

Contents

1	Sampling for the Analysis of Soil and Plant Sample Materials . . .	1
1.1	Soil	1
1.1.1	Soil Sampling	1
1.1.2	Soil Preparation for the Analysis and Determination of Metals	2
1.1.3	Extraction of Inorganic Substances from Soil	3
1.1.4	Extraction of Organic Substances from Soils	6
1.2	Plants and Crops	18
1.2.1	Plant and Crop Sampling	18
1.2.2	Preparation of Plant Extracts	20
	References	20
2	Determination of Metals in Soils	27
2.1	Actinides	27
2.2	Aluminium	27
2.3	Ammonium	28
2.4	Antimony	29
2.5	Arsenic	30
2.6	Barium	33
2.7	Beryllium	33
2.8	Bismuth	33
2.9	Cadmium	33
2.10	Caesium	36
2.11	Calcium	37
2.12	Cerium	38
2.13	Chromium	39
2.14	Cobalt	40
2.15	Copper	40
2.16	Curium	41
2.17	Europium	41
2.18	Hafnium	41
2.19	Indium	41
2.20	Iridium	41
2.21	Iron	41

2.22	Lanthanum	42
2.23	Lead	42
2.24	Magnesium	44
2.25	Manganese	44
2.26	Mercury	45
2.27	Molybdenum	47
2.28	Nickel	49
2.29	Palladium	49
2.30	Platinum	50
2.31	Plutonium and Americium	50
2.32	Potassium	50
2.33	Rubidium	50
2.34	Scandium	50
2.35	Selenium	51
2.36	Silver	55
2.37	Sodium	55
2.38	Strontium	55
2.39	Thullium	55
2.40	Tantalum	56
2.41	Technetium	56
2.42	Tellurium	56
2.43	Terbium	56
2.44	Thallium	56
2.45	Thorium	57
2.46	Tin	57
2.47	Titanium	57
2.48	Tungsten	57
2.49	Uranium	58
2.50	Vanadium	59
2.51	Yttrium	59
2.52	Zinc	60
2.53	Zirconium	60
2.54	Selective Extraction of Metal Ions Associated with Humic Acid from Soil	60
2.54.1	Extraction with Aqueous Reagents	60
2.55	Multi-Metal Analysis of Soils	65
	References	70
3	Determination of Radioactive Elements in Soil	79
3.1	¹³⁷ Caesium	79
3.2	¹²⁷ Iodine and ¹²⁹ Iodine	79
3.3	⁶³ Nickel	79
3.4	²¹⁰ Polonium	79
3.5	²²⁶ Radium	79

3.6	⁸⁹ Strontium and ⁹⁰ Strontium	80
3.7	⁹⁹ Techneium	81
3.8	Transuranic Elements	82
3.8.1	Americium	82
3.8.2	Californium	82
3.8.3	Neptunium	82
3.8.4	Plutonium	82
3.8.5	Uranium	84
	References	86
4	Determination of Organic Compounds in Soils	89
4.1	Aliphatic Hydrocarbons	89
4.2	Aromatic Hydrocarbons	91
4.3	Polycyclic Aromatic Hydrocarbons [PAH]	92
4.4	Heteropolycyclic Hydrocarbonyl [NSO]	96
4.5	Oils and Greases	97
4.6	Polystyrene	97
4.7	Phenols	97
4.8	Alcohols, Ketones, Aldehydes and Organic Acids	98
4.9	Volatile Organic Compounds	99
4.10	Chloroaliphatic Hydrocarbons	101
4.11	Chloroaromatic Hydrocarbons	103
4.12	Polychlorophenols	104
4.13	Polychlorobiphenyls	105
4.14	Polychlorodibenzo- <i>p</i> -dioxins and Polychlorodibenzofurans	108
4.15	Trifluoroacetic Acid	109
4.16	Compounds Containing Nitrogen, Sulfur and Phosphorus	110
4.16.1	Nitrogen Compounds	110
4.16.1.1	Aromatic Amines	110
4.16.2	Sulfur Compounds	112
4.16.3	Phosphorus Compounds	112
4.17	Miscellaeous Organic Compounds	112
4.17.1	Flame Retardants	112
4.17.2	Humic and Fulvic Acids	113
4.17.3	Mestranol	114
4.17.4	Enteroviruses and Antibacterial Agents	114
4.17.5	Miscellaneous	114
4.18	Insecticides and Pesticides	115
4.18.1	Chlorinated Insecticides	115
4.18.2	Carbamate Insecticides	117
4.18.3	Organophosphorus Insecticides	118
4.18.4	Miscellaneous Insecticides	118
4.19	Herbicides	119
4.19.1	Carbamate Type	119

