

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	BIOREMEDIACIJSKE TEHNOLOGIJE
<b>Course Title:</b>	BIOREMEDIATION TECHNOLOGIES

Študijski program in stopnja Study Programme and Level	Študijska smer Study Field	Letnik Academic Year	Semester Semester
MAG Kemijsko inženirstvo, 2. stopnja	/	2.	4.
USP Chemical Engineering, 2 <sup>nd</sup> Cycle	/	2 <sup>nd</sup>	4 <sup>th</sup>

**Vrsta predmeta / Course Type:** izbirni strokovni / Elective Professional

**Univerzitetna koda predmeta / University Course Code:** IN2I11

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Work	Druge oblike študija	Samost. delo Individual Work	ECTS
45	15	15 LV	/	/	75	5

**Nosilec predmeta / Lecturer:** prof. dr. Aleksander Pavko / Dr. Aleksander Pavko, Full Professor

**Jeziki / Languages:** slovenski / Slovenian  
**Predavanja / Lectures:** slovenski / Slovenian  
**Vaje / Tutorial:** slovenski / Slovenian

**Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**

Študent oz. kandidat mora imeti predmet opredeljen kot študijsko obveznost.

**Prerequisites:**

The course has to be assigned to the student.

**Vsebina:**

**Uvod:** industrijski stranski produkti in odpadki. Uničevanje, odstranjevanje ali izkoriščanje; prioritete in kriteriji. **Mikrobiološke aktivnosti in odpadki.** Posebne kulture mikroorganizmov. Kinetika biodegradacije: procesi povezani z rastočimi oziroma nerastočimi mikroorganizmi. Vpliv kemijske strukture na biodegradacijo in možni produkti glede na sestavo odpadkov. **Bioremediacija.** Bioremediacija kovin in drugih anorganskih polutantov. Bioremediacija organskih polutantov. Lahko in težko razgradljive molekule. Razgradnja ksenobiotikov. **Izbrani primeri bioremediacijskih tehnologij za odpadke iz:** naftne industrije, biotehnološke proizvodnje antibiotikov, kemikalij, živil; blata

**Content (Syllabus outline):**

**Introduction:** industrial side-products and waste. Degradation, removal or reuse - priorities and selection criteria. **Microbial activities and waste.** Special microbial cultures. Biodegradation kinetics: processes related to growth and non-growth of microorganisms. Effect of pollutant chemical structure on biodegradation and estimation of possible degradation products. **Bioremediation.** Bioremediation of metal ions and inorganic pollutants. Bioremediation of organic pollutants. Easily and heavily degradable molecules. Degradation of xenobiotics. **Selected examples of bioremediation technologies:** waste from oil industry, waste biomass from fermentation industries and waste treatment

iz čistilnih naprav, hlapnih nehalogeniranih in halogeniranih spojin iz kemijske industrije, organskih pesticidov in herbicidov.

plants, waste from food industry, waste halogenated and non-halogenated compounds from chemical industry, organic pesticides and herbicides.

### Temeljna literatura in viri / Readings:

- Biodegradation and Bioremediation, M.Alexander, Academic Press, 1999, 453 str. (30%)  
- Renewables-based technology: sustainability assessment, J.Dewulf and H. Van Langenhove, John Wiley and Sons, 2006, 339 str. (30%)

### Cilji in kompetence:

Slušatelj spozna vrste polutantov glede na sestavo, strukturo in lastnosti in postopke za njihovo biorazgradnjo. To mu omogoča naslednje kompetence:

- poznavanje oziroma klasifikacijo polutantov,
- poznavanje primernih postopkov za njihovo odstranjevanje,
- sposobnost izbire primerne naprave oziroma tehnologije za odstranjevanje določene izbrane snovi,
- sposobnost izbire odgovarjajočih obratovalnih parametrov ter njihovega optimiranja,
- sposobnost opravljanja raziskav na tem področju in vodenja procesa v industrijskem merilu,
- sposobnost razumevanja in povezovanja bioremediacije z drugimi tehnikami in znanji pri zaščiti in varovanju okolja.

