UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	KAKOVOST, SANACIJA IN REMEDIACIJA TAL
Course title:	SOIL QUALITY, REHABILITATION AND REMEDIATION

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

Vrsta predmeta / Course type Modularni predmet / Modular course

Univerzitetna koda predmeta / University course code:

Predavanja **Lectures**	**Sem. vaje** **Tutorial**	**Lab. vaje** **Laboratory work**	**Teren. vaje** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
20		10	10	80	**4**

Nosilec predmeta / Lecturer: <izr. prof. dr. Borut Vrščaj>

Jeziki / Languages:	
Predavanja / Lectures:	Slovenski / Slovenian
Vaje / Tutorial:	Slovenski / Slovenian

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

Vsebina:	**Content (Syllabus outline):**
Pregled predmeta Predmet zagotavlja celovito razumevanje ocenjevanja kakovosti tal, procesov degradacije, metod in praktičnih tehnik za rehabilitacijo in remediacijo tal. Poudarja pristope, ki temeljijo na strokovnih temeljih, upravljanja onesnaženih ali degradiranih tal, pri čemer se opira na regulativne okvire in tehnološke inovacije. Učni načrt uravnava teoretična načela s študijami primerov, da bi študente pripravil na delo v okoljskem svetovanju, upravljanju zemljišč in regulativnih agencijah. **<u>Glavne teme:</u>** **Vsebina in učne teme (20-urna struktura predavanj)** **Modul 1: Kakovost in degradacija tal** (4 ure) Koncepti kakovosti/zdravja tal: fizikalni, kemijski in biološki kazalniki. Pomembni procesi degradacije: erozija, zbijanje, zasoljevanje, kontaminacija	**Subject Overview** This course provides an integrated understanding of soil quality assessment, degradation processes, and practical techniques for soil rehabilitation and remediation. It emphasizes evidence-based approaches to managing contaminated or degraded soils, drawing on regulatory frameworks and technological innovations. The curriculum balances theoretical principles with case studies to prepare students for careers in environmental consulting, land management, and regulatory agencies. **<u>Main topics:</u>** **Content and Teaching Topics (20-Hour Lecture Structure)** ***Module 1: Soil Quality and Degradation*** *(4 hours)* Concepts of soil quality/health: physical, chemical, biological indicators. Major degradation processes: erosion,

(anorganska/organska onesnaževala).
Uvod v okvire za spremljanje in ocenjevanje tal (npr. Strategija EU za tla, indeks zdravja tal USDA).
Modul 2: Kontaminacija tal in ocena okoljskih tveganj (4 ure)
Viri in usoda onesnaževal (težke kovine, naftni ogljikovodiki, pesticidi, nova onesnaževala).
Ocena tveganja za ljudi in okolje: poti izpostavljenosti, toksičnost, regulativni pragovi (npr. britanski CLEA, ameriški EPA RSL). Karakterizacija lokacije in načrtovanje vzorčenja.
Modul 3: Načela in tehnologije sanacije tal (6 ur)
Fizikalne metode: pranje tal, termična desorpcija, enkapsulacija.
Kemijske metode: stabilizacija/strjevanje, oksidacija/redukcija, elektrokinetika. Biološke metode: fitoremediacija, bioremediacija (in situ/ex situ). Izbira tehnologije na podlagi vrste onesnaževala, pogojev na lokaciji in meril trajnosti.
Modul 4: Sanacija in trajnostno upravljanje tal (4 ure)
Rekultivacija mestnih, industrijskih in izkopanih tal. Strategije za izboljšanje tal: organske snovi v tleh, biooglje, mikrobni inokulanti. Integracija s krožnim gospodarstvom: uporaba obdelanih tal, recikliranih dodatkov. Dolgoročno spremljanje in vrednotenje učinkovitosti.
Modul 5: Politike, regulativa in študije primerov (2 uri)
Regulatorni okviri: Direktiva EU o tleh
Študije primerov: Prenova degradiranih območij, obnova rudarskih območij, obnova kmetijskih tal.
Ekonomski in socialni vidiki: odgovornost, analiza stroškov in koristi, sodelovanje deležnikov.

