UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	OKOLJSKE TEHNOLOGIJE
Course title:	ENVIRONMENTAL TECHNOLOGIES

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Varstvo okolja in ekotehnologije, 2. stopnja	/	1.	/
Environmental Protection and Eco-technologies, 2nd level	/	1st	/

Vrsta predmeta / Course type	Obvezni predmet / Obligatory course
Univerzitetna koda predmeta / University course code:	OKT

Predavanja Lectures	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
40	20	10	10	160	**8**

Nosilec predmeta / Lecturer:	doc. dr. Ilja Gasan Osojnik Črnivec, sonosilca: dr. Patricia Jovičević-Klug, dr. Matic Jovičević-Klug, dr. Janvit Teržan

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenščina / Slovenian, Angleščina / English
	Vaje / Tutorial:	Slovenščina / Slovenian, Angleščina / English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Pogojev ni.	No formal prerequisites.

Vsebina:	**Content (Syllabus outline):**
Razumevanje okoljskih sprememb in posledic (globalne in regionalne spremembe okolja v časovnih in prostorskih razsežnostih/ Vplivi na okolje zaradi človekove rabe virov energije, tal, vode in atmosfere, kot posledica podnebnih sprememb, urbanizacije ter industrijskih dejavnosti/ Trajnostna prihodnost okolja: možnosti in omejitve v okviru pojmovanja planetarnih meja) **Poglavitne teme:** **Definicija okoljskih tehnologij** in osnova za njihovo uporabo (Čistilne tehnologije/ Čiste (integrirane) tehnologije/ Nove tehnologije in procesi temelječi na: večstopenjski izrabi, prihodnih materialih, energetski učinkovitosti in alternativnih ter obnovljivih energetskih virih/ Okoljska zakonodaja in trajnostno upravljanje) **Ekološke aplikacije** za doseganje okoljske vzdržnosti na nivoju individuuma, populacije in združbe (Ekoremediacije/ Obnova habitatov/ Ohranjanje biodiverzitete in ogroženih vrst/	Understanding environmental issues (global and regional environmental change in time and space / The effects on the environment arising from human use of the resources of energy, land, water and the atmosphere under climate change, urbanization pressure and industrial activity/ Sustainable environmental future: opportunities and constraints within resource efficiency and planetary boundaries frameworks) **Main topics:** **Definition of environmental technologies** and rationale for its use (Treatment technologies/ Clean (integrated) technologies/ New technologies and processes based on cascading approaches, emerging materials, energy efficiency and alternative and renewable energies/ Environmental legislation and sustainability governance) **Ecological applications** for managing environmental sustainability at individual, populations and community levels (Ecoremediation/ Restoration of

Celostno upravljanje s škodljivci/ Upravljanje z obnovljivimi viri/ Ekosistemske storitve in zdravje ekosistema)

Energija in okolje (Svetovne zaloge energije in poraba v okviru energetsko intenzivnih procesov ter ciljev razogličenja/ Okoljski vplivi ekstrakcije, dobave in uporabe fosilnih goriv/ Alternative fosilnim gorivom – sončna, vetrna, vodna, biomasna, plimovna, vodnokinetična, geotermalna in nuklearna ter fuzijska energija – in njihov okoljski vpliv / Vodik in drugi nosilci kot energetski vir / Trajnostna in odporna prihodnost z nizkimi toplogrednimi emisijami in nizkim oziroma nevtralnim ogljičnim odtisom.

Trajnost industrijskih procesov na primerih iz prakse: obravnavanje celotnega življenskega cikla za predstavitev okoljskih, ekonomskih in socialnih vplivov, t.i. ocena trajnosti življenjskega cikla, *life cycle analysis* – LCA in tehnoekonomska analiza – TEA.