### Objectives and Competences:

Recognizing types of pollutants regarding their chemical composition, structure and basic principles of their removal. This allows:

- ability to classify the pollutants,
- evaluation of suitable processes for their removal, selection of equipment and technology as well as process parameters, ability to perform research work in this field in a laboratory and industrial scale,
- ability to understand and include bioremediation into other techniques for environmental protection.

### Predvideni študijski rezultati:

#### Znanje in razumevanje

Študent pridobi znanja o vrstah polutantov, vrstah postopkov za njihovo odstranjevanje in izbiri primerne naprave oziroma tehnologije. To mu omogoča analizo določene problematike in sintezo znanj pri njenem reševanju: zna opredeliti nalogo in jo rešiti na teoretskem in praktičnem nivoju.

#### Uporaba

S pridobljenim znanjem je študent sposoben za izbran polutant izbrati primeren proces skupaj z obratovalnimi pogoji bodisi v laboratorijskem merilu za raziskovalne namene ali pa v industrijskem merilu za

### Intended Learning Outcomes:

#### Knowledge and Comprehension

Student learns about the types of pollutants, types of processes for their removal and selection of a suitable equipment and technology. This allows the analysis of a particular problem and synthesis of knowledge for its solution: he knows how to define the problem and how to solve it on a theoretical and practical level.

#### Application

With the acquired knowledge student is able to select a suitable process together with operating conditions on a laboratory scale for research purposes as well on an industrial scale for a process technology for a particular

<p>proizvodno tehnologijo.</p> <p><u>Refleksija</u> Na osnovi pridobljenega teoretičnega znanja in praktične vaje študent pridobi občutek za ovrednotenje podatkov in prenos znanja v raziskovalni in/ali tehnološki proces.</p> <p><u>Prenosljive spretnosti</u> Uporaba različnih literaturnih virov (knjige, članki, elektronsko gradivo) omogoča zbiranje podatkov oziroma vrednotenje lastnih rezultatov in njihovo interpretacijo ter preverjanje pravilnosti. Končni rezultat je boljše razumevanje proučevanega procesa. Hkrati se razvijajo sposobnosti za vključevanje v skupinsko delo, komunikacijo in pripravo pisnega materiala.</p>	<p>pollutant.</p> <p><u>Analysis</u> On the basis of acquired theoretical and practical knowledge, student gets the feeling for data evaluation and knowledge transfer to the research and/or industrial process.</p> <p><u>Skill-transference Ability</u> Use of various literature sources (books, papers, electronic data) enables data collection and evaluation of own results, their interpretation and correctness control. The final result is a better understanding of the process. Skills for a team work, communication and written report preparation are simultaneously developed.</p>
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**Metode poučevanja in učenja:**

Predavanja, laboratorijske vaje, seminarji.

**Learning and Teaching Methods:**

Lectures, laboratory exercises, seminars.

**Načini ocenjevanja:**

Ustni izpit 40%  
Seminarska naloga (pogoj za pristop k izpitu) 40%  
Poročila o opravljenih vajah (pogoj za pristop k izpitu) 20%

Delež (v %) /

Weight (in %) **Assessment:**

**Reference nosilca / Lecturer's references:**

- BABIČ, Janja, LIKOZAR, Blaž, **PAVKO, Aleksander**. Optimization of ligninolytic enzyme activity and production rate with *Ceriporiopsis subvermispora* for application in bioremediation by varying submerged media composition and growth immobilization support. *International journal of molecular sciences*, 2012, vol. 13, no. 9, str. 11365-11384.
- **PAVKO, Aleksander**. Fungal decolourization and degradation of synthetic dyes some chemical engineering aspects. V: EINSCHLAG, Fernando S. García (ur.). Waste water - treatment and reutilization. Rijeka: Intech, 2011, str. 65-88.
- BABIČ, Janja, **PAVKO, Aleksander**. Production of ligninolytic enzymes by *Ceripoiopsis subvermispora* for decolourization of synthetic dyes. *Acta chimica slovenica*, 2007, vol. 54, no. 4, str. 730-734.