compaction, salinization, contamination (inorganic/organic pollutants).
Introduction to soil monitoring and assessment frameworks (e.g., EU Soil Strategy, USDA Soil Health Index).
Module 2: Soil Contamination and Environmental Risk Assessment *(4 hours)*
Sources and fate of contaminants (heavy metals, petroleum hydrocarbons, pesticides, emerging contaminants).
Human and ecological risk assessment: exposure pathways, toxicity, regulatory thresholds (e.g., UK CLEA, US EPA RSLs).
Site characterization and sampling design.
Module 3: Remediation Principles and Technologies *(6 hours)*
Physical methods: soil washing, thermal desorption, encapsulation.
Chemical methods: stabilization/solidification, oxidation/reduction, electrokinetics.
Biological methods: phytoremediation, bioremediation (in situ/ex situ).
Technology selection based on contaminant type, site conditions, and sustainability criteria.
Module 4: Rehabilitation and Sustainable Management *(4 hours)*
Reclamation of urban, industrial, and mined soils.
Soil amendment strategies: soil organic matter, biochar, microbial inoculants.
Integration with circular economy: use of treated soils, recycled amendments.
Long-term monitoring and performance evaluation.
Module 5: Policy, Regulation and Case Studies *(2 hours)*
Regulatory frameworks: EU Soil Directive
Case studies: Brownfield redevelopment, mining site restoration, agricultural soil recovery.
Economic and social aspects: liability, cost-benefit analysis, stakeholder engagement.

Temeljna literatura in viri / Textbooks:

Obvezna / Required:

- Soil Pollution: A Hidden Reality, FAO (2018), ISBN: 978-92-5-130505-8 (Note: Comprehensive overview of global soil contamination)
- Remediation of Contaminated Sites, K. R. Reddy et al. (2019), DOI: 10.1201/9780429061238

- Soil Health and Climate Change, Editors: B. Singh et al. (2011), DOI: 10.1007/978-3-642-20256-8
- Phytoremediation: Management of Environmental Contaminants, Vol. 1–7, Editors: A. A. Ansari et al. (2015–2022), DOI: 10.1007/978-3-319-52381-1

Priporočena / Recommended:

- Biochar for Environmental Management: Science, Technology and Implementation, Editors: J. Lehmann, S. Joseph (2015), DOI: 10.4324/9780203762264
- Advances in Agronomy, Academic Press, "In Situ Remediation of Heavy Metal–Contaminated Soils" (2015)
- Environmental Chemistry of Soils, M. B. McBride (2023, 2nd ed.), ISBN: 978-0197659656
- Handbook of Soil Sciences, Editors: P. M. Huang et al. (2012), DOI: 10.1081/E-ESS

Cilji in kompetence:	**Objectives and competences:**
Predmetno specifični cilji in kompetence: **Cilji:** Opremiti študente s celovitim znanjem o ocenjevanju kakovosti tal, procesih degradacije in sodobnih tehnikah rehabilitacije/remediacije ; njihovo uposobljenje na poklicne vloge v okoljskem upravljanju in pri sanacijah onesnaženih/degradiranih zemljišč. **Specifične kompetence:** Sposobnost izbire in oblikovanja strategij sanacije; interpretacija podatkov o kakovosti tal; krmarjenje po regulativnih okvirih. **Splošne kompetence:** Kritična analiza problemov tal; uporaba znanstvenih načel v resničnih projektih sanacije.	**Objectives:** To equip students with integrated knowledge of soil quality assessment, degradation processes, and modern rehabilitation/remediation techniques, preparing them for professional roles in environmental management and contaminated/degraded land sectors. **Specific competences:** Ability to select and design remediation strategies; interpret soil quality data; navigate regulatory frameworks **General competences:** Critical analysis of soil problems; application of scientific principles to real-world remediation projects.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Mehanizmi degradacije tal; usoda onesnaževalcev v teh; bistvene metode in tehnologije sanacij tal. **Prenosljive/ključne spretnosti in drugi atributi:** Ocena tveganja, izbira tehnologije, vrednotenje trajnostnosti sanacij. Sposobnost komunikacij tehničnih rešitev; interdisciplinarno reševanje problemov pri upravljanju in sanacijah tal.	**Knowledge and understanding:** Mechanisms of soil degradation; contaminant fate; core remediation technologies. **Transferable/key skills and other attributes:** Risk assessment, technology selection, sustainability evaluation. Ability to communicate technical solutions; interdisciplinary problem-solving in soil management.