Biološke tehnologije čiščenja onesnaženih virov: Okoljska biotehnologija / Fitoremediacija – fitotehnologije: karakterizacija onesnaženja in ocena tveganja, biološki procesi, predstavitev tehnoloških rešitev, izbira in uporaba primernih tehnologij, izvedba programa nadzornih meritev, ključni principi načrtovanja, omejitve tehnoloških rešitev in možnosti za povečane tehnološke zmogljivosti

Fizikalno-kemijske tehnologije čiščenja onesnaženih virov (karakterizacija onesnaženja, snovne in energijske bilance, principi načrtovanja tehnoloških rešitev, meritve ter s senzorji podprto spremljanje, primeri iz prakse). Varovanje vodnih virov: kakovost vode (organoleptična, fizikalna, kemijska, biološka); postopki čiščenja voda (sedimentacija, flotacija, koagulacija, filtracija, kemijski/ biološki postopki ter okoljska kataliza); priprava tehnološke in pitne vode (groba/ fina/ nano-filtracija, zniževanje vsebnosti karbonatov, ionska izmenjava, mehčanje, razsoljevanje, membranski postopki), mikro/ nanoplastika in druga nova onesnažila. Varovanje zraka: onesnaženje zraka (trdni delci, aerosoli, organski plini, neorganski plini); glavni onesnaževalci zraka in sevalni prispevki (ogljikov monoksid, ogljikov dioksid, žveplove spojine, metan, dušikove spojine, fotokemijski oksidanti, organske spojine); postopki čiščenja zraka (gravitacijski in ciklonski usedalniki, cikloni, pralniki delcev, filtri, elektrostatični izločevalniki, absorpcijski stolpi, adsorpcijske naprave, kondenzacijsko čiščenje, zgorevalni

habitats/ Conservation of biodiversity and endangered species/ Integrated pest management/ Harvest management/ Ecosystem services and ecosystem health)

Energy and the environment (Global energy supply and use for energy intensive processes, as well as under decarbonisation goals/ Environmental effects of extracting, delivering and using fossil fuels/ Alternatives to fossil fuels - solar, biomass, tidal, hydrokinetic, geothermal, and nuclear energy with fusion, wind power and water power – and their environmental impact/ Hydrogen and other vectors as an energy source/ Intermittent energy supply, short term and long term energy (electricity, chemical, heat) storage/ A sustainable and resilient future with low greenhouse gas emissions and a low or net zero carbon footprint.).

Case studies from different **sustainable industrial processes**: Life cycle analysis (LCA) to address environmental, economic and social issues and technoeconomic approach (TEA analysis).

Biological approaches for reclaiming contaminated resources: Environmental biotechnology/ Phytoremediation - phytotechnology: contamination characterization and risk assessment, biological processes, presentation of technological solutions, appropriate technology selection and application, monitoring programme design, key design principles, limitations of technological solutions and scalability considerations.

Physicochemical pollution control approaches (pollution determination, mass and energy balances, design principles of pollution control systems, measurements and sensor-based monitoring, practical examples). Water sources: water quality (organoleptic, physical, chemical, biological); water treatment operations (sedimentation, flotation, coagulation, filtration, chemical, biological operations and environmental catalysis); industrial and drinking water preparation (coarse/ fine/ nano-filtration, carbonate reduction, ion exchange, softening, desalination, membrane operations), micro/ nanoplastics and other emerging pollutants. Air pollution control: air pollution species (solid particles, aerosol, organic gases, inorganic gases); air pollution compounds and emission contributors (carbon dioxide, carbon monoxide, sulphur compounds, methane, nitrogen compounds, photochemical oxidants, organic compounds,); air treatment operations (gravitational and cyclone scrubbers, filters, electrostatic precipitators, absorption columns, adsorption devices,

postopki in zajem ogljika). Problematika in vpliv na ozonsko plast ter efekt tople grede. Trdni odpadki: vrste trdnih odpadkov (komunalni, industrijski, nevarni in elektronski odpadki); obdelava trdnih odpadkov (reciklaža, kompaktiranje, kompostiranje, uplinjanje, sežig, odlaganje ter ponovna izraba virov).	condensation treatment, combustion-based operations and carbon capture). The challenges and impact on ozone layer, greenhouse effect and climate feedback. Solid waste: solid waste types (municipal, industrial, hazardous and electronic waste); solid waste treatment (recycling, size reduction, composting, gasification, combustion, waste disposal and resource recovery).

