320072 - TRAR - Treatment and Reuse of Blackwater

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering
702 - CMEM - Department of Materials Science and Metallurgy

Academic year: 2019
Degree: BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN TEXTILE TECHNOLOGY AND DESIGN ENGINEERING (Syllabus 2009).
(Teaching unit Optional)

ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: Martí Crespi Rosell
Others: Martí Crespi Rosell, Josep Garcia Raurich, Mercè Vilaseca Vallsé, Valentina Buscio Olivera.

Prior skills
In order to successfully achieve the objectives of this course, it is advisable to have passed the course Environmental technologies and sustainability.

Teaching methodology
This subject also contributes to the following skill of the degree in Chemical Engineering:
EC 23. Knowledge and skills to delve into specific technologies in the field.

For the student achieves objectives and competencies described above, the course is divided into the following types of sessions:
- Sessions exposure and application content.
- Sessions of group work (lab)
- No classroom sessions freelance work: study, implementation problems, work deliverables individual reports individual practices
- No face sessions of group work: preparation of practical work on the results obtained in the laboratory.

Communication with students for information dissemination is done via the Digital Campus of the UPC (Athena) is currently serving teachers and students, and in some cases by service reprographics the TSE.

Learning objectives of the subject
This elective course is offered in odd semesters to the degrees in:
- Chemical engineering
- Technology and textile design

The objectives of the course are to enable students to:
- Evaluate the quality of wastewater through a parameter-based characterisation, and make them able to perform the conceptual design of treatment processes depending on wastewater quality, its final subsequent use (disposal, recycling, reuse) regulations and other factors.
- Make the engineering analysis and the basic design of the main processes of individual treatment of sewage and industrial.
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- Make the basic design of a complete system of a wastewater treatment plant.
- Experiment with the main mechanisms and treatment processes in the laboratory.
- Perform basic wastewater analyses in the laboratory.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>15h</td>
<td>10.00%</td>
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<td></td>
<td>Hours small group:</td>
<td>15h</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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</tbody>
</table>
### Content

<table>
<thead>
<tr>
<th>Topic 1. Introduction to wastewater treatment</th>
<th>Learning time: 17h 30m</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>- The role of wastewater treatment in the water cycle.</td>
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<td>- Main wastewater parameters.</td>
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<tr>
<td>- Treatment processes: goals and methods</td>
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<tr>
<td>Specific objectives:</td>
<td></td>
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<tr>
<td>At the end of the topic the student should be able to:</td>
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<tr>
<td>- Identify and interpret key parameters of wastewater pollution.</td>
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<td>- Determine the main treatment methods and their role in the treatment of wastewater.</td>
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<tr>
<td>- Perform calculations related to the Declaration of use and water pollution (DUCA) existing in Catalonia.</td>
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<table>
<thead>
<tr>
<th>Topic 2. Pretreatment and primary processes</th>
<th>Learning time: 15h</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
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<tr>
<td>- Screening, grit removal and degreasing, neutralisation tanks, equalisation tanks, oxygen transfer, aeration systems.</td>
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<tr>
<td>Related activities:</td>
<td></td>
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<tr>
<td>Practice 4. Oxygen transfer rate of an air diffuser</td>
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<tr>
<td>Specific objectives:</td>
<td></td>
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<tr>
<td>At the end of the topic the student should be able to:</td>
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<tr>
<td>- Specify the pollutants and relate them to each pretreatment and primary treatment.</td>
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<tr>
<td>- Perform basic calculations for analysis and design of pre-treatment and primary processes.</td>
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<tr>
<td>- Determine the oxygen transfer rate of a diffuser (laboratory)</td>
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</tbody>
</table>
**Topic 3. Physiochemical treatment**

**Learning time:** 16h
- Theory classes: 2h
- Practical classes: 2h
- Laboratory classes: 3h
- Self study: 9h

**Description:**
- Size distribution of pollutants, choice of physicochemical treatment method.
- Coagulation and flocculation, solid-liquid separation.
- Laboratory testing (Jar Test)
- Physicochemical treatment plant design: general scheme of WWTP. Importance of Equalisation. Coagulation tanks, flocculators, settling tanks calculations. Floatation: DAF and electrofloatation.

