

COURSE DESCRIPTION

Detection of Chemical Pollutants Using Advanced Analytical Techniques

Academic year 2026-2027

1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University Cluj-Napoca
1.2. Faculty	Faculty of Environmental Science and Engineering
1.3. Department	Environmental Analysis and Engineering
1.4. Field	Environmental Engineering
1.5. Level of study	Master's Degree
1.6. Degree programme / Qualification	Sustainable Development and Environmental Management / master
1.7. Form of education	Full-time

2. Course-related data

2.1. Course title	Detection of Chemical Pollutants Using Advanced Analytical Techniques			Course code	NME 4111
2.2. Course coordinator	Dr. Bocoş-Binţinţan Victor, Assoc. Prof. (Habil.)				
2.3. Seminar coordinator	Dr. Bocoş-Binţinţan Victor, Assoc. Prof. (Habil.)				
2.4. Year of study	III	2.5. Semester	6	2.6. Type of assessment	Exam
2.7. Course status	Compulsory			2.8. Course type	Specialisation subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	4	of which: 3.2. course	2	3.3. seminar/ laboratory/ project	2
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	28
Time allocation for individual study (IS) and self-taught activities (ST)					hours
Learning from textbooks, course materials, bibliography, and notes (IS)					20
Additional research in the library, on subject-specific electronic platforms, and on-site					15
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					25
Tutoring (professional guidance)					3
Other activities [i.e.: two-way communication with the course coordinator/tutor]					2
3.7. Total hours of individual study (IS) and self-taught activities (ST)				65	
3.8. Examinations				4	
3.9. Total hours per semester				125	
3.10. Number of credits				5	

4. Prerequisites (where applicable)

4.1. curriculum-related	<ul style="list-style-type: none"> Promoting disciplines in the chemistry and physics category is recommended, with special emphasis onto environmental & instrumental analytical chemistry.
4.2 skills-related	<ul style="list-style-type: none"> Cognitive skills: possession of basic acquisitions in the fields of analytical chemistry. Action skills: information and documentation, group work, argumentation and use of information technologies for acquisition + processing of analytical data; carrying out active and critical analyses; operationalization and application of knowledge. Affective-attitudinal skills: availability to be involved in the teaching process, in an active and interactive manner; availability to carry out experiments.

5. Specific conditions (where applicable)

5.1. course-related	Classroom, equipped with computer, video projector and multi-media system.
5.2. seminar/laboratory-related	Laboratory equipped with adequate analytical instrumentation (i.e., photoionization detectors PID & ion mobility spectrometers IMS)

	and systems for preparation of standard atmospheres.
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6.1. Competencies resulting from the completion of the degree programme (as referred to in the curriculum)¹

Professional competencies	
Competency code	Competency
PC 4	Investigate pollution
PC 10	Test samples for pollutants
PC 11	Manage air quality
PC 12	Perform scientific research
Transversal competencies	
Competency code	Competency
TC 1	Think analytically
TC 3	Report on environmental issues

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)²

Learning outcomes targeted by the subject		
Competency code	Knowledge and comprehension	Specific academic skills
PC 4 PC 10 PC 11 PC 12 TC 1	4. The student/graduate identifies and describes advanced analytical techniques for the detection and quantification of chemical pollutants, as well as methods for sampling, preparation and analysis of environmental samples.	4. The student/graduate applies advanced analytical techniques for measuring pollutant concentrations in environmental samples. The student/graduate selects appropriate sampling and analysis methods depending on the type of sample and contaminant. The student/graduate interprets analytical results in the context of environmental quality assessment.
TC 3	10. The student/graduate describes the stages of the scientific research process and of carrying out an applied research project in the field of environmental engineering.	10. The student/graduate actively participates in research and professional practice processes, documenting activities and results. The student/graduate applies integrated theoretical and practical knowledge in solving complex environmental problems. The student/graduate formulates research questions, applies appropriate methodologies and draws well-founded conclusions.

¹ The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

² The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. Student knows and comprehends the essential theoretical and practical notions related to advanced analytical techniques – fast, ultra-high-performance and “green” – used to investigate environmental quality, which are those based on vapor ionization at atmospheric pressure: photoionization-based detection (PID) + ion mobility spectrometry (IMS), with highly relevant applicability in protecting environmental quality and health.
2. Student knows and comprehends the basic concepts and principles for operation of chemical sensors.
3. Student knows and comprehends the particular importance of measuring low concentration levels of chemical compounds / pollutants present in various environmental samples, with maximum emphasis on hazardous & toxic chemical compounds.
Specific academic skills
1. Student will be able to use advanced analytical techniques for the detection of traces of chemical compounds (PID and IMS), in order to perform rapid qualitative & quantitative determinations of pollutants / compounds in the environment, at trace & ultra-trace levels, in accordance with concrete situations and available resources.
2. Student will be able to effectively use the methods of processing the analytical information obtained, and then to adequately interpret these information.
3. Student will be able to correctly calibrate & validate PID & IMS instrumentation, by preparing standard atmospheres with very low concentrations of target analyte.
4. Student will be able to measure very low concentration levels – at trace (parts per million ppm _v) and ultra-trace (parts per billion ppb _v) levels of chemical compounds present in the environment – with a focus on hazardous & toxic ones.

