| UČNI NAČRT PREDMETA / COURSE SYLLABUS | |
|---|---|
| **Predmet:** | Radioaktivnost in jedrske metode za študij procesov |
| **Course title:** | Radioactivity and Nuclear Methods for the Study of Processes |

| Študijski program in stopnja<br>Study programme and level | Študijska smer<br>Study field | Letnik<br>Academic year | Semester<br>Semester |
|---|---|---|---|
| Ekotehnologije, 3. stopnja | / | 1 | 1 |
| Ecotechnologies, 3rd cycle | / | 1 | 1 |

**Vrsta predmeta / Course type** Izbirni / Elective

**Univerzitetna koda predmeta / University course code:** EKO3-769

| Predavanja<br>Lectures | Seminar<br>Seminar | Vaje<br>Tutorial | Klinične vaje<br>work | Druge oblike študija | Samost. delo<br>Individ. work | ECTS |
|---|---|---|---|---|---|---|
| 15 | 15 | | | 15 | 105 | **5** |

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transferred to individual work.*

**Nosilec predmeta / Lecturer:**
Prof. dr. Borut Smodiš
Prof. dr. Janja Vaupotič
Doc. dr. Marko Štrok

**Jeziki / Languages:**
**Predavanja / Lectures:** slovenščina, angleščina / Slovenian, English
**Seminar:** angleščina / English

**Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**
Zaključen študij druge stopnje naravoslovne ali tehniške smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).

**Prerequisits:**
Completed second level studies in natural sciences or engineering or completed second level studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

**Vsebina:**
Uporaba radioaktivnih snovi in jedrskih metod:
- Radioaktivnost (viri ionizirajočih sevanj, interakcije ionizirajočih sevanj s snovjo, instrumentacija za detekcijo in meritve radioaktivnosti);
- Izpostavljenost človeka sevanju v naravi, v bivalnem in delovnem okolju;
- Jedrske analizne metode za študij procesov v okolju in tehnologijah;
- Uporaba radioaktivnih sledilcev za spremljanje procesov.

**Content (Syllabus outline):**
Applications of radioactivity and nuclear methods:
- Radioactivity (sources of ionising radiation, interactions of radiation with substance, radiation detection instruments and measurements);
- Human exposure to environmental and ambient radiation;
- Nuclear analytical methods for the study of processes in the environment and technologies;
- The use of radioactive tracers for monitoring processes.

**Temeljni literatura in viri / Readings:**

- M. F. L'Annunziata. Handbook of Radioactivity Analysis, 3rd Edition, Academic Press, 2012.
- G. F. Knoll. Radiation Detection and Measurements, 4th Edition, John Wiley & Sons, 2011.
- N. Tsoulfanidis, S. Landsberger. Measurement and Detection of Radiation, 3rd Edition, CRC Press, 2011.
- J. E. Martin. An Introduction to Radiation Protection, CRC Press 2012.
- D. A. Atwood. Radionuclides in the Environment, John Wiley & Sons, 2010.
- Neutron Generators for Analytical Purpose, Radiation Technology Reports Series No. 1, International Atomic Energy Agency, Vienna, 2012.
- Nuclear Techniques for Cultural Heritage Research, Radiation Technology Series No. 2, International Atomic Energy Agency, Vienna, 2011.
- Radiotracer Generators for Industrial Applications, Radiation Technology Series No. 5, International Atomic Energy Agency, Vienna, 2013.
- Commercial Products and Services of Research Reactors, TECDOC-1715, International Atomic Energy Agency, Vienna, 2013.
- Ciljani izbor znanstvenih objav. / Targeted selection of scientific publications.

**Cilji in kompetence:**

Cilj predmeta je poglobiti poznavanje ionizirajočih sevanj in seznanitev z uporabo jedrskih metod za študij procesov.

Cilj se navezuje na kompetence:

- Obvladovanje metod in tehnik znanstvenega raziskovanja ionizirajočih sevanj;
- Sposobnost za samostojno in skupinsko raziskovalno delo na akademski ravni;
- Sposobnost uporabe znanja v praksi;
- Razvoj komunikacijskih sposobnosti in spretnosti, s poudarkom na med-disciplinarnem sodelovanju v mednarodnem okolju.