Metode poučevanja in učenja:	**Learning and teaching methods:**
<u>Oblike in metode poučevanja:</u> Predavanja z virtualnimi simulacijami (npr. modeliranje transporta onesnaževalcev). Gostujoča predavanja: strokovnjaki iz okoljskih agencij ali izvajalskih podjetij. Terenski obisk (neobvezno): Lokalno območje sanacije.	**<u>Forms and methods of teaching:</u>** Lectures with virtual simulations (e.g., contaminant transport modeling). Guest lectures: Practitioners from environmental agencies or consulting firms. Field visit (optional): Local remediation site.

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

Pogoj za pristop k izpitu: … Laboratorijske vaje in/ali terensko delo **Končna ocena pri predmetu je sestavljena iz:** Analiza študije primera (50 %) Pisni izpit (50 %). **Ocenjevalna lestvica:** ▪ zadostno 6: 55 - 65 % ▪ dobro 7: 68–75 % ▪ prav dobro 8: 76–83 % ▪ prav dobro 9: 84–90 % ▪ odlično 10: 91–100 %		**A prerequisite for access to the exam**: Laboratory work and/of Field work **Final evaluation consists of:** • Case study analysis (50%) • Written exam (50%). **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 kakovostnim projektorem, računalnikom s hitrim dostopom do spleta.
Osnovni laboratorij za analitiko tal.
terenska oprema za raziskave tal.

Material conditions for subject realization:

Lecture room with high-quality projector, computer with fast internet access.
Basic soil analysis laboratory.
Field equipment for soil research.

Obveznosti študentov:

Ustrezna prisotnost na predavanjih (>75 %).
Opravljene vaje.
Prisotnost na terenskih vajah, morebitnih terenskih ogledih dobrih praks.

Student's commitments:

Adequate attendance at lectures (>75%).
Completed exercises.
Attendance at field exercises, possible field visits to good practices.

Reference nosilca predmeta:

Pedagoško delo:

- 2021 - <sedaj> Fakulteta za varstvo okolja, Velenje, delovno mesto: izr.prof.dr. nosilec/univ. učitelj premeta Geokemija okolja
- 2021 - <sedaj> Fakulteta za varstvo okolja, Velenje, delovno mesto: izr.prof.dr. nosilec/univ. učitelj premeta Tla in okolje
- 2008 - 2020 Fakulteta za varstvo okolja, Velenje, delovno mesto: izr.prof.dr. nosilec/univ. učitelj premeta Raba in varstvo tal
- 2009 -2017 Univerza v Mariboru, Fakulteta za kmetijstvo in biosistemske vede, delovno mesto: doc. dr., profesor, nosilec /univ. učitelj premetov Pedologija, Ekopedologija ter Raba in varstvo tal
- 2015 - 2017 Univerza na Primorskem, Fakulteta za matematiko, naravoslovje in informacijske tehnologije, delovno mesto: doc. dr., profesor, nosilec /univ. učitelj premeta Pedologija in raba tal
- 1984 - 2005 Univerza v Ljubljani, Biotehniška fakulteta, Center za pedologijo in varstvo okolja, delovno mesto: asistent Pedologija in Ekopedologija.

