	title/topics	hours	Lecture/ Exercise
I	**Introduction to LSC and its application to NORM measurements**	**3**	
1	General information about NORM: definitions and terminology, natural radionuclides importance and sources of NORM, sequential decay and disequilibrium in natural decay series	2	L
2	General information about LSC: background, history, applications	1	L
II	**Basics of radiochemistry: analytical method used in separation of natural radionuclides**	**3**	
1	Sample digestion and dissolution	1	L
2	Ion exchange procedure and extraction chromatography used in radiochemistry	1	L
3	Coprecipitation techniques with different carriers. Methods employed in radioactive sources preparation.	1	L
III	**Radiochemical procedure of radium isotopes separation and test sample preparation for LSC**	**17x2**	
1	Radium in environmental samples - procedure	1	L
2	Radium in environmental samples - chemical separation, practical exercises	14	E
3	Radium source preparation for LS counting, practical exercises	2	E
IV	**Radium determination by means of LSC**	**4**	
1	Special set up of LS spectrometer Wallac Quantulus for radium determination: anticoincidence guard, alpha/beta discrimination, PSA optimization, counter calibration, double window method	2	E/L
2	Radium spectra analysis, correction coefficients quantification, quenching correction	1	E/L
3	Calculation: radium isotopes concentration, uncertainty budget, detection limit	1	E/L
V	**Fundamentals of alpha spectrometric analysis**	**3**	
1	Major parts of alpha spectrometers, characterization of the detectors	1.5	L

2	Radiochemical separations, source preparation for alpha spectrometry	1.5	L
VI	**Determination of 210Pb by LSC and 210Po by alpha-particle spectrometry: preparations**	**3**	
1	Introduction to the applied analytical method for measurements of 210Pb and 210Po in NORMs	2	L
2	Preparation of the samples, use of radioactive tracer 209Po and lead carrier	1	E
VII	**Radiochemical procedure: separation of lead (Pb) and polonium (Po) from matrix components and each other**	**6**	
1	Separation of Pb and Po by extraction chromatography	2	E
2	Preparation of Pb source for LSC measurement, determination of chemical recovery by gravimetry	2	E
3	Po alpha source preparation (spontaneous deposition on silver disc)	1.5	E
4	Starting counting of the sources by LSC and alpha spectrometry, respectively	0.5	
VIII	**Setting up the spectrometers**	**3**	
1	Calibration of the LSC (counting efficiency and quench) using 210Pb calibration source	1.5	E
2	Calibration of the alpha spectrometer (counting efficiency and geometry) using calibration sources	1.5	E
IX	**Data transfer, calculations**	**3**	
1	Calculations I: activity concentration of 210Pb isotope, determination of lead recovery, establishing uncertainty budget, performance characteristics (decision threshold, detection limit)	1.5	E/L
2	Calculations II: activity concentration of 210Po, determination of polonium recovery, establishing uncertainty budget, performance characteristics (decision threshold, detection limit)	1.5	E/L
X	**Uranium measurements by alpha-particle spectrometry: preparations (Day-1)**	**3**	
1	Introduction of the hands-on training and the applied analytical method for uranium measurements in NORMs	2	L
2	Preparation of laboratory, forming groups, distributing samples	1	E
XI	**Radiochemical procedure: sample preparation and separation of natural radionuclides and matrix components**	**7x2**	

1	Sample preparation (U-232 tracer weighing and spiking, dissolution, preconcentration of U isotopes, centrifuging)	1	E
2	Separation of uranium from natural radionuclides and matrix elements by extraction chromatography	3	E
3	Uranium alpha source preparation (evaporation, source treatment)	2	E
4	Laboratory clean-up, contamination prevention	1	L/E
XII	**Setting up alpha spectrometer**	**2**	
1	Determination of detector resolution (Full Width at Half Maximum) and counting efficiencies using calibration sources	1	E
2	Setting up measurement parameters (detector source distance, data acquisition time) and starting data acquisition (duration: 12-18 hours, overnight)	1	E
XIII	**Data transfer, calculations and quality assurance (Day-2)**	**3**	
1	Uranium alpha spectrum analysis: region of interest (ROI), resolution (FWHM), counting efficiency, peak-tailing	1	E/L
2	Calculations: massic activity of uranium isotopes, determination of uranium recovery, establishing uncertainty budget, performance characteristics (limit of detection, limit of quantification etc.)	1	E/L
3	Quality assurance and feedback	1	L