Temeljna literatura in viri / Textbooks:

Obvezno gradivo:
Zbrana gradiva s predavanj.

Priporočeno gradivo:
Davis, L.; Cornwell, D.A.(2023). Introduction to Environmental Engineering, 6th ed., McGraw Hill.
Tatrishvili, T., Abraham, A.R., Haghi, A.K. (2024). Environmental Technology and Sustainability: Physical, Chemical and Biological Technologies for Environmental Protection, 1st ed., Routledge.
Vrhovšek, D., Vovk Korže, A. (2007). Ekoremediacije. Maribor: Filozofska fakulteta, Mednarodni center za ekoremediacije; Ljubljana: Limnos.

Cilji in kompetence:

Predmetno specifični cilji in kompetence:
- Razvoj poglobljenega in odgovornega razumevanja kompleksnih medsebojnih vplivov med tehnologijo in okoljem ter prepletenosti ekosistemov, tehnosfere in njihovih medsebojnih odnosov.
- Usposobljenost za vrednotenje okoljskih problemov in tehnoloških rešitev.
- Pridobljena znanja s področja strateškega, finančnega in tehničnega načrtovanja okoljskih in trajnostnih tehnoloških rešitev.
- Pridobljena znanja o najnovejših trajnostnih tehnologijah.
- Sposobnost kritične presoje in na podlagi znanstvenih in strokovnih kriterijev utemeljene izbire ustreznih tehnologij za trajnostni tehnološki razvoj.

Splošne kompetence:
- Sistemsko in interdisciplinarno razmišljanje.
- Analitični in problemsko-usmerjeni pristopi za realne strokovne izzive.
- Samostojno pridobivanje, vrednotenje in učinkovita uporaba strokovnih ter znanstvenih informacij;
- Strokovna komunikacija in argumentirano odločanje v interdisciplinarnem okolju.

Objectives and competences:

Specific competences:
- Development of an in-depth and responsible understanding of the complex interactions between technology and the environment, as well as the interconnectedness of ecosystems, the technosphere, and their mutual relationships.
- Competent assessment of environmental problems and technological solutions evaluation.
- Knowledge in strategic, financial, and technical planning of environmental and sustainable technological solutions.
- Knowledge of the latest sustainable technologies.
- Ability to critically assess and justify scientific and professional criteria to select appropriate sustainable technological development technologies.

General competences:
- Systems thinking and interdisciplinary reasoning.
- Analytical and problem-oriented approaches to address real-world professional challenges.
- Independent sourcing, evaluation, and effective application of professional and scientific information.
- Professional communication and making evidence-based decisions in an interdisciplinary settings.

Predvideni študijski rezultati:

Intended learning outcomes:

Znanje in razumevanje: Študenti bodo ob zaključku predmeta sposobni: • Izkazati znanje in razumevanje na področju medsebojnih vplivov trajnostnih tehnologij in okolja ter prednosti in pomanjkljivosti posameznih okoljskih tehnologij. • Prepoznati in oceniti okoljski problem ter na podlagi analize izbrati ustrezno tehnološko rešitev. **Prenosljive/ključne spretnosti in drugi atributi:** • Nadgrajene sposobnosti kritične presoje, samostojne interpretacije ter strnjenega ustnega in pisnega poročanja pri vrednotenju dostopnih podatkov ter zahtevnejše strokovne literature. • Med pripravo tehnoloških prototipov bodo pridobili spretnosti samostojne konceptualizacije, identifikacije, analitičnega vrednotenja in reševanja problemov.	**Knowledge and understanding:** At the end of the subject, the students will be able: • To demonstrate knowledge and understanding on the field of complex interplay between sustainable technologies and the environment and advantages and disadvantages of individual environmental technologies. • To recognise and assess the environmental problem and perform an analysis-based identification of the appropriate technological solution. **Transferable/key skills and other attributes:** • Upgraded critical evaluation, independent interpretation, and concise oral and written reporting skills for the assessment of available data and scholarly literature. • Technological prototypes preparation will develop skills in independent conceptualisation, identification, critical thinking, and problem-solving.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Oblike dela: Predavanja/ Seminarji/ Laboratorijske vaje/ Terensko delo/ Samostojno delo **Metode dela:** Predavanja za podajanje teoretičnih osnov ter seminarji in laboratorijske vaje za predstavitev izbranih primerov iz prakse ter računsko in problemsko obravnavanje. Demonstracije in ogledi na terenu. Samostojna priprava poročil vaj in seminarjev. Delo z dodeljenim gradivom za branje. Samostojno snovanje ter pisna in ustna predstavitev tehnoloških prototipov na lastno izbrano temo.	**Forms of teaching:** Lectures/ Tutorials/ Laboratory exercise/ Fieldwork/ Independent work **Teaching methods:** Lectures for delivering theoretical foundations. Tutorials and laboratory exercises for presenting selected practical case studies as well as for numerical and problem-based tasks. Field demonstrations and site visits. Independent preparation of laboratory and seminar reports. Work with assigned reading materials. Independent design, writing and presentation of technological prototypes on a self-selected topic.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**