**Objectives and competences:**

The objective of the course is to deepen knowledge on ionising radiation and acquaintance with applications of nuclear methods for studying processes.

This objective is related to the competences:

- Mastering of methods and techniques of scientific research of ionising radiations;
- Ability to carry out both individual and team research work at the academic level;
- Ability to use the knowledge in practice;
- Development of communicative abilities and skills, with emphasis on multi-disciplinary cooperation at international level.

**Predvideni študijski rezultati (Izidi):**

- Poznati in razumeti radioaktivnost in ionizirajoča sevanja.
- Pojasniti radiološke učinke in posledice vpliva posameznih vrst ionizirajočega sevanja na živa bitja.
- Načrtovati zaščito pred ionizirajočimi sevanji in izračunati obsevne doze za izbrane praktične primere.
- Uporabiti jedrske metode za izbrane aplikacije.
- Izbrati ustrezne jedrske tehnike za ugotavljanje industrijskih onesnažil ter za spremljanje procesov pri uvajanju novih tehnologij.
- Vzpostaviti sposobnost komunikacije v angleškem jeziku na področju radioaktivnosti in jedrskih metod.

**Intended learning outcomes:**

- Know and understand radioactivity and ionising radiations.
- Explain radiological effects of particular types of ionising radiation on biota.
- Plan protection against ionising radiation and calculate exposure doses for selected practical cases.
- Apply of nuclear methods for selected applications.
- Select appropriate nuclear techniques for the determination of industrial pollutants and for monitoring processes during implementation of new technologies.
- Establish the ability to communicate in English in the field of radioactivity and nuclear methods.

| Metode poučevanja in učenja: | Learning and teaching methods: |
|---|---|
| Predavanja.<br>Seminar.<br>Vključevanje v projekte za reševanje izbranih problemov.<br>Priprava seminarske predstavitve. | Lectures.<br>Seminar work.<br>Participation in projects for solving selected problems.<br>Preparation of the seminar presentation. |

| Načini ocenjevanja: | Delež (v %) / Weight (in %) | Assessment: |
|---|---|---|
| Seminarska naloga.<br>Zagovor seminarske naloge, pri katerem študent dokaže osvojitev vseh študijskih izidov z vsaj po enim konkretnim primerom. | 50 %<br>50 % | Seminar work.<br>Defence of the seminar work where the student demonstrates the achievement of all learning outcomes with at least one specific case for each outcome. |

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


- SMODIŠ, Borut. Thirty years of $k_0$-NAA at JSI, Ljubljana : implementation, progress, achievements. Journal of radioanalytical and nuclear chemistry, ISSN 0236-5731, 2018, vol. 315, str. 685-688, doi: 10.1007/s10967-017-5633-z.
- ŠTROK, Marko, SMODIŠ, Borut, MAZEJ, Darja. Bi-210 - from interference to advantage in Pb-210 determination with liquid scintillation counter, Applied radiation and isotopes, ISSN 0969-8043, 2016, vol. 109, str. 296-300, doi: 10.1016/j.apradiso.2015.12.049.
- SMODIŠ, Borut, ČERNE, Marko, JAĆIMOVIĆ, Radojko, BENEDIK, Ljudmila. Transfer of uranium and radium to Chinese cabbage from soil containing elevated levels of natural radionuclides. Journal of radioanalytical and nuclear chemistry, ISSN 0236-5731, 2015, vol. 306, iss. 3, str. 685-694, doi: 10.1007/s10967-015-4198-y.
- SMODIŠ, Borut, BUČAR, Tinkara, JAĆIMOVIĆ, Radojko. Comparison of different approaches to estimate uncertainty budget in $k_0$-INAA measurement. Journal of radioanalytical and nuclear chemistry, ISSN 0236-5731, 2014, vol. 300, issue 2, str. 573-579, doi: 10.1007/s10967-014-3066-5.
- ŠTROK, Marko, SMODIŠ, Borut, PETRINEC, Branko, FRANIĆ, Zdenko. Correcting for potential Rn-222 loss in Pb-210 dating of sediments from the South Adriatic Pit. Quaternary geochronology, ISSN 1871-1014, 2013, vol. 18, str. 93-98, doi: 10.1016/j.quageo.2013.06.002.