250654 - INTBIOAMB - Introduction to Environmental Biotechnology

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 745 - DEAB - Department of Agri-Food Engineering and Biotechnology
Academic year: 2019
Degree: MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2014). (Teaching unit Compulsory)
ECTS credits: 5  Teaching languages: Spanish

Teaching staff
Coordinator: OSCAR HUERTA PUJOL
Others: OSCAR HUERTA PUJOL

Opening hours
Timetable: To be arranged, preferably after class hours.

Degree competences to which the subject contributes

Specific:
13340. Apply scientific concepts to environmental problems and their correlation with technological concepts.
13341. Analyze systems, environmental problems and their resolution using models and evaluate them.
13342. Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Transversal:
8562. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
8563. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology

The course consists of 3 hours per week of classroom activity (large size group):
- About 1.5 h are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.
- About 1.5 h are devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives. Some strategies for solving the problems posed to the students will be discussed also.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, written documentation prepared by the professor, collection of solved problems, collection of proposed problems to be solved, codes of simulation programs to be used as templates and assessment activities conducted.

Learning objectives of the subject

CE01 - Apply scientific concepts to environmental problems and their correlation with technological concepts.
CE02 - Analyze systems, environmental problems and their resolution using models and evaluate them.
CE03 - Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Very aware of the structure of land, water and artificial ecosystems and their interactions.
Meet the ecology and the cycling of elements.
Meet the major environmental problems globally.
Analyze energy bases, stoichiometric and kinetic of different processes.
Modeling process and quantifies the performance and efficiency of systems.
Determine the basis of environmental hazards to human health and ecosystems.
Apply material balances and energy to environmental problems.
Interpret water-rock and water-air interactions using thermodynamic and kinetic methods.
Meet the pollutants and identify their impact.
Learn the basics of how the atmosphere and applies them in maintaining air quality.
Learn the basics of climate and discusses the implications of current climate change.
Conceptualized an environmental problem described by equations and poses analytical or numerical solution.
Identify the codes you need to solve a problem as conceptualized.
Recognize the spatial and temporal scales required to resolve the problem.
Familiar with solutions to problems relating to dynamical systems.
Learn about simple solutions to problems advection-dispersion-reaction.
Recognize the existence of uncertainty in the parameters of the equations and is capable of performing an uncertainty analysis and sensitivity.
Learn methods for information and action on various parameters or variables.
Understand that any measure inherently carries an associated error and is able to work with them.
It is critical to the values reported by others when the measurement method is not specified.
He has worked in the laboratory measurement of some parameters of environmental interest.

Dynamic processes, reactions and reactors.
Bioenergetics and stoichiometry of biological reactions.
Kinetics of biological processes of interest in environmental engineering.
Kinetics of biofilm reactors and immobilized biomass.
Simultaneous expression of matrix kinetic biological processes.
Technical parameter identification of biological processes.
Techniques of qualitative and quantitative measurement of microbial populations.

The specific objective of the course is to build solid knowledge and to develop skills to further deal with the design and operation of biological processes interesting in the field of environmental engineering.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 15h</th>
<th>Hours medium group: 10h</th>
<th>Hours small group: 10h</th>
<th>Guided activities: 10h</th>
<th>Self study: 80h</th>
<th>Study load</th>
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# Content

<table>
<thead>
<tr>
<th>Process dynamics, reactions and reactors</th>
<th>Learning time: 9h 36m</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 3h</td>
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<td>Practical classes: 1h</td>
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<td>Self study : 5h 36m</td>
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**Description:**
- Transport and reaction processes
- Equations of the mass balance
- Transport by diffusion and convection
- The equation of continuity
- Homogeneous and heterogeneous reactions
- Order of reaction and treatment of kinetic data
- Applications of the first order reaction
- Enzymatic reactions. Michaelis-Menten kinetics
- Monod kinetics
- Associated physico-chemical processes: chemical equilibria and gas-liquid transfer
- Completely mixed batch reactor
- Completely mixed continuous reactor
- Completely mixed continuous reactor with biomass recirculation
- Ideal plug flow continuous reactor