4.19.2	Substituted Urea Types	119
4.19.3	Sulfonylurea Type	121
4.19.4	Triazine Type	121
4.19.5	Phenoxyacetic Acid Type	124
4.19.6	Imidazolinones	126
4.19.7	Pre-emergent Pesticides	127
4.19.8	Miscellaneous Insecticides/Herbicides	131
4.20	Fungicides	131
4.21	Soil Fumigants	131
	References	132
5	Determination of Organometallic Compounds in Soils	147
5.1	Organoarsenic Compounds	147
5.2	Organolead Compounds	148
5.3	Organomercury Compounds	149
5.4	Organotin Compounds	150
	References	151
6	Determination of Anions in Soil	153
6.1	Arsenate/Arsenite	153
6.2	Borate	153
6.3	Bromide	155
6.4	Carbonate	156
6.5	Chlorate	156
6.6	Chloride	156
6.7	Chromate	158
6.8	Cyanide	158
6.9	Iodide	158
6.10	Manganate	158
6.11	Molybdate	158
6.12	Nitrate	158
6.13	Nitrite and Nitrate	163
6.14	Nitric Oxide and Nitrous Oxide	164
6.15	Phosphate	165
6.16	Selenite	165
6.17	Sulfate	165
6.18	Sulfide and Other Sulfur Functions	167
6.19	Thallate	170
6.20	Tungstate	170
6.21	Uranate	170
6.22	Vanadate	170
6.23	Multiple Anions	170
	References	171

7	Determination of Cations in Plant Materials, Vegetables and Fruit	175
7.1	Aluminium	175
7.2	Antimony	175
7.3	Arsenic	175
7.4	Barium	175
7.5	Beryllium	175
7.6	Bismuth	175
7.7	Cadmium	176
7.8	Calcium	176
7.9	Chromium	176
7.10	Cobalt	176
7.11	Copper	176
7.12	Germanium	177
7.13	Gold	177
7.14	Iron	177
7.15	Lead	178
7.16	Magnesium	180
7.17	Manganese	180
7.18	Mercury	181
7.19	Molybdenum	186
7.20	Nickel	188
7.21	Potassium	189
7.22	Rubidium	189
7.23	Ruthenium	189
7.24	Selenium	190
7.25	Sodium	192
7.26	Strontium	192
7.27	Tellurium	192
7.28	Thallium	192
7.29	Tin	192
7.30	Titanium	193
7.31	Uranium	193
7.32	Vanadium	193
7.33	Zinc	193
7.34	Multi-Cation Analysis	193
7.34.1	Atomic Absorption Spectrometry (AAS)	194
7.34.2	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	204
7.34.3	Spectrophotometry	208
7.34.4	Polarography	209
7.34.5	Gas Chromatography	210
7.34.6	Neutron Activation Analysis	210
7.34.7	X-Ray Fluorescence Spectroscopy (XFS)	211
	References	212

8	Determination of Organic Compounds in Plant Materials, Vegetables and Fruit	217
8.1	Carboxylic Acids and Ethers	217
8.2	2,4-Dichlorophenol	217
8.3	<i>N</i> -Nitroso Compounds	217
8.4	Thiabendazole and <i>S</i> -Methylmethionine	218
8.5	Miscellaneous Organic Compounds	219
8.6	Mycotoxins	219
8.6.1	Liquid Chromatography (LC)	219
8.6.2	Thin-Layer Chromatography (TLC)	221
8.6.3	Supercritical Fluid Extraction (SCFE)–Direct Fluid Injection Mass Spectrometry (DFI–MS)	221
8.6.4	Differential Pulse Polarography (DPP)	221
8.6.5	High-Performance Liquid Chromatography with Laser Fluorometric Detection	222
8.7	Volatile Organic Compounds	223
8.7.1	Volatiles in Plant Materials	223
8.7.2	Volatiles in Fruit and Vegetables	224
8.7.3	Volatiles in Grains	225
8.8	Insecticides and Pesticides	225
8.8.1	Plant Materials	225
8.8.2	Fruit and Vegetables	226
8.8.3	Grains and Cereals	230
8.9	Herbicides in Plant Materials, Vegetables and Grain	236
8.10	Fungicides in Vegetables, Fruit and Grain	236
8.11	Growth Regulators	241
	References	241
9	Determination of Organometallic Compounds in Plants and Crops	247
9.1	Organomercury Compounds	247
9.2	Organotin Compounds	247
	References	248
10	Determination of Anions in Plants and Crops	249
10.1	Borate	249
10.2	Bromate	250
10.3	Bromide	250
10.4	Chloride	250
10.5	Cyanide	251
10.6	Fluoride	251
10.7	Nitrate and Nitrite	252
10.8	Phosphate	253
10.9	Sulfate	253

Contents		XIII
10.10	Vanadate	253
10.11	Multi-Anion Analysis	254
	References	255
11	Contaminant Contents of Soil and Crops	257
	References	261
Subject Index	263