8. Contents

8.1. Course	Teaching and learning methods	Remarks³
<p>This course introduces a set of most relevant & proven advanced analytical techniques based onto ionization of target chemicals at atmospheric pressure – PID and IMS – that are widely used in the investigation of environmental samples. The course is structured on a set of modules, which correspond to the main themes of the course. These modules have as a common denominator the target of the educational approach, namely the rapid detection of chemical compounds in the air at very low concentration levels – of the order of ppm_v (traces) and ppb_v (ultra-traces).</p> <p>Both basic terminology (absolutely necessary as a starting point), as well as reasoning and examples (useful for deepening and understanding concrete issues) are provided. For increased accessibility, a large number of figures, schematics and tables were used, which facilitate a good grasp of the major impact that sensors have in general and in the control/monitoring of the environment in particular.</p> <p>By the type and multitude of information involved, this course is characterized by a high degree of inter-disciplinarity and trans-disciplinarity, as it includes & integrates various complex information from the fields of chemistry, physics, electronics, etc.</p> <p style="text-align: center;">CONTENT:</p> <p>MODULE 1. <u>Analytical techniques used in the detection of chemical pollutants at trace levels</u> – Necessity and general concepts. Low concentrations in the case of chemical compounds present in the air. [2 hours]</p>	<p>Interactive lecture</p> <p>Demonstration</p> <p>Problem-based learning</p> <p>Problematization</p> <p>Exercises and problem solving</p>	<p>Attendance at the course is optional, but highly recommended.</p> <p>Attendance at applied activities and seminars is mandatory. The number of absences accepted in special situations is a maximum of 20% of the total number of hours.</p> <p>Students who have >20% absences at the seminar / laboratory cannot present for the examination.</p>

³ For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

<p>MODULE 2. <u>Methods for calibrating detection instrumentation at ultra-trace levels</u>. Preparation of standard atmospheres with low concentrations of target compounds: static methods; dynamic methods; method based on exponential dilution. [6 hours]</p>	<p>Case studies presentation</p>	<p>Individual projects / laboratory papers will be handed to the course instructor before the exam / colloquium.</p>
<p>MODULE 3. Advanced Analytical Techniques Based on Analyte Vapor Ionization at Atmospheric Pressure – Part 1. Photoionization Detection (PID). PID Theory and Instrumentation. Applications of Photoionization Detectors. [8 hours]</p>	<p>Heuristic conversation</p>	<p>Plagiarism involves the cancellation of the work developed by the student.</p>
<p>MODULE 4. Advanced Analytical Techniques Based on Analyte Vapor Ionization at Atmospheric Pressure – Part 2. Ion Mobility Spectrometry (IMS). Fundamental concepts and instrumentation. Atmospheric pressure ionization & methods for improving selectivity by using alternative ionization chemistries (“dopants”). Qualitative and quantitative information derived from ion mobility spectra. Applications of Ion Mobility Spectrometry – with emphasis on environmental protection, bio-medical, and security applications. [12 hours]</p>	<p>Explanation Modeling</p>	<p>Cases of exam fraud involve: automatic exclusion from the exam, awarding a grade of 1 and expelling the student from university.</p>
<p><i>TOTAL: 28 hours / semester (2 hours / week × 14 weeks).</i></p>		

Bibliography

Course Support – is available in PDF format, is available at the FSEE library on CD and is sent to students by email.

a) Mandatory Bibliography:

1. **Course Support** – Assoc. Prof. Dr. Bocoş-Bințișan Victor.
2. Victor Bocoş-Bințișan, „*Tehnici moderne în analiza de ultraurme, cu impact în igiena industrială, protecția mediului și aplicații de securitate*”, 2004, 250 p., Editura Presa Universitară Clujeană, Cluj-Napoca, ISBN 973-610-243-2, 250 pp.
3. Gary A. Eiceman; Zeev Karpas, „*Ion Mobility Spectrometry*” (Second Edition), 2005, 366 p., Taylor and Francis Group, CRC Press, Boca Raton, FL, USA.
4. Campbell, M. (Ed.), „*Sensor Systems for Environmental Monitoring – Volume One: Sensor Technologies*”, Springer Verlag, 1st Edition, 1997.
5. Campbell, M. (Ed.), „*Sensor Systems for Environmental Monitoring – Volume Two: Environmental Monitoring*”, Springer Verlag, 1st Edition, 1997.
6. James P. Lodge, Jr. (Editor), „*Methods of Air Sampling and Analysis*” (Third Edition), 1988, 763 p., Taylor and Francis Group, CRC Press, Boca Raton, FL, USA.
7. Robert E. Henderson, „*Portable Gas Detectors Used in Confined Space and Other Industrial Atmospheric Monitoring Programs*”, 2006, 88 p., Technical Report, RAE Systems Inc., Sunnyvale, CA, USA.

b) Supplementary Bibliography:

1. RAE Systems Inc., *Technical Reports & Application Notes collection*, company website: www.raesystems.eu/AppTech_Notes.
2. Jack Cazes (Ed.), „*Ewing’s Analytical Instrumentation Handbook*” (Third Edition), 2005, 1037 p., Marcel Dekker, New York, USA.
3. Hobart H. Willard, Lynne L. Merritt, Jr., John A. Dean, Frank A. Settle, Jr., „*Instrumental Methods of Analysis*” (Seventh Edition), 1988, 895 p., Wadsworth Publishing Company, Belmont, CA, USA.
4. Gary A. Eiceman, „*Advances in Ion Mobility Spectrometry*”, *Critical Reviews in Analytical Chemistry*, 1991, 22, 17-36.
5. Jörg Ingo Baumbach; Gary A. Eiceman, „*Ion Mobility Spectrometry: Arriving On Site and Moving Beyond a Low Profile*”, *Applied Spectroscopy*, 1999, 53(9), 338A-353A.

Access locations: Central University Library of BBU; Library of the Faculty of Environmental Science and Engineering Library; Personal library of Dr. Victor Bocoş-Bințișan.

8.2. Seminar/ laboratory	Teaching and learning methods	Remarks
<p>Content:</p> <p>L #1: Calibration of trace & ultra-trace detection instrumentation: Part 1. Generation of standard atmospheres. Construction of vapor sources and standard atmosphere preparation facilities; their correct use. [2 hours]</p> <p>L #2: Calibration of trace & ultra-trace detection instrumentation: Part 2. Calibration of a PID (photoionization-based detector) instrument with volatile organic compounds. [4 hours]</p> <p>L #3: <u>Demonstration experiment</u>: Determination of vapors of a volatile organic compound (VOC) in air using a PID (photoionization-based) detector – Part 1: Rapid monitoring of soil contamination with petroleum hydrocarbons with a PID photoionization detector, using headspace analysis. [4 hours]</p> <p>L #4: <u>Demonstration experiment</u>: Rapid, real-time determination of volatile organic compound (VOC) vapors in air using a PID photoionization detector – Part 2: Studying the dispersion of organic solvent vapors in the air of a room. [4 hours]</p> <p>L #5: <u>Demonstration experiment</u>: Rapid, real-time determination of volatile organic compound (VOC) vapors in air using a PID photoionization detector – Part 3: Differentiation of various fruits by determining the total concentration of photoionizable compounds emitted by them. [4 hours]</p> <p>L #6: <u>Demonstration experiment</u>: Rapid and ultra-sensitive determination of some chemical compounds in air using classical (time-of-flight) IMS ion mobility spectrometry. Processing of the experimental data obtained (by interpreting ion mobility spectra) – calculation of drift velocity, reduced ion mobility and resolution. [6 hours]</p> <p>L #7: <u>Demonstration experiment</u>: Rapid detection of organic compound vapors in air using IMS aspiration ion mobility spectrometry (a-IMS). [4 hours]</p> <p><i>TOTAL: 28 hours / semester (2 hours/week × 14 weeks).</i></p>	<p>Problem-based learning</p> <p>Experiments</p> <p>Problematization</p> <p>Exercises and problem solving</p> <p>Heuristic conversation</p> <p>Explication</p> <p>Modeling</p> <p>Case studies</p>	<p>Attendance at applied activities and seminars is mandatory. The number of absences accepted in special situations is a maximum of 20% of the total number of hours.</p> <p>Students who have >20% absences at the seminar / laboratory cannot present for the examination.</p> <p>Individual projects / laboratory papers will be handed to the course instructor before the exam / colloquium.</p>
<p>Bibliography:</p> <p>Similar to that provided in 8.1</p>		

9. Evaluation



















Type of activity	9.1 Evaluation criteria ⁴	9.2 Evaluation methods ⁵	9.3 Percentage in the final grade
9.4. Course	Correctness of answers to theoretical and practical problems, within the exam.	Exam (written – 2 hours) – access to the examination is strictly conditioned upon	75%

⁴ The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

⁵ Both final evaluation methods and ongoing evaluation strategies should be established.

	Ability to identify problems & situations with critical status.	attendance of at least 80% of seminar sessions. Attempted fraud during the examination is penalized by removal from the examination. Fraud during the examination is penalized by expulsion from university, in accordance with UBB ECTS regulations.	
9.5. Seminar/ laboratory	Correctness of answers – correct acquisition and understanding of the issues addressed in the seminar & laboratory.	Grading of active participation in solving seminar problems.	25%
	Ability to solve problems and integrate the acquisitions acquired in the study of this discipline with the acquisitions of related disciplines.	Preparation & submission of all laboratory papers.	
9.6 Minimum standard for passing			
<ul style="list-style-type: none"> Final grade: 5 (five) as a minimum grade for passing. Attendance: minimum 80% in seminar/laboratory classes. 			

10. SDG labels (Sustainable Development Goals)⁶

	<input type="radio"/>	Sustainable Development Generic Label						
								
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
								No label applies
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Date of entry:
20.04.2026

Signature of course coordinator



Signature of seminar coordinator



Date of approval in the department:

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Signature of the head of department

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⁶ Select a single label which, according to the [Implementation of SDG labels in the academic process](#), best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: "No label applies."