COURSE OUTLINE

1. COURSE INFORMATION

SCHOOL	Technical University of Crete		
DEPARTMENT	Mineral Resources Engineering		
COURSE LEVEL	Graduate		
COURSE ID		**SEMESTER**	Spring
COURSE TITLE	Modern Technologies for the Near-Zero Waste Processing of Low-Grade Primary Ores and Secondary Raw Materials		

COURSE MODULES *in the case of credits being awarded in distinct parts of the course eg. Lectures, Laboratory Exercises, etc. If credit units are awarded uniformly for the whole course, indicate the weekly hours of teaching and the total number of credits.*	**INSTRUCTION HOURS PER WEEK**	**CREDITS**
Lectures	3	
Laboratories		
Tutorial Exercises		
Total	3	6
Add rows if needed. The teaching organization and teaching methods used are described in detail in (4).		

COURSE TYPE *Background, General Knowledge, Scientific Area, Skills Development*	Core elective
PREREQUISITES:	Knowledge of Inorganic Chemistry, Mineralogy, Ore processing, Extractive metallurgy, Waste management, Social aspects
INSTRUCTION/EXAM LANGUAGE:	English
THE COURSE IS OFFERED TO ERASMUS STUDENTS:	Yes
COURSE URL:	EURECA PRO LMS Moodle URL: https://moodle.eurecapro.tuc.gr/course/view.php?id=76

2. LEARNING OUTCOMES

Learning Outcomes

The learning outcomes of the course describe the specific knowledge, skills and competences of an appropriate level that students will acquire after successfully completing the course.

Refer to Appendix A.

- *Description of the Level of Learning Outcomes for each course of study in line with the European Higher Education Area Qualifications Framework*
- *Descriptive Indicators of Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Annex B*
- *Learning Outcomes Writing Guide*

After completing this course, the student will be able to:

- ✓ Carry out literature review, assess the State of the Art (SoA) in this field and identify innovative technologies
- ✓ Perform basic analyses for each ore / waste type and decide which are the most appropriate treatment technologies
- ✓ Design relevant flowsheets for treatment technologies and carry out mass balance calculations
- ✓ Define the most appropriate ranges of the operating parameters
- ✓ Carry out basic tecno-economic analysis
- ✓ Assess the potential toxicity of the wastes (solids and liquids) and select appropriate waste

management technologies
- ✓ Identify options for the valorization of wastes
- ✓ Do project work, also using PBL, as member of a team
- ✓ Respect the natural environment and contribute towards reaching the respective sustainable development goals (SDGs)

General Competencies/Skills

Considering the general competencies that the graduate must have acquired (as listed in the Diploma Supplement and below), which one(s) the course enhances?

Search, analysis and synthesis of data and information, using the necessary technologies	*Project design and management*
Adaptation to new situations	*Respect for diversity and multiculturalism*
Decision making	*Respect for the natural environment*
Autonomous work	*Demonstration of social, professional and moral responsibility and sensitivity to gender issues*
Teamwork	*Exercise criticism and self-criticism*
Working in an international environment	*Promoting free, creative and inductive thinking*
Working in an interdisciplinary environment	
Production of new research ideas	

Search, analysis and synthesis of data and information
Assessment of the State of the Art (SoA)
Technology assessment (economic, environmental, social)
Assessment of the progress beyond the SoA
Decision making
Teamwork
Working in an interdisciplinary environment
Production of new research ideas
Identify relevant SGDs and Technology Readiness Levels (TRLs)

3. COURSE SYLLABUS

Content

Lecture 1: Evolution of metal production and waste recycling towards a zero-waste approach
Lecture 2: Considerations on ore grades and available low-grade materials - technical aspects
Lectures 3-4: Mineral processing (fundamentals, including case studies)
Lectures 5-7: Metal extraction (SoA, innovation in pyrometallurgical processes, atmospheric and heap leaching, bioleaching, other extraction processes)
Lectures 8: Metal recovery (fundamentals, innovations)
Lecture 9-10: Residue valorization (as construction materials, cements and binders (supplementary cementitious materials, alkali-activated materials))
Lecture 11: Economic sustainability, environmental and safety impact
Lectures 12-13: Social aspects in mining / metallurgical projects

4. TEACHING and LEARNING METHODS – ASSESSMENT

LECTURE METHOD *Face to face, distance learning, etc.*	Face to face, distant learning and PBL: the presence of students in all lectures is obligatory
USE OF INFORMATION AND COMMUNICATION TECHNOLOGY *Use of ICT in Teaching, in Laboratory Exercises, in Communication with students*	Microsoft Excel and Microsoft Powerpoint will be used during classes and project implementation.

