Ed. (2001); Colin Ratledge and Bjorn Kristiansen. Cambridge University Press.
2. Bioreaction Engineering Principles 3rd Ed. (2011); John Villadsen, Jens Nielsen, Gunnar Lide´n, Springer
3. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
4. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
5. Industrial Microbiology by A.H. Patel.
6. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
7. A text book of Industrial Microbiology by WulfCrueger and AnnelieseCrueger, Panimam Publishing Corporation.
8. Industrial Microbiology: An Introduction (2001); Michael J. Waites, Neil L. Morgan, John S. Rockey& Gary Higton.
9. Biology of Industrial microorganisms (1981); Arnold L. Demain.
10. Prescott & Dunn's Industrial microbiology (1987); G. Reed.
11. Modern Industrial Microbiology and Biotechnology (2007); NdukaOkafor.
12. Biotechnology: a text book of industrial microbiology (1990); WulfCrueger, AnnelieseCrueger, Thomas D. Brock.
13. Practical Fermentation Technology. Brian McNeil, Linda Harvey, Wiley.
14. Batch Fermentation Modeling: Monitoring, and Control. Authors: Ali Cinar; Satish J. Parulekar; CenkUndey
15. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Hill Publishing Co.

F. Y. B. Sc. Industrial Microbiology (Voc.) Syllabus CBCS Pattern
Practical Course
(Implemented from 2019)
Title: Practical Course based on theory paper I and II (IMB113)

Semester I		
Expt. No.	**Topics**	**No. of Practicals**
1	Good Laboratory Practices in Industrial Microbiology laboratory	**1**
2	Study of Bioreactor and its essential parts	**1**
3	Necessity and procedure of writing SOPs for instruments and equipments used in Industry	**2**
4	Microscopic observation of industrially important microorganisms using Light microscopy	**1**
5	Microscopic observation of industrially important microorganisms using Phase-contrast microscopy-real time microscopy of yeast	**1**
6	Culturing and Characterization of microorganisms used in Dairy industry	**2**
7	Culturing and Characterization of microorganisms used in Agro-industry	**1**
8	Culturing and Characterization of yeast used in Bakery/distillery/winery	**1**
9	Culturing and Characterization of fungi used in pharmaceutical industry	**2**
10	Culturing and Characterization of actinomycetes used in pharmaceutical industry	**2**

F. Y. B. Sc. Industrial Microbiology (Voc.) Syllabus CBCS Pattern
Practical Course
(Implemented from 2019)
Title: Practical Course based on theory paper I and II (IMB123)

Semester II		
Expt. No.	**Topics**	**No. of Practicals**
1	Photo-documentation of industrially important microorganisms	**1**
2	Record-keeping for microbial cultures	**1**
3	Maintenance and Preservation of microorganisms-Short term and long term	**1**
4	Retrieval and culturing of lyophilized cultures	**1**
5	Bio-burden estimation of Air	**2**
6	Introduction to Pharmacopiea (IP,BP and USP)	**1**
7	Bio-burden estimation of raw material to be used in fermentation process	**2**
8	Design and use of typical fermentation process medium using crude raw material such as molasses and agro-waste	**2**
9	Isolation of microorganism from an environmental sample	**2**
10	Determine activity of pharm/nutraceutical /commercial product	**1**

Recommended Books:

1. Basic Biotechnology 2nd Ed. (2001); Colin Ratledge and Bjorn Kristiansen. Cambridge University Press.
2. Bioreaction Engineering Principles 3rd Ed. (2011); John Villadsen, Jens Nielsen, Gunnar Lide´n, Springer
3. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
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6. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
7. A text book of Industrial Microbiology by WulfCrueger and AnnelieseCrueger, Panimam Publishing Corporation.
8. Industrial Microbiology: An Introduction (2001); Michael J. Waites, Neil L. Morgan, John S. Rockey& Gary Higton.
9. Biology of Industrial microorganisms (1981); Arnold L. Demain.

10. Prescott & Dunn's Industrial microbiology (1987); G. Reed.
11. Modern Industrial Microbiology and Biotechnology (2007); NdukaOkafor.
12. Biotechnology: a text book of industrial microbiology (1990); WulfCrueger, AnnelieseCrueger, Thomas D. Brock.
13. Practical Fermentation Technology. Brian McNeil, Linda Harvey, Wiley.
14. Batch Fermentation Modeling: Monitoring, and Control. Authors: Ali Cinar; Satish J. Parulekar; CenkUndey
15. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Hill Publishing Co.