Lecturer's references:

Teaching:

- 2021 - <present> Faculty of Environmental Protection, Velenje, Asoc. Prof., teaching Geochemistry of the environment.
- 2021 - <present> Faculty of Environmental Protection, Velenje, post: Assoc. Prof., univ.; teaching Soils and environment
- 2008 - 2020 Faculty of Environmental Protection, Velenje, post: Assoc. Prof., univ.; teaching Land use and soil protection course
- 2009 -2017 University of Maribor, Faculty of Agriculture and Life Sciences, Assist. Professor, subjects: Soil Science (Pedology), Ecopedology and Land use and soil protection
- 2015 - 2017 University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technology, post: assistant professor., teaching Soil Science and land use.
- 1984 - 2005 University of Ljubljana, Biotechnical Faculty, position: teaching assistant Pedology and Ecology.

Raziskovalno delo:

- 2005 - <sedaj> Kmetijski inštitut Slovenije, Oddelek za kmetijsko ekologijo in naravne vire, Center za tla in okolje, delovno mesto: - višji znanstveni sodelavec na domačih in mednarodnih projektih s področja tal in okolja; - predstojnik oddelka.
- 2003 - 2004 EC Joint Research Centre, Institute for Environment and Sustainability, Soil Action, Ispra, Italija, delovno mesto: visiting scientist/ gostujoči znanstvenik za področje tal/pedologije in informatike tal
- 1984 - 2005 Univerza v Ljubljani, Biotehniška fakulteta, Center za pedologijo in varstvo okolja, delovna mesta: asistent za področje pedologije in ekopedologije; raziskovalec na domačih ter FP5 in drugih mednarodnih projektih; vodja laboratorija za pedološko informatiko

Pomembnejša raziskovalna dela:

- Znanstvena monografija **Klasifikacija tal Slovenije 2025** (v tisku) www.springer.com/la/book/9789401785846)
- Znanstvena monografija **The Soils of Slovenia** (Springer Verlag www.springer.com/la/book/9789401785846)
- Monografija **Tla v okolju:** Lastnosti, pestrost in ekosistemske storitve tal www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/publikacije/tla_v_okolju.pdf
- Vrščaj in sod. Pesticide residues and heavy metals in vineyard soils of the Karst and Istria. DOI: 10.3390/land11122332
- Poggio in sod: Metals pollution and human bioaccessibility of topsoils in Grugliasco (Italy); DOI: 10.1016/j.envpol.2008.08.009
- VRŠČAJ, Borut. Strukturne spremembe kmetijskih zemljišč, njihova urbanizacija in kakovost v obdobju 2002-2007 = The structural changes of agricultural land, their quality and urbanization between 2002-2007. Hmeljarski bilten, ISSN 0350-0756. [Tiskana izd.], 2008, letn. 15, str. 73-84. [COBISS.SI-ID 2870632]
- VRŠČAJ, Borut, POGGIO, Laura, AJMONE MARSAN, Franco. A method for soil environmental quality evaluation for management and planning in urban areas. Landscape and urban planning, ISSN 0169-2046. [Print ed.], 2008, vol. 88, iss. 2, str. 81-94, doi: 10.1016/j.landurbanplan.2008.08.005. [COBISS.SI-ID 2783336],
- VRŠČAJ, Borut, VERNIK, Tomaž. The structural changes of agricultural land, their quality and process of urbanisation in Slovenia between 2002 and 2007. Local land & soil news : the bulletin of the European Land and Soil Alliance (ELSA) e. V., I/09, no. 28/29, str. 28-31. [COBISS.SI-ID 3006056]

Research work:

- 2005 - <now> Agricultural Institute of Slovenia, Department of Agricultural Ecology and Natural Resources, Center for Soil and Environment, post: - senior scientific assistant on domestic and international projects in the field of soil and the environment; - Head of Department.
- 2003 - 2004 EC Joint Research Center, Institute for Environment and Sustainability, Soil Action, Ispra, Italy, workplace: visiting scientist in the field of soil science and soil informatics
- 1984 - 2005 University of Ljubljana, Biotechnical Faculty, Pedology and Environmental Protection Center, jobs: Assistant in pedology and ecology; researcher at home and FP5 and other international projects; head of the laboratory for soil informatics

Significant research work:

- Monograph **Classification of Slovenina Soils 2025** (in print)
- Scientific monograph The Soils of Slovenia (Springer Verlag www.springer.com/la/book/9789401785846)
- Monography Soil in the environment: Properties, diversity and ecosystem services of the soil www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/publikacije/tla_v_okolju.pdf
- Vrščaj in sod. Pesticide residues and heavy metals in vineyard soils of the Karst and Istria. DOI: 10.3390/land11122332
- Poggio et al: Metals pollution and human bioaccessibility of topsoils in Grugliasco (Italy); DOI: 10.1016/j.envpol.2008.08.009
- VRŠČAJ, Borut. Structural changes of agricultural land, their urbanization and quality in the period 2002-2007 = The structural changes of agricultural land, their quality and urbanization between 2002-2007. Hopmine Bulletin, ISSN 0350-0756. [Printed Edition], 2008, year. 15, p. 73-84. [COBISS.SI-ID 2870632]
- VRŠČAJ, Borut, POGGIO, Laura, AJMONE MARSAN, Franco. A method for soil environmental quality assessment for management and planning in urban areas. Landscape and urban planning, ISSN 0169-2046. [Print ed.], 2008, vol. 88, iss. 2, p. 81-94, doi: 10.1016 / j.landurbanplan.2008.08.005. [COBISS.SI-ID 2783336],
- VRŠČAJ, Borut, VERNIK, Tomaž. Local land and soil news: the Bulletin of the European Land and Soil Alliance (ELSA) e. V., I / 09, no. 28/29, p. 28-31. [COBISS.SI-ID 3006056]

Professional work:

- VRŠČAJ, Borut. Tla ali prst? Contribution to discussions on the use of terms 'tla' and 'prst' in Slovene popular and professional terminology. Acta agriculturae Slovenica, ISSN 1581-9175.
- VRŠČAJ, Borut. Regulation and agricultural ecosystems. Packaging, environment, logistics: specialist spe-

Strokovno delo:

- VRŠČAJ, Borut. Tla ali prst? Prispevek k razpravam o rabi izrazov 'tla' in 'prst' v slovenskem poljudnem in strokovnem izrazoslovju. Acta agriculturae Slovenica, ISSN 1581-9175.
- VRŠČAJ, Borut. Uredba in kmetijski ekosistemi. Embalaža, okolje, logistika : strokovna specializirana revija za embalažo, okolje in logistiko, ISSN 1855-4849, avg. 2016
- VRŠČAJ, Borut. Varovanje kmetijskih zemljišč in racionalna raba prostora sta osnova trajnostnega razvoja. Kmečki glas, ISSN 0350-4093, 27. jan. 2010
- VRŠČAJ, Borut. Hrana bo ponovno strateško blago, zato so tudi rodovitna zemljišča strateška dobrina : varovanje kmetijskih zemljišč v okviru trajnostnega gospodarskega razvoja. Delo FT : gospodarsko-finančna priloga
- VRŠČAJ, Borut, POGGIO, Laura, AJMONE MARSAN, Franco. A method of soil quality evaluation for more sustainable urban planning = Eine Methode zur Bewertung von Bodenqualitäten für eine nachhaltigere räumliche Planung. V: Bodenbewertung : Vorsorgender Bodenschutz und kommunale Planung. München: Boden-Bündnis europäischer Städte, Kreise und Gemeinden. 2006, f. 52-55. [COBISS.SI-ID 2308456]

Izpopolnjevanja v tujini na področju tal

- 2002, delavnica FAO, Global Terrestrial Observing System, Praga
- 2001, EC Joint Research Centre, Soil Action, Ispra, Italija, študijski obisk
- 2000, United States Department of Agriculture, National Resource Conservation Service-
- USDA Cochran Fellowship (štipendija ameriškega ministrstva za kmetijstvo za področje informatike tal in talnih informacijskih sistemov. Štipendija je zajemala predvsem seznanjanje z US National Soil Information System (NASIS - Talni informacijski sistem ZDA)

Članstvo v pomembnejših nacionalnih komisijah

- 2006 Ministrstvo za obrambo RS, ekspertna skupina za oceno posledic suše v Sloveniji leta 2006.
- 2000: Vlada RS, Ekspertna skupina za izdelavo Dolgoročnega prostorskega plana Republike Slovenije - področje kmetijstva.