TEACHING ORGANISATION *Describe in detail the way and methods of teaching.* *Lectures, Seminars, Laboratory Exercise, Field Exercise, Literature review & analysis, Tutoring, Practice (Placement), Clinical Exercise, Artistic Lab, Interactive teaching, Educational visits, Project work, project, etc.* *The student's study hours for each learning activity and the hours of non-guided study according to the ECTS principles are mentioned.*	***ACTIVITY***	***Workload per semester (in Hours)***
	Lectures	26
	Tutorials	
	Lab assignments	
	Projects	26
	Autonomous study	98
	Course Total (25 hours' workload/ECTS credit)	***150***
ASSESSMENT METHODS *Description of the evaluation process* *Assessment Language, Assessment Methods, Formative or Concluding, Multiple Choice Test, Short Answer Questions, Essay Development Questions, Problem Solving, Written Assignment, Essay / Report, Oral Exam, Public Presentation, Laboratory Assignment, Clinical Examination of Patients, Artistic Interpretation, Other* *Well defined student assessment criteria are mentioned. Mention whether and how the students can access them.*	2 Projects per student (involving teamwork) through PBL. 20' presentation with a ppt file, Q&A: 60% A research article in a relevant topic will be prepared by each student. A ~3 page summary and ppt presentation will be prepared, involving critical analysis of the topic: 40%	

5. DIGITIZATION (use of tools & software)

Students are required to do calculations in Microsoft Excel spreadsheets (mass balance, economic and energy indicators etc) using the relevant tools and also prepare ppt presentations.

6. RECOMMENDED INTERNATIONAL LITERATURE

Ore / Waste Treatment

1. Komnitsas, K., Petrakis, E., O. Pantelaki, A. Kritikaki (2018). Column leaching of Greek low-grade limonitic laterites, Minerals, *Minerals*, 8(9):377; https://doi.org/10.3390/min8090377
2. Mystrioti, C., Papassiopi, N., Xenidis, A., Komnitsas, K. (2018). Counter-current leaching of low-grade laterites with the use of hydrochloric acid and proposed purification options of pregnant solution, *Minerals*, 8:599; https://doi.org/10.3390/min8120599
3. Komnitsas, K., Petrakis, E., Bartzas, G., Karmali, V. (2019). Column leaching of low-grade saprolitic laterites and valorization of leaching residues, *Science of the Total Environment*, 665:347-357 https://doi.org/10.1016/j.scitotenv.2019.01.381
4. Spooren, J., Breemersch, K., Dams, Y., Mäkinen, J., Lopez, M., González-Moya, M., Tripiana, M., Pontikes, Y., Kurylak, W., Pietek, G., Komnitsas, K., Binnemans, K., Varia, J., Horckmans, L., Yurramendi, L., Snellings, R., Peys, A., Onisei, S., Björkmalm, J., Willquist, K., Kinnunen, P. (2020). Near-zero-waste processing of low-grade, complex primary and secondary ores: challenges and opportunities, *Resources, Conservation and Recycling*, 160:104919, https://doi.org/10.1016/j.resconrec.2020.104919
5. Komnitsas, K., Bartzas, G., Petrakis, E. (2023). A novel and greener sequential column leaching approach for the treatment of two different Greek laterites, *Science of the Total Environment*,

854, 158748, http://dx.doi.org/10.1016/j.scitotenv.2022.158748

Waste Valorization

6. Komnitsas, K., D. Zaharaki, V. Perdikatsis (2007). Geopolymerisation of low calcium ferronickel slags, *Journal of Materials Science*, 42(9), 3073-3082, http://dx.doi.org/ 10.1007/s10853-006-0529-2
7. Komnitsas, K., Zaharaki, D., V. Perdikatsis, (2009). Effect of synthesis parameters on the compressive strength of low-calcium ferronickel slag inorganic polymers, *Journal of Hazardous Materials*, 161:760-768, http://dx.doi.org/10.1016/j.jhazmat.2008.04.055
8. Zaharaki, D., K. Komnitsas, V. Perdikatsis (2010). Use of analytical techniques for identification of inorganic polymer gel composition, *Journal of Materials Science*, 45(10):2715-2724, http://dx.doi.org/10.1007/s10853-010-4257-2
9. Komnitsas, K. (2011). Potential of geopolymer technology towards green buildings and sustainable cities, *Procedia Engineering*, 21: 1023-1032, http://dx.doi.org/10.1016/j.proeng.2011.11.2108
10. Komnitsas, K., Zaharaki, D., Vlachou, A., Bartzas, G., Galetakis, M. (2015). Effect of synthesis parameters on the quality of construction and demolition wastes (CDW) geopolymers, *Advanced Powder Technology* 26(2):368-76, http://dx.doi.org/10.1016/j.apt.2014.11.012
11. Komnitsas, K., Bartzas, G., Karmali, V., Petrakis, E., Kurylak, W., Pietek, G., Kanasiewicz, J. (2019). Assessment of alkali activation potential of a Polish ferronickel slag, *Sustainability*, 11:1863, https://doi.org/10.3390/su11071863
12. Petrakis, E., Karmali, V., Bartzas, G., Komnitsas, K. (2019). Grinding kinetics of slag and effect of final particle size on the compressive strength of alkali activated materials, *Minerals*, 9:714, doi:10.3390/min9110714
13. Komnitsas K., Bartzas, G., Karmali, V., Petrakis, E. (2021). Factors Affecting Alkali Activation of Laterite Acid Leaching Residues, *Environments*, 8, 4, https://doi.org/10.3390/environments8010004
14. Karmali, V., Petrakis, E., Bartzas, G., Komnitsas, K. (2022). Valorization Potential of Polish Laterite Leaching Residues through Alkali Activation. *Minerals*, 12(11), 1466, https://doi.org/10.3390/min12111466

Environmental topics

15. Xenidis, A., N. Papassiopi, **K. Komnitsas** (2003). Carbonate rich mine tailings in Lavrion: Risk assessment and proposed rehabilitation schemes, *Advances in Environmental Research*, 7(2), 207-222, http://dx.doi.org/10.1016/S1093-0191(02)00017-5
16. Triantafyllidis S., Skarpelis N., **Komnitsas K.** (2007). Environmental characterisation of the Kirki (NE Greece) flotation tailings, *Environmental Forensics*, 8(4), 351-359, http://dx.doi.org/10.1080/15275920701729688
17. **Komnitsas, K.**, K. Manousaki, D. Zaharaki (2009). Assessment of reactivity of sulphidic tailings and river sludges, *Geochemistry: Exploration, Environment, Analysis*, 9(4):313-318, http://dx.doi.org/10.1144/1467-7873/09-198
18. **Komnitsas, K.**, Pyliotis, I., Zaharaki, D., Manoutsoglou, E. (2015). Using various guidelines and approaches for the assessment of marine sediment quality, *Environmental Forensics*, 16:109-116, http://dx.doi.org/10.1080/15275922.2014.991006

19. Bartzas, G., **Komnitsas, K.** (2015). Life cycle assessment of FeNi production in Greece: A case study, *Resources Conservation and Recycling*, 105:113-122, http://dx.doi.org/10.1016/j.resconrec.2015.10.016

20. **Komnitsas, K.**, Zaharaki, D., Bartzas, G., Kaliakatsou, G., Kritikaki, A. (2016). Efficiency of pecan shells and sawdust biochar on Pb and Cu adsorption, *Desalination and Water Treatment*, 57(7): 3237-46, http://dx.doi.org/10.1080/19443994.2014.981227

21. Kritikaki, A., Zaharaki, A., **Komnitsas, K**. (2016). Valorization of industrial wastes for the production of glass ceramics, *Waste and Biomass Valorization*, 7(4):885-898, http://dx.doi.org/10.1007/s12649-016-9480-x

22. Bartzas, G., **Komnitsas, K.** (2017). Life cycle analysis of pistachio production in Greece, *Science of the Total Environment*, 595:13-24, http://dx.doi.org/10.1016/j.scitotenv.2017.03.251

23. Ekman Nilsson, A., Macias Aragones, M., Royo, F., Dunon, V., Oorts, K., Angel, H., **Komnitsas, K.**, Willquist, K. (2017). A Review of the Carbon footprint of Cu and Zn production from primary and secondary sources, *Minerals*, 7:168, https://doi.org/10.3390/min7090168

24. **Komnitsas, K.**, Zaharaki, D., Bartzas, G., Alevizos, G. (2017). Adsorption of scandium and neodymium on biochar derived after low-temperature pyrolysis of sawdust, *Minerals*, 7:200, https://doi.org/10.3390/min7100200

25. **Komnitsas, K.**, Yurramendi, L., Bartzas, G., Karmali, V., Petrakis, E. (2020). Factors affecting co-valorization of fayalitic and ferronickel slags for the production of alkali activated materials, *Science of the Total Environment*, 721:137753, https://doi.org/10.1016/j.scitotenv.2020.137753

Social Aspects

26. **Komnitsas, K.** (2020). Social License to Operate in Mining. Present views and future trends, *Resources* 2020, 9:79, doi:10.3390/resources9060079

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