**Related activities:**
Practice 1. Coagulation and flocculation of wastewater

**Specific objectives:**
At the end of the topic the student should be able to:
- Applying physicochemical mechanisms for understanding and defining processes.
- Identify and select coagulants and flocculants agents
- Design and evaluation trials Jar Test (theory and laboratory)
- To design functional calculations of physicochemical treatment processes included in this topic
### Topic 4. Fundamentals of biological treatment processes

#### Learning time: 17h 30m
- Theory classes: 2h
- Practical classes: 3h
- Laboratory classes: 2h
- Self study: 10h 30m

#### Description:
- Biological processes: basic mechanisms.
- Microorganisms involved in biological processes.
- Types of metabolism. Environmental conditions.
- Death rate.
- Biomass production.
- Determination of kinetic coefficients.
- Types of biological treatment processes.
- Pilot plant studies.

#### Related activities:
Practice 3. Biological wastewater treatment by the activated sludge process (II): respirometry of the sludge and microscopic observation

#### Specific objectives:
At the end of the topic the student should be able to:
- Specify different types of microorganisms involved in biological purification and its role in the process.
- List and define the different processes and kinetic parameters and stoichiometric processes of biological wastewater treatment.
- Manage the kinetic equations of biological treatment processes and apply them to specific cases.
- List and classify the different biological treatment processes
- Define basically a pilot study.
- Perform a respirometric characterisation of a sludge.
Topic 5. Design and modelling of processes in suspended-biomass processes

Description:
- The activated sludge process.
- Membrane bioreactors.
- Calculation of an activated sludge wastewater treatment plant by using kinetic constants.
- Calculations using data obtained in a pilot plant.

Related activities:
Practice 2. Biological treatment by activated sludge process (I): characterization of influent and effluent
Practice 3. Biological wastewater treatment by the activated sludge process (II): respirometry of the sludge and microscopic observation
Practice 4. Visit of a wastewater treatment plant

Specific objectives:
At the end of the topic the student should be able to:
- Define and explain the process diagram of an activated sludge process with membrane bioreactors.
- Specify the correct nomenclature and symbols used in the study of these processes.
- Consider conceptually and mathematically formulate mass balances in activated sludge processing and additional relations used in the design.
- Solve the equations above to define the basic design process.
- Make a basic calculation process based on data from a pilot plant.
- Identify and define correctly the influence of process parameters in the operation.
- Operate and characterise an activated sludge process with elimination of carbon at laboratory scale.
### Topic 6. Fixed biomass systems

**Learning time:** 5h  
- Theory classes: 1h  
- Practical classes: 1h  
- Self study: 3h

**Description:**  
- Elimination of material in a fixed-bed system  
- Percolator filters  
- Design of a biological plant with percolator filters  
- Biocilinders and biodiscs  
- Submerged bed systems  
- Advantages and disadvantages of fixed bed systems  
- Design of a physico-biological system: different possibilities.  
- Systems of mobile bed

**Specific objectives:**  
- Substrate removal in a fixed-bed system  
- Trickling filter.  
- Design of a biological plant based on a trickling filter  
- Biocilinders and rotating biological contactors  
- Systems of submerged bed  
- Advantages and disadvantages of fixed bed systems  
- Design of a physicochemical-biological system: different possibilities.  
- Moving bed systems
### Topic 7. Fundamentals of nutrient removal

**Learning time:** 13h  
Theory classes: 3h  
Laboratory classes: 2h  
Self study: 8h

**Description:**
At finalizar el tema el estudiante debe ser capaz de:
- Indicar concentraciones típicas de las diferentes especies de N y P en las aguas residuales.
- Explicar los fundamentos de los métodos de eliminación fisicoquímica de nitrógeno
- Explicar los mecanismos y condiciones de la nitrificación y nitrificación biológicas
- Diagrama y explicación de los principales procesos biológicos de eliminación de N y P, haciendo cálculos básicos de ratios sustrato / nutriente y similares.
- Cálculo básico de la precipitación química del P inorgánico.