Problems and exercises of the topic

<table>
<thead>
<tr>
<th>Stoichiometry and bioenergetics of biological reactions</th>
<th>Learning time: 16h 48m</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
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<tr>
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<td>Practical classes: 3h</td>
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<td>Self study : 9h 48m</td>
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**Description:**
- Microorganisms classification
- Cell structure and components
- Functions and characteristics of microorganisms
- Nutritional requirements for growing
- Carbon and energy sources. Microbial diversity
- Qualitative and quantitative techniques for measuring microbial populations
- Stoichiometric equations
- Anabolism and catabolism. Energy and growth
- Partition of substrate and cells production
- Coefficients of biomass production, free energy and energetics of the biological reactions

Problems and exercises of the topic
<table>
<thead>
<tr>
<th>Biological process kinetics in environmental engineering</th>
<th>Learning time: 12h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 3h</td>
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<tr>
<td>- Growth rate and decay rate</td>
<td>Practical classes: 2h</td>
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<td>- Effect of toxics and inhibitors</td>
<td>Self study : 7h</td>
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<td>- Effect of temperature</td>
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<td>- Effect of pH</td>
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<td>- Transformation of substrate into biomass. Stoichiometric coefficients</td>
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<td>- Hydrolysis: first order and Contois kinetics</td>
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<tr>
<td>- Decay</td>
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<td>- Growth of heterotrophic organisms in oxic conditions</td>
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<td>- Growth of autotrophic ammonium-oxidizing organisms in oxic conditions (nitrification)</td>
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<td>- Growth of heterotrophic organisms in anoxic conditions (denitrification)</td>
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<td>- Growth of autotrophic ammonium-oxidizing organisms in anoxic conditions (anammox)</td>
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<td>- Growth of heterotrophic / autotrophic organisms in anaerobic conditions (anaerobic digestion)</td>
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<td>- Growth of phosphorus-accumulating organisms</td>
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<td>- Growth of sulfate-reducing organisms</td>
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<td>Problems and exercises of the topic</td>
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<th>Simultaneous biological processes</th>
<th>Learning time: 9h 36m</th>
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<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 2h</td>
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<tr>
<td>- Simultaneous biological processes</td>
<td>Practical classes: 2h</td>
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<tr>
<td>- Matrix notation. Matrix of Petersen</td>
<td>Self study : 5h 36m</td>
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<tr>
<td>- Equations of the system</td>
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<td>- IWA ASM models</td>
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<td>- IWA ADM1 model</td>
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<td>- Three-phase model for the composting process</td>
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<td>Problems and exercises of the topic</td>
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## Biofilm kinetics and immobilized biomass reactors

**Description:**
- Biofilms and aggregates. Definition and characteristics
- Biofilm kinetics
- Analytical solutions for zero- and first-order kinetics
- Effect of the external transport resistance
- Mass balance equations for biofilm reactors
- Solutions of the continuity equation for several kinetics
- Application to completely mixed and plug flow reactors
- Biofilm penetration and limiting substrate
- Effect of effluent recirculation

Problems and exercises of the topic

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## Case studies

**Description:**
- Suspended biomass systems
- Attached and immobilized biomass systems
- Systems for heterogeneous, liquid, solid or gaseous media
- Combination of processes based on objectives
- Oxidation of organic matter and ammonium
- Oxygen transfer
- Anaerobic processes
- Anaerobic digestion and methane production
- Combination aerobic - anoxic
- Combination anaerobic - anoxic - aerobic

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## Subject evaluation

**Learning time:** 4h 48m
- Laboratory classes: 2h
- Self study: 2h 48m
Qualification system

The qualification of the course will be obtained from the rating of the activity of numerical simulation, the collection of solved exercises during the course, and the final exam. The weighting for calculating the final qualification is as follows:

- Theory part of the exam: 30%
- Problems part of the exam: 30%
- Activity of numerical simulation: 25%
- Solved exercises collection: 15%

The students with a final qualification between 4 and 5 could attend to a re-evaluation exam. In case of passing such exam, the student will obtain a final qualification of 5.

Regulations for carrying out activities

- The collection of solved exercises and the report of the numerical simulation of a complex biological system can be done individually or in groups of a maximum of 3 people. The deadline for the delivery is the last day of class before the final exam.
- The theoretical part of the examination will require of written answers on conceptual questions, and the student can not consult any documentation.
- The problem part of the exam will consist of a written resolution of one or two problems or exercises. Students will have the calculator and can consult the documentation they wish individually. They could also consult information on digital support individually.
Bibliography

Basic:


Complementary:


