## Contents

1	Soil	Quality and Human Health	1
	1.1	Public Awareness for Soil Quality and Protection	2
	1.2	Land Resources and Land Quality	3
	1.3	Soil Quality	5
	1.4	Influence of Land Management on Soil Quality	13
	1.5	Impacts of Climate Change on Soil Quality	22
	1.6	Relationship Between Soil Quality	
		and Agricultural Products	25
	1.7	Organic vs. Conventional Farming	27
	Refe	rences	30
2	Med	icinal Uses of Soil Components, Geophagia	
-	and	Podoconiosis	35
	2.1	Minerals as a Source of Essential Elements	37
	2.2	Role of Minerals for Therapeutic Purposes	41
		2.2.1 Minerals Used for Pharmaceutical Preparations	
		and Cosmetic Products	41
		2.2.2 Therapeutic Effects of Minerals Administered	
		Orally	43
		2.2.3 Therapeutic Effects of Minerals Administered	
		Topically	47
		2.2.4 Minerals Administered Parenterally	49
	2.3	Minerals Used as Excipients	49
	2.4	Minerals Used in Cosmetic Products	50
		2.4.1 Toothpaste	50
		2.4.2 Sun Protection Products	51
		2.4.3 Creams, Powders and Emulsions	51
		2.4.4 Bathroom Salts and Deodorants	51

2.5	Soil M	laterials for Fangotherapy	52
	2.5.1	Peat	53
	2.5.2	Clay	55
	2.5.3	Mud	57
	2.5.4	Therapies	60
2.6	Soil M	licroorganisms Producing Drugs	62
	2.6.1	Antibiotics from Natural Products	64
	2.6.2	The Need for New Antibiotics	65
	2.6.3	Other Drugs from Natural Products	67
2.7	Geoph	agia	71
	2.7.1	Nutritional Aspects of Geophagia	73
	2.7.2	Microbiological Benefits of Geophagia	76
	2.7.3	Hazards Resulting from Soil Pathogens	77
	2.7.4	Hazards Resulting from Toxic Elements	78
2.8	Podoco	oniosis	79
	2.8.1	Clinical Effects	80
	2.8.2	Prevention and Therapy	81
2.9	Biocor	npatibility of (Nano-)particles Released from Dental	
	Materi	als	82
	2.9.1	Inhaled Nanoparticles	82
	2.9.2	Risk Assessment for the Uptake of Nanoparticles	
		Abraded from Dental Materials	83
	2.9.3	Toxicity of Titan (Nano-)particles In Vitro	83
	2.9.4	Titan (Nano-)particles in Human Jawbones with Ti	
		Implants	85
	2.9.5	Histological Analyses	86
_	2.9.6	Silver Nanoparticles	86
Refe	rences.		87
Soil-	Borne P	articles and Their Impact on Environment	
and	Human	Health	99
3.1	Backg	round	101
3.2	Defini	tion of Dust Particles	101
3.3	Source	es of Dust Particles	102
	3.3.1	Volcanic Ash	103
	3.3.2	Mineral Dust	106
	3.3.3	Asbestos and Asbestiform Minerals	111
	3.3.4	Crystalline Silica	113
	3.3.5	Coal Combustion	115
	3.3.6	Liquid Fossil Fuel Combustion	118
	3.3.7	Landscape Fires	119
3.4	Global	l Pathways	124
	3.4.1	Volcanic Ash	124
	3.4.2	Mineral Dust	125
	3.4.3	Particles from Landscape Fires	129

3

	3.4.4	Bacteria, Fungi and Viruses in Dust	129
	3.4.5	Plant and Animal Pathogens in Dust	130
3.5	Human	Health-Affecting Properties of Dusts	132
	3.5.1	Crystalline Silica	132
	3.5.2	Asbestos	134
	3.5.3	Dust Particles Contaminated with Toxic Elements	134
	3.5.4	Bacteria, Fungi and Viruses in Dust	136
	3.5.5	Dusts from Coal and Liquid Fossil Fuel Burning	137
	3.5.6	Dust from Terrestrial Biomass Burning	138
3.6	Exposu	re	139
	3.6.1	Exposure Levels	140
3.7	Clinical	Effects	140
	3.7.1	Disease Associated with Inhalation	
		of Dust from Silica and Coal Burning	140
	3.7.2	Disease Associated with Inhalation of Dust Particles	
		Contaminated with Toxic Elements	143
	3.7.3	Disease Associated with Coal Mining	144
	3.7.4	Disease Associated with Biomass Burning	145
	3.7.5	Asbestos-Related Lung Disease	146
3.8	Therapy	/	149
	3.8.1	Silicosis	149
	3.8.2	Coal Worker's Pneumoconiosis	150
	3.8.3	Asthma	151
	3.8.4	Asbestosis	151
	3.8.5	Asbestos-Related Lung Cancer	152
	3.8.6	Malignant Mesothelioma	152
	3.8.7	Pleural Fibrosis	153
3.9	Measure	es to Minimize Exposure to Particulate Matter	153
	3.9.1	Regulation Guidelines for Particulate Matter	153
	3.9.2	Measures to Reduce Occupational Exposure	154
	3.9.3	Protective Measures to Minimize Exposure	
		to Dust Storms	158
	3.9.4	Measures to Reduce Dust Generation	
		on Agricultural Land	159
	3.9.5	Protective Measures to Minimize Exposure	
		to Volcanic Plumes	160
	3.9.6	Measures to Minimize Exposure to Particles	
		Generated by Land Fires	161
	3.9.7	Measures to Minimize Exposure to Particles	
		Generated from Fossil Fuel Combustion	162
Refer	rences	•••••••••••••••••••••••••••••••••••••••	164

4	Soil-	Soil-Borne Gases and Their Influence on Environment							
	and	Human	Health	1/9					
	4.1	Overvi	ew of Soil-Borne Gases	180					
	4.2	Source	s of Soil-Borne Gases	180					
		4.2.1	Carbon Dioxide Emission	182					
		4.2.2	Methane Emission	185					
		4.2.3	Nitrous Oxide Emission	189					
		4.2.4	Ammonia Emission	191					
		4.2.5	Aerosols or Particulate Matter	194					
	4.3	Impact	on Atmosphere and Climate	196					
	4.4	Impact	t on Ecosystems	197					
		4.4.1	Impact of Greenhouse Gases	197					
		4.4.2	Impact of Ammonia and Aerosols	200					
	4.5	Exposi	are and Human Health Effects	200					
		4.5.1	Climate Change Effects	201					
		4.5.2	Exposure to Ammonia	204					
		4.5.3	Exposure to Aerosols and Particulate Matter	205					
	4.6	Mitiga	tion Options	207					
		4.6.1	Carbon Dioxide	207					
		4.6.2	Methane	209					
		4.6.3	Nitrous Oxide	210					
		4.6.4	Ammonia	211					
		4.6.5	Particulate Matter and Aerosols	212					
		4.6.6	Mitigating Climate Change Effects	212					
	Refe	rences		213					
5	Read	ctive Wa	ter-Soluble Forms of Nitrogen and Phosphorus						
	and	Their In	npacts on Environment and Human Health	223					
	5.1	Humar	Dependence on Water	224					
	5.2	Source	s of Water-Soluble Nitrogen and Phosphorus						
		Compo	ounds	224					
		5.2.1	Nitrogen	224					
		5.2.2	Phosphorus	226					
	5.3	Impact	ts on Water Ouality	227					
		5.3.1	Nitrogen	227					
		5.3.2	Phosphorus	228					
	54	Effects	s on Ecosystems	229					
	5.1	541	Leaching and Runoff	230					
		542	Futrophication	232					
	55	Exposi	ure and Health Risks	233					
	5.5	5 5 1	Nitrogen	233					
		552	Dhoenhorus	235					
	56	J.J.Z Mitica	tion Options	240					
	5.0	5 6 1	Environmental Protection Measures	242					
		560	Dreventive Health Care	273					
	Dafa	5.0.2		240					
	<b>NCIG</b>	ichees.		∠~ <b>т</b> 0					

