Environmental isotopes in hydrogeological and hydrogeochemical studies: fundamentals and applications

- COURSE SYLLABUS

1.	**Course title:** ***Environmental isotopes in hydrogeological and hydrogeochemical studies: fundamentals and applications***	
2.	**Lecturers:** *Dr Adam Porowski – ING PAN*	
3.	**Field, type and level of studies, year of study:** *Hydrogeology, geochemistry, geology, groundwater – full-time doctoral studies, all years*	
4.	**Course character:** *Monographic lecture*	
5.	**Teaching method:** ***ONLINE** (interactive contact with lecturers in real time)*	
6.	**Language:**	*English*
7.	**Course type and number of hours:** *Lecture (15h), The lectures will take place every Tuesday from 10:00 to 11:00 AM, starting on October 16th, 2025.*	
8.	**Estimated load of student's independent work:**	**10 h**
9.	**Total workload and number of ECTS points:**	**1 ECTS**
10.	**Short description and main focus of the course:** *The lecture aims to familiarize students with basis of isotope hydrogeology and application of selected environmental isotopes in hydrogeological and hydrogeochemical research. Hydrogeology is defined as the study of groundwater, encompassing its origin, occurrence, movement in geological environment and interactions with rocks and surface water.The analysis of the Oxygen and Hydrogen isotopic composition of water molecules is a very fundamental tool for discovering the origin of all the marine and terrestrial waters, their circulation pathways in geological environment, mixing patterns, residence times, water-rock interaction and chemical evolution, etc. About 50% of the total volume of groundwater occurs in the strata below 1 km depth, where saline waters and brines dominate. Mining activities, oil and gas exploration and exploitation, the use of geothermal energy, and of therapeutic mineral waters, are examples for human activities of growing up economic relevance that come into touch with various types of groundwater of different chemical*	

	compositions and origins. Investigation and explanation of hydrogeology of such waters, their origin, geochemistry, and interaction with shallow fresh waters has a great scientific and socioeconomic significance and always is strongly linked with determination of isotopic composition of water molecules and selected compounds dissolved in water. *The proposed lecture will cover the following areas and issues: (a) introduction to isotope hydrogeology, (b) basis of environmental isotopes geochemistry in aquatic environment, (c) fundamentals of isotope fractionation: O and H isotope fractionation in hydrological cycle and formation of isotopic composition of terrestrial waters, (d) overview of genetic types of groundwaters, (e) factors affecting isotopic composition of waters and dissolved compounds: tracking bio-geo-chemical processes, (f) groundwater sampling and preparation techniques for isotope analysis, (g) application of isotopic methods in science and industry – author's case studies: copper mines, oil industry, bottling water industry.*	
11.	**References:** • *Zuber A., Różański K., Ciężkowski W. (eds.), 2007. Metody znacznikowe w badaniach hydrogeologicznych. Poradnik metodyczny. Wydawnictwa Politechniki Wrocławskiej, Wrocław, 402 s.* • *Porowski A., 2014. Isotope hydrogeology (chapter 17). W: Eslamian S. (ed.), Handbook of Engineering Hydrology. Fundamentals and applications. Vol. 1, Taylor & Francis Group, USA, 345-378* • *Balderer W., Porowski A., Idris H., LaMoreaux J. (eds), 2014. Thermal and Mineral Waters: Origin, Properties, Applications. Springer, 125 p.* • *Porowski A. (2019) Mineral and Thermal Waters. In: LaMoreaux J. (ed.) Environmental Geology. Encyclopedia of Sustainability Science and Technology Series. Springer, New York, NY. pp. 149-181* • *Porowski A., Romanova A., Gebus-Czupyt B., Radzikowska M. Wach B. (2021) Stable hydrogen and oxygen isotopic composition of bottled waters in Poland: Characterization in the context of different market categories and implications for the origin authentication and natural isotopic quality preservation. Journal of Geochemical Exploration 220: 106684* • *Clark I., Fritz P, 1997. Environmental Isotopes in Hydrogeology. Lewis Publishers, Boca Raton, USA, 328 s.* • *Cook P., Herczeg A.G., 2000. Environmental Tracers in Subsurface Hydrogeology. Kluwer Academic Publishers, USA, 529 s. (selected issues).*	
12.	**Prerequisites:** *Knowledge of radiochemistry, sedimentology, environmental geochemistry, radioecology*	
13.	**Educational outcomes:**	**PQF level 8 codes:**
	Knowledge: *After completing the course a student:* *- knows a basis of isotope hydrogeology;* *- has a general knowledge in the area of geochemistry of environmental isotopes of O, H, C, S, N;* *- understands isotope fractionation processes in water-rock and aquatic systems;* *- is familiarized with fundamental bio-geo-chemical processes affecting isotopic composition of water and selected dissolved compounds;*	*P8S_WG*
	Practical Skills: *After completing the course a student:* *- is able to design a sampling campaign of groundwater for*	*P8S_UW, P8S_UU*

	isotopic analyses; *- knows how to make basic sample preparation required in the field;* *-is able to chose proper sample preparation techniques and analytical methods in collaboration with isotope laboratory;*	
	Social Skills: *After completing the course a student:* *- is aware of the possibilities of application of environmental isotopes in hydrogeology and aquatic geochemistry;* *- is able to design basic research with application of isotopic methods in the field of environmental studies;*	*P8S_KK*
14.	**Evaluation of the educational outcomes:** *attendance at lectures; student's commitment during the classes, discussions during lecture*	
15.	**Criteria to complete the course:** *Minimum 80% of attendance (passed / failed)*	
16.	**Contact with the course leader/lecturer:** *adamp@twarda.pan.pl; personal meeting (Institute of Geological Sciences, Polish Academy of Sciences, Research Center in Warsaw, Twarda 51/55, 00-818 Warsaw) are possible upon earlier agreements;*	