

Contents

Compilation of the Analytical Methods	4
1. Methodology of Liquid Scintillation	6
1.1. The Scintillation Process	6
1.2. Instrumentation	8
1.3. Calibration and Standardization	10
1.3.1. Counting Efficiency	10
1.3.2. Quenching	11
1.3.3. Quench Correction	14
1.3.4. Recording a Quench Correction Curve	16
1.4. Methods	18
1.4.1. Dual Labeled Samples	18
1.4.2. Cerenkov Counting	20
1.5. Separation of α - and β - γ -radiation	21
1.5.1. Pulse Shape Discrimination PSD	23
1.5.2. Parameters and Their Influences	25
1.5.3. α/β -PSD with the Mobile Triathler System	31
1.6. Plastic Scintillators Using Microspheres	33
2. Fundamentals of Solvent Extraction	35
2.1. Theoretical Considerations	35
2.2. Extraction Behavior of Natural Radionuclides	38
2.2.1. Solvent Extraction of Radon	38
2.2.2. Solvent Extraction of Radium	38
2.2.3. Solvent Extraction of Uranium	38

3. Natural Radionuclides and Their Importance for Radiation Exposure	40
3.1. Radon	42
3.2. Radium	43
3.2.1. ^{226}Ra and Progenies	43
3.2.2. ^{228}Ra and Progenies	44
3.3. Uranium and Others	45
4. Analytical Part and Method Development	46
4.1. Goal and Motivation	46
4.1.1. Gross α Measurements	46
4.2. Radon Analysis	48
4.2.1. Radon in Air	48
4.2.2. Radon in Water	52
4.3. Radium in Water	57
4.3.1. Determination through ^{222}Rn	58
4.3.2. Enrichment by Exchange Methods	59
4.3.3. Determination by Extractive Scintillators (RADAEX)	61
4.3.4. Enrichment on Radium RAD Disk Filter	63
4.4. Uranium and Others	70
4.4.1. Uranium	70
4.4.2. Lead and Polonium	76
4.5. Fast Method for the Determination of Key Nuclides in Drinking and Mineral Water	78
4.6. Tritium and Radiocarbon	79
4.6.1. Tritium in Water	79
4.6.2. Tritium in Off-gas	80
4.6.3. Radiocarbon in Off-gas	81
4.6.4. Tritium and Radiocarbon in Biological Samples	82
4.7. Electron Capture Nuclides in Decommissioning Activities by TDCR	84

5. Quality Assurance	86
5.1. Uncertainty Budget in LS Spectrometry	86
5.2. Method Evaluation and Validation	89
5.2.1. Definition of the Lower Limit of Detection	89
5.2.2. In-vial Extraction for ^{226}Ra	89
5.2.3. ^{226}Ra by RAD Disk Filter	91
6. Method Comparison and Discussion	94
7. Literature	98
Annex 1: Abbreviations	108
Annex 2: List of Figures and Tables	109