## Mapping the Chemical Environment of Urban Areas

Editors
 Christopher C. Johnson
 Alecos Demetriades
 Juan Locutura
 Rolf Tore Ottesen



## **Contents**

Fore Ack	Contributors Foreword Acknowledgements Abbreviations and Acronyms	
PAR	RT 1: GENERAL ASPECTS AND METHODOLOGIES	
1	Introduction References	<b>1</b>
2	Urban Geochemical Mapping: A Review of Case Studies in this Volume 2.1 Introduction 2.2 Methodologies and strategies for urban sampling 2.3 Chemical analysis 2.4 Quality control	<b>7</b> 7 9 14 17
	<ul> <li>2.5 Interpreting and presenting the results</li> <li>2.6 Legislation</li> <li>2.7 Communication</li> <li>2.8 Future trends</li> <li>References</li> </ul>	17 21 24 24
3	Sample Preparation and Inorganic Analysis for Urban Geochemical Survey Soil and	
	Sediment Samples	28
	3.1 Introduction	28
	3.2 Field sample preservation 3.3 Physical sample preparation	30 30
	3.4 Determination of bulk properties	35
	3.5 Analytical sample preparation	36
	3.6 Instrumental analysis for inorganic analytes	40
	3.7 Application of quality assurance	43
	3.8 Health and safety issues References	43 44
4	Organic Analysis for Urban Geochemical Survey Soil Samples	47
	4.1 Introduction	47
	4.2 Field sample preservation	48 49
	4.3 Organic sample preparation 4.4 Instrumental analysis for organic analytes	49 53
	4.5 Application of quality assurance/quality control	55
	References	56
5	Understanding the Quality of Chemical Data from the Urban Environment –	
	Part 1: Quality Control Procedures	61
	5.1 Introduction	61
	5.2 Preparing for quality control	62
	<ul><li>5.3 Operational aspects of quality control</li><li>5.4 Assessing data quality</li></ul>	66 67

	5.5 Data storage	71
	5.6 Concluding remarks	73
	Acknowledgements	74
	References	74
c	Understanding the Quality of Chemical Data from the Urban Environment – Part 2: Measurement	
6	Uncertainty in the Decision-Making Process	77
	· · · · · · · · · · · · · · · · · · ·	
	6.1 Introduction	77 79
	6.2 Estimation of uncertainty due to sampling and analysis	79 81
	6.3 Practical detection limit and analytical precision	83
	6.4 Limitations of the geochemical data set: quality and reliability	84
	6.5 Effects of uncertainty and probabilistic risk assessment maps	86
	6.6 Worked examples	93
	6.7 Probabilistic risk assessment mapping using kriging	95
	6.8 Discussion and conclusions	96
	Acknowledgements References	96
7	Data Analysis for Urban Geochemical Data	99
	7.1 Introduction	99
	7.2 Preparations for data analysis	100
	7.3 Urban geochemistry of Berlin	101
	7.4 Conclusions	114
	References	114
8	Sources of Anthropogenic Contaminants in the Urban Environment	116
U	8.1 Introduction	116
	*	117
	8.2 Heavy metals 8.3 Gaseous pollutants	119
	8.4 Organic compounds	121
	8.5 Discussion and conclusions	123
	References	124
_	to Policificated Pickers (PCPs)	
	uilding Materials: An Important Source for Polychlorinated Biphenyls (PCBs)	128
	n Urban Soils	
	9.1 Introduction	128
	9.2 What are PCBs?	129
	9.3 PCBs in the urban environment: levels and concerns	131
	9.4 Discussion: the road ahead	132 133
	References	133
10	Children, Soils, and Health: How Do Polluted Soils Influence Children's Health?	134
	10.1 Introduction	134
	10.2 Sources of arsenic, lead, BaP and PCB in urban soils	136
	10.3 Exposure, uptake and health effects	141
	10.4 Discussion and conclusions	144
	References	147
11	Hazard and Exposure Assessment in Contaminated Land Investigations	
11	and Environmental Management	151
		151
	11.1 Introduction	151
	11.2 Site conceptual model	152
	11.3 Hazard and exposure assessment	156
	11.4 Environmental management	163
	11.5 Risk perception and communication	167
	11.6 Discussion and conclusions	168
	11.7 Recommendations References	170