6	Macro- and Secondary Elements and Their Role						
	in H	uman H	ealth	257			
	6.1	Overvi	ew of Macro- and Secondary Elements	258			
	6.2	Source	s of Macroelements	259			
		6.2.1	Nitrogen	260			
		6.2.2	Phosphorus	265			
		6.2.3	Potassium	268			
		6.2.4	Secondary Nutrients: Sulphur, Calcium				
			and Magnesium	270			
	6.3	Macro	element Transformations in Soil	274			
		6.3.1	Nitrogen	274			
		6.3.2	Phosphorus	277			
		6.3.3	Potassium	279			
		6.3.4	Secondary Nutrients: Sulphur, Calcium				
			and Magnesium	280			
	6.4	Cyclin	g of Nitrogen and Phosphorus	282			
	6.5	Benefi	cial Effects of Macronutrients	284			
		6.5.1	Carbon, Oxygen and Hydrogen	284			
		6.5.2	Nitrogen	285			
		6.5.3	Phosphorus	286			
		6.5.4	Potassium	288			
		6.5.5	Sulphur, Calcium and Magnesium	289			
	6.6	Effects	s of Excessive Macronutrient Uptake	291			
		6.6.1	Nitrogen	291			
		6.6.2	Phosphorus	293			
		6.6.3	Potassium	294			
		6.6.4	Sulphur, Calcium and Magnesium	295			
	6.7	Effects	s of Deficient Macronutrient Uptake	296			
	6.8 Optimizing Macro- and Secondary Element Status						
		6.8.1	Soils	301			
		6.8.2	Humans	302			
	Refe	rences		307			
7	Mici	oelemen	nts and Their Role in Human Health	317			
	7.1	Overvi	iew of Microelements	318			
	7.2	Source	es of Microelements	319			
	7.3	Microe	element Transformations in Soil	323			
	7.4	Benefi	cial Effects of Microelements	328			
		7.4.1	Plants	328			
		7.4.2	Humans	331			
	7.5	Effects	s of Excessive Micronutrient Untake	333			
		7.5.1	Plants	333			
		7.5.2	Humans	335			
	7.6	Effects	of Deficient Micronutrient Untake	336			
		7.61	Plants	336			
		7.6.2	Humans	338			
		1.0.2		550			

	7.7	Sympto	oms of Micronutrient Deficiencies	343
		7.7.1	Plants	343
		7.7.2	Humans	345
	7.8	Optimiz	zing Microelement Status	346
		7.8.1	Soils and Plants	346
		7.8.2	Humans	350
		7.8.3	Factors Affecting Bioavailability of Iron and Zinc	363
	Refer	ences	• • • • • • • • • • • • • • • • • • • •	367
8	Role	of Poten	tially Toxic Elements in Soils	375
	8.1	Overvie	ew of Potentially Toxic Elements	376
	8.2	Sources	s of Potentially Harmful Trace Elements	378
		8.2.1	Geochemical Background	378
		8.2.2	Anthropogenic Sources	37 <b>9</b>
	8.3	Chemis	stry of Toxic Elements in Soils	387
		8.3.1	Factors Influencing Toxic Element Bioavailability	
			in Soils	388
		8.3.2	Toxic Elements Speciation	391
	8.4	Pathwa	ys of Toxic Elements	396
		8.4.1	Toxic Elements in Soil, Water, Air, Plants	
			and Food Products	397
	8.5	Human	Exposure, Clinical Effects and Therapy Associated	
		with To	oxic Elements	414
		8.5.1	Arsenic	414
		8.5.2	Cadmium	417
		8.5.3	Copper	418
		8.5.4	Chromium	419
		8.5.5	Mercury	420
		8.5.6	Nickel	421
		8.5.7	Lead	422
		8.5.8	Zinc	424
	8.6	Measur	res to Reduce Human Exposure to Toxic Elements	424
		8.6.1	Approaches to Reduce Toxic Element Uptake	
			by Plants	425
		8.6.2	Incorporation of Amendments for Toxic Element	
			Immobilization	426
		8.6.3	Technologies for Remediation of Heavy Metal	
			Contaminated Soils	427
	Refer	ences	•••••••••••••••••••••••••••••••••••••••	435
9	Heal	th Risks	Associated with Radionuclides in Soil Materials	451
-	9.1	Types	of Radiation	452
		9.1.1	Alpha Particles	452
		9.1.2	Beta Particles	452
		9.1.3	Gamma Particles	453

9.2	Determi	nation of Radioactivity: Definition	
	of the U	nits Used	453
	9.2.1	Bequerel	453
	9.2.2	Gray	453
	9.2.3	Sievert	454
9.3	Naturall	y Occurring Radionuclides	454
	9.3.1	Cosmogenic and Terrestrial Sources	
		of Radionuclides	455
	9.3.2	Natural Sources Modified by Humans	457
	9.3.3	Anthropogenic Radionuclides	465
9.4	Behavio	our of Important Radionuclides	
	in Soil-V	Water Systems	470
	9.4.1	Nickel-59,63 ( <sup>63,59</sup> Ni)	471
	9.4.2	Selenium-79 ( <sup>79</sup> Se)	472
	9.4.3	Strontium-90 ( $^{90}$ Sr)	472
	9.4.4	Technetium-99 ( $^{99}$ Tc)	473
	9.4.5	Tin-126 ( <sup>126</sup> Sn)	474
	9.4.6	Iodine-129 ( <sup>129</sup> I)	474
	9.4.7	Cesium-137 ( $^{137}$ Cs)	475
	9.4.8	Thorium-232 ( <sup>232</sup> Th)	475
	9.4.9	Uranium-235 ( <sup>235</sup> U)	476
	9.4.10	Neptunium-237 ( <sup>237</sup> Np)	477
	9.4.11	Plutonium-239 + 240 ( $^{239+240}$ Pu)	477
	9.4.12	Americum-241 ( <sup>241</sup> Am)	478
	9.4.13	Curium-242 ( <sup>242</sup> Cm)	479
9.5	Routes	of Exposure	479
	9.5.1	Exposure from Cosmogenic Radiation	481
	9.5.2	Exposure from Natural Terrestrial Radiation	481
	9.5.3	Exposure from Nuclear Weapons Tests	481
	9.5.4	Exposure from the Nuclear Fuel Cycle	482
	9.5.5	Exposure from Nuclear Accidents	482
	9.5.6	Contaminated Food and Water	483
	9.5.7	Total Radiation Exposure	483
9.6	Clinical	Effects of Radiation	484
	9.6.1	Alpha Radiation	484
	9.6.2	Beta Radiation	484
	9.6.3	Gamma Radiation	485
9.7	Isotopes	s of Concern for Human Health	485
9.8	Biologi	cal Significance of Radiation	485
9.9	Therapy	/	486
	9.9.1	Determination of Radioactive Contamination	486
	9.9.2	External Decontamination	487
	9.9.3	Internal Decontamination	487

	9.10	Measure	es for Remediation of Radionuclide	
		Contam	inated Sites	490
		9.10.1	Classification of Radionuclide-Contaminated Sites	490
		9.10.2	Mechanically or Physio-chemically	
			Based Technologies	490
		9.10.3	Phytoremediation	492
	Refer	ences		495
10	Healt	h Risks A	Associated with Pesticides in Soils	503
	10.1	History	of Pesticide Use	504
	10.2	Types o	f Pesticides	508
	10.3	Environ	mental Fate of Pesticides	511
		10.3.1	Soil-Pesticide Interactions	512
		10.3.2	Degradation of Pesticides and Other Organic	
			Pollutants	523
		10.3.3	Pesticide Losses to the Environment	529
		10.3.4	Pesticides in Non-target Organisms	533
	10.4	Pesticid	es in Food Products	538
	10.5	Human	Health Risks Associated with Pesticides	541
		10.5.1	Human Exposure	542
		10.5.2	Clinical Effects	542
		10.5.3	Therapy of Acute Toxicity	547
		10.5.4	Chronic Toxicity Related to Long-Term Contact	
			to Pesticides	549
	10.6	Technic	al Measures for Reducing Pesticide Dispersal	
		in the E	nvironment	553
		10.6.1	Storage, Mixing, Loading and Application	
			of Pesticides	553
		10.6.2	Reducing Flows of Applied Pesticides	554
	10.7	Remedi	ation of Pesticide-Contaminated Soils	555
		10.7.1	Physical and Chemical Remediation Technologies	555
		10.7.2	Bioremediation	556
	10.8	Alternat	tives for Minimizing Pesticide Use	557
		10.8.1	Organic Farming	558
		10.8.2	Integrated Pest Management	560
		10.8.3	Plant Genetic Engineering	561
	Refer	ences		561
11	Healt	h Risks	Associated with Organic Pollutants in Soils	575
	11 1	Organic	Pollutants of Concern	576
	11.2	Structur	e and Properties of Priority Organic Pollutants	579
	11.2	Sources	and Emissions of Organic Pollutants	585
	11.5	11 2 1	Composts Digestates and Sewage Sludge	505
		11.3.1	as Sources of Diverse Organic Pollutants	502
		11 2 2	Dumps and Landfills as Sources	575
		11.3.2	of Diverse Organic Pollutants	504
				574