Pogoj za pristop k izpitu: Končna ocena pri predmetu je sestavljena iz ▪ aktivno sodelovanje na predavanjih ▪ poročilo z vaj in seminarjev ▪ tehnološki prototip – pisni izdelek ▪ tehnološki prototip – zagovor ▪ končni izpit ali vmesno pisno preverjanje Ocenjevalna lestvica: ▪ zadostno 6: 60–67 % ▪ dobro 7: 68–75 % ▪ prav dobro 8: 76–83 % ▪ prav dobro 9: 84–90 % ▪ odlično 10: 91–100 %	 **5** **10** **20** **10** **55**	A prerequisite for access to the exam: Final evaluation consists of ▪ active in-class discussion ▪ laboratory and tutorial report ▪ technological prototype – written ▪ technological prototype – defence ▪ final exam or midterms Grading scale: ▪ Sufficient D (6): 60–67% ▪ Good C (7): 68–75% ▪ Very good B (8): 76–83% ▪ Very good B+ (9): 84–90% ▪ Excellent A (10): 91–100%

Materialni pogoji za izvedbo predmeta :

- Predavalnica z multimedijsko opremo

Material conditions for subject realization:

- Classroom with multimedia equipment

Obveznosti študentov:

Študentje se morajo predhodno seznaniti z objavljenim študijskim gradivom, pripraviti poročilo z vaj in seminarjev ter zasnovati tehnološki prototip okoljske rešitve po lastni izbiri. Prisotnost terenskih vajah je obvezna. Na seminarjih in laboratorijskih vajah je potrebna vsaj 80% prisotnost. Priporočljiv je reden obisk predavanj na katerih se spodbuja diskusija in komunikacija. Na koncu predavanj sledi pisni izpit, ki ga je mogoče opraviti tudi z vmesnimi kolokviji.

Student's commitments:

Students are expected to read the available materials and prepare a lab and tutorial report, as well as develop technological prototype for an environmental solution of their own choosing. Fieldwork attendance is mandatory. For tutorials and laboratory sessions, at minimum of 80% attendance is required. Regular lecture attendance is recommended, where active in-class discussion and communication are encouraged. At the end of the course, students will take a final exam, which may also be completed through midterms.

Reference nosilca predmeta:

Ilja Gasan OSOJNIK ČRNIVEC

Pedagoško delo:

Od leta 2006 redno izvajanje vaj in predavanj na dodiplomskih in podiplomskih visokošolskih in univerzitetnih programih ter številna predavanja na univerzah v tujini, med njimi pri predmetih Varstvo okolja, Okoljski monitoring, Mikrobna biotehnologija in Bioekonomija (ULBF). Soavtor ter recenzent različnih učnih gradiv.

Mentor in somentor več kot 30 BSc, MSc ter doktorskim študentom na domačih in tujih univerzah ter pri več kot 50 dijaških in študentskih raziskovalnih nalogah.

Znanstveno-raziskovalno delo:

Vodenje in koordiniranje številnih raziskovalnih projektov s področja: (i) Pridobivanja, kemijskega shranjevanja in pretvorbe vodika s katalitskimi in biotehnološkimi postopki. (ii) Zajema CO2 ter drugih plinov ter onesnažil s postopki absorpcije in adsorpcije. (iii) Izrabe odpadnih surovin za

Lecturer's references:

Ilja Gasan OSOJNIK ČRNIVEC

Pedagogic activities:

Since 2006, regular teaching of tutorials and lectures at undergraduate and postgraduate higher education and university programs and numerous lectures at universities abroad, including in the subjects of Environmental Protection, Environmental Monitoring, Microbial Biotechnology and Bioeconomy (ULBF). Co-author and reviewer of various teaching materials.

Mentor and co-mentor to more than 30 BSc, MSc and PhD students at domestic and foreign universities and in more than 50 high school and student research projects.

Scientific and research work:

Leading and coordination of numerous research projects in the fields of: (i) Production, chemical storage and conversion of hydrogen using catalytic and biotechnological processes. (ii) Capture of CO2 and other gases and pollutants using absorption and adsorption processes. (iii) Utilization of

energijo, pridobivanje ter ekstrakcijo dragocenih organskih spojin, anorganskih kritičnih surovin ter pripravo novih naprednih materialov.

Strokovno delo in izbrane strokovne publikacije:
Dolgoletne izkušnje z razvojnim delom za kemijsko, farmacevtsko ter prehransko industrijo, kakor tudi v okoljevarstvu in kmetijstvu z več kot 50 dokumentiranimi razvojnimi poročili.
Dva podeljena patenta (*P-202300123, 2023-09-12; EP4529920A1, 2025-04-02/ P-202000229, 2020-12-08*) in ena mednarodna patentna prijava (*EP2926904 (A1), 2015-10-07*).

Priznanja in nagrade:
Nagrada za nov tip katalizatorja in proces reforminga - Energy & Sustainability Prize, Emerging Technologies Competition, Royal Society of Chemistry, 2015, London, ZK, Nagrada Maksa Samca za najboljšo doktorsko delo s področja kemijskega inženirstva, FKKT UL, 2015, Ljubljana.
Več mentorirancev je prejelo Krkine nagrade in imelo visoko uspešnost na mednarodnih znanstvenih tekmovanjih za mlade (npr. EUCYS, I-SWEEEP, GeniUS, HS-iGEM, itn.).

waste raw materials for energy, recovery and extraction of valuable organic compounds, inorganic critical raw materials and preparation of new advanced materials.

Professional work and selected professional publications:
Many years of experience with R&D work for the chemical, pharmaceutical and food industries, as well as for environmental protection and agriculture with more than 50 documented development reports.
Two granted patents (*P-202300123, 2023-09-12; EP4529920A1, 2025-04-02/ P-202000229, 2020-12-08*) and one international patent application (*EP2926904 (A1), 2015-10-07*).

Awards:
Awarded for a new type of catalyst and reforming process - Energy & Sustainability Prize, Emerging Technologies Competition, Royal Society of Chemistry, 2015, London, UK, Maks Samec Award for the best doctoral thesis in the field of chemical engineering, FKKT UL, 2015, Ljubljana.
Several mentees have received Krka awards and achieved top results in international youth scientific competitions (e.g. EUCYS, I-SWEEEP, GeniUS, HS-iGEM, etc.).

Izbrani znanstveni članki / Selected scientific papers:

Kang, P., Gabrijelčič, M., Krajnc, A., Osojnik Črnivec, I.G., Likozar, B., Sharma, R.K. (2025) Organically functionalized mesoporous silica network for one-pot synthesis of 5-hydroxymethylfurfural from glucose in water. ACS sustainable chemistry & engineering. 2025, vol. 13, iss. 13, str. 4997–5008, DOI: 10.1021/acssuschemeng.4c09579.

Čič, M., Petek, N., Dogša, I., Damjanović, A., Genorio, B., Poklar Ulrih, N., Osojnik Črnivec, I.G. (2025) Sustainable cyclodextrin modification and alginate incorporation: viscoelastic properties, release behavior, and morphology in bulk and microbead hydrogel systems. Gels. 2025, vol. 11, issue 11, 875, DOI: 10.3390/gels11110875.