Sodelovanje v mednarodnih organizacijah:

- Predstavnik Slovenije v FAO/Global Soil Partnership - European Soil Partnership, Pillar 2 in Pilar 4
- 2014 – 2016 FAO Soil information consultant – Macedonian Soil Information System (MASIS)
- 2012 UNCCD 2nd Scientific Conference – UNCCD White Paper Working Group, član –(ISBN 978-92-95043-67-1)
- 2010 Digital Soil Mapping Working Group¸ EC Joint

cialized magazine for packaging, environment and logistics, ISSN 1855-4849, Aug. 2016

- VRŠČAJ, Borut. The protection of agricultural land and the rational use of space are the basis of sustainable development. Agricultural voice, ISSN 0350-4093, Jan 27. 2010
- VRŠČAJ, Borut. Food will be again strategic goods, so fertile land is also a strategic asset: the protection of agricultural land in the context of sustainable economic development. FT: economic and financial contribution
- VRŠČAJ, Borut, POGGIO, Laura, AJMONE MARSAN, Franco. A method of soil quality assessment for more sustainable urban planning = Eine Methode zur Bewertung von Bodenqualitäten für eine nachhaltigere räumliche Planung. V: Bodenbewertung: Vorsorgender Bodenschutz und kommunale Planung. Munich: Boden-Bündnis europäischer Städte, Kreise und Gemeinden. 2006, f. 52-55. [COBISS.SI-ID 2308456]

Training abroad in the field of soil science

- 2002, FAO workshop, Global Terrestrial Observing System, Prague
- 2001, EC Joint Research Center, Soil Action, Ispra, Italy, study visit
- 2000, United States Department of Agriculture, National Resource Conservation Service-
- USDA Cochran Fellowship (scholarship of the US Department of Agriculture for the field of informatics of the soil and floor information systems. The scholarship was mainly to familiarize with the US National Soil Information System (NASIS - US Information System)

Membership in major national commissions

- 2006 Ministry of Defense of the Republic of Slovenia, expert group for the assessment of the consequences of drought in Slovenia in 2006.
- 2000: Government of the Republic of Slovenia, Expert Group for the Preparation of the Long-Term Spatial Plan of the Republic of Slovenia - Agriculture.

Participation in international organizations:

- Representative of Slovenia in FAO / Global Soil Partnership - European Soil Partnership, Pillar 2 and Pilar 4
- 2014 - 2016 FAO Soil Information Consultant - Macedonian Soil Information System (MASIS)
- 2012 UNCCD 2nd Scientific Conference - UNCCD White Paper Working Group, Member - (ISBN 978-92-95043-67-1)
- 2010 Digital Soil Mapping Working Group, EC Joint Research Center, European Soil Bureau Network.
- 2010 European Soil Data Center and INSPIRE WG; EC Joint Research Center.

Membership and participation in national and international soil science organizations

- Soil Science Society of Slovenia, President

Research Centre, European Soil Bureau Network. ▪ 2010 European Soil Data Centre and INSPIRE WG; EC Joint Research Centre. **Članstva in sodelovanja v nacionalnih in mednarodnih pedoloških organizacijah** ▪ Pedološko društvo Slovenije, predsednik ▪ Slovensko partnerstvo za tla, član ustanovne skupine ▪ Alpine Soil Partnership, član ustanovne skupine ▪ EC Joint Research Centre European Soil Bureau Network: Technical Expert, član ▪ Global Soil Partnership, član International Union of Soil Sciences, član	▪ Slovenian Soil Partnership, member of the founding group ▪ Alpine Soil Partnership, a member of the founding group ▪ EC Joint Research Center European Soil Bureau Network: Technical Expert, member ▪ Global Soil Partnership, member International Union of Soil Sciences, member