12	Regulation and Administration of Soil Pollution in Trondheim, Norway: Development of	
	Awareness, Land Use-Specific Criteria and Local Disposal Facilities	173
	12.1 Introduction	173
	12.2 Raising awareness of soil pollution in site development	174
	12.3 Increasing predictability	178
	12.4 Increasing disposal and storage facilities	180
	12.5 Conclusions	183
	References	184
PAR	T 2: CASE STUDIES	
13	Soil Geochemical Baselines in UK Urban Centres: The G-BASE Project	186
	13.1 Introduction	186
	13.2 G-BASE urban geochemistry methods	189
	13.3 Results	192
	13.4 Discussion of G-BASE urban geochemical data	194 203
	13.5 Conclusions Acknowledgements	203
	References	204
14	Geochemical Baseline Levels and Suggested Local Guideline Values in Urban Areas in Sweden	207
	14.1 Introduction	207
	14.2 Methods	208
	14.3 Study area description	211
	14.4 Results	211
	14.5 Discussion and conclusions	217
	References	221
15	Using Geochemical Baselines in the Assessment of Soil Contamination in Finland	223
	15.1 Introduction	223
	15.2 Geochemical baselines in the assessment procedure	223
	15.3 Data producers and the national database	224 227
	15.4 Example: geochemical baseline data from the Pirkanmaa region and a study site 15.5 Conclusions	229
	Acknowledgements	229
	References	230
16	The Scale of an Urban Contamination Footprint: Results from a Transect through Oslo, Norway	232
	16.1 Introduction	232
	16.2 Sampling and analytical methods	236
	16.3 Results	237
	16.4 Conclusions References	242 243
17	Urban Geochemistry of Berlin, Germany	245
1/		245
	17.1 Introduction 17.2 Geology and hydrogeology	245
	17.3 Soils	246
	17.4 Land use in Berlin	247
	17.5 Material and methods	247
	17.6 Results and discussion	249
	17.7 Conclusions	262
	References	267
18		
	Area in Sachsen-Anhalt, Germany	269
	18.1 Introduction	269
	18.2 Site conditions	270

	18.3 Regional geology 18.4 Soil properties 18.5 Materials and methods 18.6 Results and discussion 18.7 Discussion and conclusions References	272 274 274 276 305 305
19	Systematic Urban Geochemistry of Madrid, Spain, Based on Soils and Dust	307
19	19.1 Introduction	
	19.2 Methods	307 310
	19.3 Results and discussion	315
	19.4 Conclusions	343
	Acknowledgements References	346 347
20	Urban Geochemistry of Tallinn (Estonia): Major and Trace-Elements Distribution in Topsoil	348
	20.1 Introduction	348
	20.2 Methods of sampling and analysis	351
	20.3 Results	352
	20.4 Conclusions	360
	Acknowledgements References	361 361
21	Geochemical and Ecological Survey of the Prague City Area, Czech Republic	364
	21.1 Introduction	364
	21.2 Materials and methods	365
	21.3 Results and discussion 21.4 Conclusions	368 373
	References	374
22	Geochemical Mapping of Ljubljana Urban and Suburban Area, Slovenia	375
	22.1 Introduction	375
	22.2 Study area	375
	22.3 Materials and methods	378
	22.4 Results and discusion 22.5 Conclusions	380 390
	References	390
23	Geochemical Characteristics of Lithuanian Urban Areas	393
	23.1 Introduction	393
	23.2 History of geochemical investigations	393
	23.3 Application of results for health-risk assessment	397
	23.4 Discussion of results 23.5 Conclusions	399 406
	References	406
24	Advancements in Urban Geochemical Mapping of the Naples Metropolitan Area:	
	Colour Composite Maps and Results from an Urban Brownfield Site	410
	24.1 Introduction	410
	24.2 Study area	411
	24.3 Soils	412
	24.4 Methods	412
	24.5 Results and discussion 24.6 Conclusions	415 421
	Acknowledgements	421
	References	422

25	The Lavrion Urban Geochemistry Study, Hellas	424
	25.1 Introduction	424
	25.2 Historical review	427
	25.3 Sampling and sample preparation	428
	25.4 Laboratory analysis	429
	25.5 Distribution of lead in parent rocks	434
	25.6 Metallurgical processing wastes	436
	25.7 Distribution of lead in overburden	441
	25.8 Distribution of lead in-house-dust	444
	25.9 Lead levels in child blood and teeth	445
	25.10 Geochemistry of groundwater	446
	25.11 Discussion	448
	25.12 Conclusions and recommendations	450
	Acknowledgements	451
	References	452
26	Polycyclic Aromatic Hydrocarbons in Urban Surface Soil in Oslo, Bergen and Trondheim,	
	Norway: PAH <sub>16</sub> levels, Compositions and Ratios	457
	26.1 Introduction	457
	26.2 Materials and methods	461
	26.3 Results and discussion	461
	26.4 Conclusions	470
	Acknowledgements	471
	References	471
27	Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (PCDDs/PCDFs) in Urban	.=-
	Surface Soil in Norway	473
	27.1 Introduction	473
	27.2 Areas investigated with an industrial past and present	474
	27.3 Sampling and analytical methods	476
	27.4 Results	477
	27.5 Interpretation and discussion	477
	27.6 Conclusions	483
	Acknowledgements	484
	References	484
28	Soil Contamination in the Urban Area of Belgrade, Serbia	487
	28.1 Geography	487
	28.2 Legal and institutional framework for soil management	487
	28.3 Availability of soil information for local soil protection	488
	28.4 Soil monitoring	490
	28.5 Presentation of soil pollution data	492
	28.6 Engineering geology in the service of environmental protection: Geological Institute of Serbia	493
	28.7 Reporting requirements	493
	28.8 Concluding remarks	495
	References	495
20	Classic Call of Child Care Continue and Bubble Blaumannide. An Imperitant Bout of Naminula	
29	Clean Soil at Child-Care Centres and Public Playgrounds – An Important Part of Norway's Chemical Policy	497
	•	
	29.1 Introduction	497
	29.2 Survey area	498 499
	29.3 Materials and methods	504
	29.4 Health-risk evaluation	504
	29.5 Results and comments	505
	29.6 Discussion 29.7 Conclusions	518
	References	518

30	Geochemical Mapping of the Denver, Colorado (USA) Urban Area: A Comparison of Studies in 1972 and 2005	521
	<ul> <li>30.1 Introduction</li> <li>30.2 Study area</li> <li>30.3 Sample design</li> <li>30.4 Sample preparation and chemical analysis</li> </ul>	521 521 522 523 525
	30.5 Results and discussion 30.6 Conclusions Acknowledgements References	527 542 543 543
31	Geochemical Characterization of Soil and Sediments of the City of Beira, Mozambique:	
	A Preliminary Approach	547
	31.1 Introduction	547
	31.2 Study area	548
	31.3 Materials and methods	551
	31.4 Results	555
	31.5 Discussion 31.6 Conclusions	564
	Acknowledgements	567
	References	568 568
32	Urban Geochemical Mapping in Nigeria with Some Examples From Southern Nigeria	570
	32.1 Introduction	570
	32.2 Review of urban mapping in Nigeria	571
	32.3 Methods used in urban geochemical mapping in Nigeria	574
	32.4 Urban geochemical mapping in Nigeria: The way forward References	578
	References	579
33	Geochemical Mapping of Trace Metal Pollutants in Urban Soils of Hong Kong	581
	33.1 Introduction	581
	33.2 Materials and methods	582
	33.3 Results and discussion 33.4 Conclusions	584
	Acknowledgements	590
	References	590 590
Inde	≥x	593