**Specific objectives:**
At the end of the topic the student should be able to:
- Indicate typical concentrations of the different species of N and P in wastewater.
- Explain the basics of physicochemical nitrogen removal methods
- Explain the mechanisms and conditions of the biological nitrification and nitrification
- Diagram and explanation of the major biological processes of elimination of N and P, making basic calculations of substrate/nutrient ratios and the like.
- Basic calculations of chemical precipitation of P.

### Topic 8. Sludge management

**Learning time:** 10h  
Theory classes: 3h  
Practical classes: 1h  
Self study: 6h

**Description:**
- Objectives of sludge management
- Features and points of sludge production
- Process for treating sludge
- Thickening: gravity, buoyancy
- Stabilization
- Anaerobic and aerobic digestion of sludge
- Systems of dehydration
- Were you drying
- Band filters, filter presses, centrifuges
- Thermal Drying
- Composting
- Sludge Incineration

**Specific objectives:**
At the end of the topic the student should be able to:
- Explain the fundamentals and applications of new sludge management processes.
- Set up and solve material balance calculations sludge treatment processes.
### Topic 9. Wastewater treatment plant control systems

**Learning time:** 7h 30m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 30m

**Description:**  
- Control of physicochemical WWTP  
- Methods of control of an activated sludge WWTP  
- Determination of the mass loading, the SVI, the OUR and RR  
- Calculation of the recycle rate and sludge waste  
- Control methods through microscopic observation  
- The most common problems in activated sludge process  
- Types and causes of filamentous microorganisms

At the end of the topic the student should be able to:  
- Explain the methods of control of a wastewater treatment plant or physicochemical biological  
- Determine control parameters from experimental data of sewage  
- Identify common problems and propose a solution.  
- Carry out the control of wastewater treatment plants in the laboratory.  

Note: two laboratory practices contribute to this objective, although formally been assigned to other issues.

**Related activities:**  
Laboratory  
Practice 3. Biological wastewater treatment  
Practice 5. Microscopic observation of activated sludge microorganisms
### Topic 10. Advanced treatment processes

**Description:**
- The need for advanced treatment systems
- Technologies used
- Granular bed filtration
- Membrane processes
- Adsorption, stripping
- Ion exchange
- Advanced oxidation systems
- Distillation

**Specific objectives:**
At the end of the topic the student should be able to:
- Explain the basic characteristics of each type of treatment.
- Basically determine the proper treatment for the secondary effluent, depending on the pollutant, the regulations and the desired quality.
- Basic calculations in membrane processes

**Learning time:** 7h 30m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 30m

### Topic 11. Disinfection

**Description:**
- Theory of disinfection
- Disinfection with chlorine
- Dechlorination
- Disinfection with ozone. Other chemical disinfectants
- UV disinfection
- Comparison of technologies.

**Specific objectives:**
At the end of the topic the student should be able to:
- Explain the basics of the different technologies of chlorination.
- Determine the applicable technologies based on socio-economic and technical considerations.

**Learning time:** 7h 30m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 30m
# Topic 12. Wastewater reuse and recycling

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<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>- Wastewater reuse and recycling</td>
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<tr>
<td>- Health-related issues. Regulations.</td>
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<tr>
<td>- Technologies used in water reclamation</td>
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<tr>
<td>- Reclaimed water tank</td>
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<tr>
<td>- Applications: agriculture, industry, aquifer recharge.</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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<tbody>
<tr>
<td>At the end of the topic the student should be able to:</td>
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<tr>
<td>- Distinguish between reuse and recycling.</td>
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<td>- Explain the basic legal and health conditions</td>
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<tr>
<td>- Describe the correct types and combinations of technologies used in the recovery of water based on the conditioning</td>
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<tr>
<td>- Perform basic calculations related to water quality and recycling or reuse.</td>
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## Qualification system

**Oral and written tests:**
- 1st bimestral exam, weight: 35%
- 2nd bimestral exam, weight: 35%
Laboratory 20%
Other deliveries (exercises): 10%

Laboratory practices will be assessed as a function of the previous preparation work, the development of the practice in the laboratory, and the final report. Other deliveries are mandatory exercises carried out by the students in the classroom or at home, and delivered on time.
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Bibliography

Basic:


Complementary:


Others resources: