GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester-VI

Course Title: Biological treatment of waste water
(Course Code: **4361301**)

Diploma programme in which this course is offered	Semester in which offered
Environmental Engineering	Sixth

1. RATIONALE

This course introduces students to the principles, processes, and technologies involved in the biological treatment of water and wastewater. Students are expected to learn the principles, objectives and basic criteria for the selection of appropriate process for biological wastewater treatment.

2. COMPETENCY

The course content should be taught and with the aim to develop required skills in students so that they are able to acquire following competencies.

- **Operate biological treatment systems and optimize them for efficiency and effectiveness.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Understand the fundamentals of microbiology related to water and wastewater treatment.
b) Identify various biological treatment processes and their mechanisms.
c) Operate biological treatment systems.
d) Summarize Emerging biological treatment technologies

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA*	ESE	CA	ESE	
3	0	0	3	30	70	0	0	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES-Not Applicable

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
			Total:

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency..*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
	For PrOs 1 to 7	
1	Identification of Glassware and Equipment to perform various test	10
2	Prepare experimental setup accurately	10
3	Observe and record readings accurately	40
4	Calculate results accurately	20
5	Interpret results and their conclusions	10
6	Submission for progressive assessment on time	10
7	Viva Voce	10
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED-Not Applicable

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1		

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a team member/ individual.
b) Follow ethical practices.
c) Follow safe practice on site and in laboratory.
d) Practice of environmental friendly methods and processes.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Introduction to Microbiology in Wastewater Treatment**	1a. Describe the Basic microbiology concepts including metabolic function 1b. Identify Microbial communities in water and wastewater 1c. Explain the Role of microorganisms in biological treatment 1d. Describe the Microbiology of secondary treatment unit process	1.1 Basic microbiology concepts including metabolic function 1.2 Microbial communities in water and wastewater 1.3 Role of microorganisms in biological treatment 1.4 Microbiology of secondary treatment unit process
Unit – II **Biological Treatment Methods**	2a. Describe various Aerobic processes 2b. Explain various Anaerobic processes 2c. Explain various Attached processes 2d. Explain various Biological treatment for nutrient removal	2.1 Aerobic processes: Activated sludge, oxidation ponds 2.2 Anaerobic processes: Anaerobic digestion, UASB reactor 2.3 Attached growth processes: Trickling filters, RBCs,SAFF,MBBR 2.4 Biological treatment for nutrient removal
Unit– III **Operation and Maintenance of Biological Treatment Systems**	3a. Describe Operation and control strategies in biological treatment 3b. Explain Nutrient management and dosing 3c. Describe Sludge handling and disposal 3d. Identify common issues in biological treatment and troubleshoot them	3.1 Operation and control strategies 3.2 Nutrient management and dosing 3.3 Sludge handling and disposal 3.4 Troubleshooting common issues in biological treatment like Poor Nutrient Balance, Inadequate Dissolved Oxygen, Foaming in Activated Sludge Systems, Bulking Sludge, pH Fluctuations, High Filamentous Bacteria etc.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit– IV **Advanced Topics and Applications**	4a. Summarize Emerging biological treatment technologies 4b. Review Case studies and practical applications 4c. Understand Future trends in biological treatment of water and wastewater	4.1 Emerging biological treatment technologies like Anammox (Anaerobic Ammonium Oxidation), Microbial Electrochemical Technologies, Constructed Wetlands with Engineered Microbes, Algal Treatment System, Bioaugmentation with Engineered Microbes etc. 4.2 Case studies and practical applications 4.3 Future trends in biological treatment of water and wastewater like Resource Recovery from Wastewater, Climate-Resilient Treatment Processes, Microbial Source Tracking etc.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Introduction to Microbiology in Wastewater Treatment	12	07	10	04	21
II	Biological Treatment Methods	12	07	10	04	21
III	Operation and Maintenance of Biological Treatment Systems	10	04	07	03	14
IV	Advanced Topics and Applications	08	04	07	03	14
Total		**42**	**22**	**34**	**14**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare report on operational problems in Biological Treatment units and their solution after industrial visit

b) Prepare sketches for : Different types of Biological Waste water Treatment Units
c) Prepare case study using internet for emerging technologies for advanced wastewater treatment.
d) Visit industrial wastewater treatment site and discuss specific features of emerging technologies and methods for biological wastewater treatment used there.
e) Undertake micro-project.
f) Give seminar on any relevant topic.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed Six.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Construct a small-scale activated sludge system to simulate wastewater treatment and study key parameters such as aeration, settling, and effluent quality.
b) Study the impact of different nutrient dosing strategies on the performance of an activated sludge system and optimize nutrient levels for efficient treatment.
c) Compare the performance of different attached growth systems (e.g., RBC, trickling filter) in terms of pollutant removal efficiency, ease of operation, and maintenance.

d) Explore the use of earthworms in wastewater treatment by designing and constructing a vermifilter system to study the removal of organic matter.
e) Set up a small-scale constructed wetland to study the effectiveness of phytoremediation in removing pollutants from water.
f) Compare the performance of batch and continuous flow reactors for biological treatment in terms of efficiency, stability, and ease of operation.
g) Conduct a microbial analysis of water from local sources to assess its quality and potential for biological treatment, considering factors like microbial load and diversity.
h) Explore the concept of bio augmentation by introducing specific microbial cultures to an existing treatment system and monitoring the impact on performance.
i) Study the problems encountered in biological treatment units and suggest remedial measures
j) Make a working model of Trickling filter/Rotating biological contactor/
k) Make a working model of Fluidized bed bioreactor/MBBR/SAFF

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Wastewater Engineering: Treatment and Reuse	Metcalf and Eddy	McGraw Hill Education; 4th edition (1 July 2017) ISBN-13 : 978−0070495395
2	Water and Wastewater Engineering	Mackenzie L. Davis	McGraw Hill Education; First Edition (1 July 2017) ISBN-13 : 978−1259064838
3	Wastewater Engineering	B.C. Punmia (Author), Ashok Kumar Jain	Laxmi Publications; Second edition (1 January 2016) ISBN-13 : 978−8131805961
4	Wastewater Engineering: Treatment and Resource Recovery	Metcalf & Eddy, Inc. (Author), George Tchobanoglous (Author), H. Stensel	McGraw-Hill Education; 5th edition (16 October 2013) ISBN-13 : 978−0073401188

14. SOFTWARE/LEARNING WEBSITES

a) www.gpcb.gov.in
b) https://cpcb.nic.in/about-namp/www.neeri.res.in
c) www.Nptel.ac.in
d) https://www.indiacode.nic.in/
e) https://archive.nptel.ac.in/courses/103/107/103107217/

f) https://archive.nptel.ac.in/courses/105/105/105105178/

15. PO-COMPETENCY-CO MAPPING

Semester II	Biological treatment of waste water (Course Code:4361300)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1 Environmental planning & deisgn	PSO 2 Environmental Impact Assessment	PSO 3 (If needed)
Competency	i. Operate biological treatment systems and optimize them for efficiency and effectiveness.									
Course Outcomes										
a) Understand the fundamentals of microbiology related to water and wastewater treatment	3	-	-	-	-	-	2	3	-	-
b) Identify various biological treatment processes and their mechanisms	3	3	3	-	3	-	2	3	3	-
c) Operate biological treatment systems	3	3	3	2	3	-	2	3	3	-
d) Summarize Emerging biological treatment technologies	3	3	3	-	3	-	3	3	3	-

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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