Levanič, J., Osojnik Črnivec, I.G., Rozman, I., Skrt, M., Štern, A., Žegura, B., Poklar Ulrih, N. (2024) Nano spray-dried particles of in-situ crosslinked alginate and their toxicological characterisation. International journal of biological macromolecules. 2024, vol. 283, issue 2, 137750, DOI: 10.1016/j.ijbiomac.2024.137750.

Warner, N., Osojnik Črnivec, I.G., Rana, V.K., Cruz, M., Scherman, O.A. (2022) A platform approach to protein encapsulates with controllable surface chemistry. Molecules. 2022, vol. 27, iss. 7, 2197, DOI: 10.3390/molecules27072197.

Osojnik Črnivec, I.G., Skrt, M., Šeremet, D., Sterniša, M., Farčnik, D., Štrumbelj, E., Poljanšek, A., Cebin, N., Pogačnik Da Silva, L., Smole Možina, S., Humar, M., Komes, D., Poklar Ulrih, N. (2021) Waste streams in onion production : bioactive compounds, quercetin and use of antimicrobial and antioxidative properties. Waste management. 2021, vol. 126, str. 476-486, DOI: 10.1016/j.wasman.2021.03.033.

Jemec Kokalj, A., Djinović, P., Osojnik Črnivec, I.G., Pintar, A. (2015) The hazard assessment of nanostructured CeO2−based mixed oxides on the zebrafish Danio rerio under environmentally relevant UV-A exposure. Science of the total environment. 2015, vol. 506/507, str. 272-278. DOI: 10.1016/j.scitotenv.2014.10.120.

Osojnik Črnivec, I.G., Jeločnik Pelicon, P., Djinović, P., Pintar, A. (2014) Biogas production from spent rose hips (Rosa canina L.) : fraction separation, organic loading and co-digestion with N-rich microbial biomass. Bioresource technology. 2014, vol. 171, str. 375-383, DOI: 10.1016/j.biortech.2014.08.085.

Jovičević-Klug, M., Ma, Y., Jovičević-Klug, P., Prabhakar, J.M., Rohwerder, M., Raabe, D. (2024) Thermal Kinetics and Nitriding Effect of Ammonia-Based Direct Reduction of Iron Oxides. ACS Sustainable Chemistry & Engineering. 2024, vol. 12-11, str. 9882-9896, DOI: 10.1021/acssuschemeng.4c02363

Jovičević-Klug, M., Souza Filho, I.R., Springer, H., Adam, C., Raabe, D. (2024) Green steel from red mud through climate-neutral hydrogen plasma reduction. Nature. 2024, vol. 625, str. 703-709, DOI: 10.1038/s41586-023-06901-z

Jovičević-Klug et al. 2025: Suppression of Cr nanoclusters and enrichments in Fe–Cr based alloys with cryogenic processing for future energy sector

Jovičević-Klug, M., Brondin, C.A., Caretta, A., Bonnekoh, C., Gossing, F., Vogel, A., Rieth, M., McCord, J., Rohwerder, M., Jovičević-Klug, P. (2025) Suppression of Cr nanoclusters and enrichments in Fe–Cr based alloys with cryogenic processing for future energy sector, Journal of Materials Research and Technology. 2025, vol. 36, str. 9262-9273, DOI: 10.1016/j.jmrt.2025.05.176.

Teržan, J., Huš, M., Likozar, B., Djinović, P. (2020) Propylene Epoxidation using Molecular Oxygen over Copper- and Silver-Based Catalysts: A Review, ACS Catalysis. 2020, vol. 10-22, str. 13415-13436, DOI: 10.1021/acscatal.0c03340

Teržan, J., Sedminek, A., Lavrič, Z., Grilc, M., Huš M., Likozar, B. (2023) Selective oxidation of biomass-derived carbohydrate monomers, Green Chemistry. 2023, vol. 25, str. 2220-2240, OI: 10.1039/d2gc04623g