	11.4	Enviror	mental Fate of Priority Organic Pollutants	594
		11.4.1	Major Principles of Transportation Routes	595
		11.4.2	Concentrations of Organic Pollutants	
			in the Atmosphere	596
		11.4.3	Concentrations of Organic Pollutants in Soils	601
		11.4.4	Concentrations of Organic Pollutants in Water	606
	11.5	Organie	c Pollutants in Non-target Organisms	610
		11.5.1	Plants	610
		11.5.2	Aquatic Food Chains	613
		11.5.3	Wildlife, Fish, Aquatic Mammals	614
	11.6	Major I	Routes of Human Exposure to Organic Pollutants	618
	11.7	Clinica	l Effects	626
	11.8	Therap	y	633
		11.8.1	Reduction of Exposure to Organic Pollutants	633
		11.8.2	Therapeutic Measures to Facilitate Excretion	
			of Organic Pollutants	635
		11.8.3	Therapeutic Measures to Enhance Elimination	
			of Organic Pollutants	635
	11.9	Remed	iation of Soils Contaminated with Organic	
		Polluta	nts	636
		11.9.1	Emerging Physico-chemical Technologies	637
		11.9.2	Emerging Thermal Technologies	638
	Refer	ences		639
12	Осси	rrence a	nd Fate of Human and Veterinary	
	Medi	cinal Pr	oducts	659
	12.1	Sources	s of Medicinal Products	661
		12.1.1	Human Medicinal Products	661
		12.1.2	Veterinary Medicinal Products	662
	12.2	Physico	o-Chemical Properties of Pharmaceuticals	665
	12.3	Enviror	nmental Fate of Pharmaceuticals	668
		12.3.1	Human Pharmaceuticals in the Waste Stream	669
		12.3.2	Veterinary Pharmaceuticals in the Manure	
			Waste Stream	676
		12.3.3	Pharmaceuticals in Soils	680
		12.3.4	Concentrations of Human Pharmaceuticals	
			in Water Matrices	684
		12.3.5	Pharmaceuticals in Edible Plants	688
		12.3.6	Effects of Pharmaceuticals on Non-target	
			Organisms	691
	12.4	Maior I	Routes of Human Exposure to Pharmaceuticals.	697
	12.5	Possibl	e Human Health Threats	698
	-	12.5.1	Adverse Health Effects	698
		12.5.2	Antibiotic Resistance	698

	12.6	Mitigati	ion Options to Reduce the Release	
		of Phar	maceuticals to the Environment	700
		12.6.1	Preventive Measures as Mitigation Options	701
		12.6.2	Pharmaceutical Removal from Wastewater	
			Treatment Plant Effluent	704
	Refer	ences		709
13	Soil a	is a Tran	smitter of Human Pathogens	723
	13.1	Global	Impact of Diseases Caused by Soil Pathogens	724
	13.2	Life Co	nditions of Pathogens in Soils	725
	13.3	Classifi	cation of Pathenogenic Soil Organisms	729
	13.4	Gatewa	ys of Introducing Soil-borne Pathogens	
		into Hu	mans	732
		13.4.1	Land Application of Animal Manures	733
		13.4.2	Animal Feedlots	737
		13.4.3	Land Application of Wastewater	
			and Sewage Sludge	738
		13.4.4	Municipal Solid Waste	739
		13.4.5	Infections Caused by Consumption of Fruits	
			and Vegetables	739
	13.5	Ecophy	siology of Pathenogenic Soil Organisms	744
		13.5.1	Viruses	744
		13.5.2	Bacteria	747
		13.5.3	Fungi	756
		13.5.4	Protozoa	761
		13.5.5	Helminths	765
	13.6	Sympto	oms and Treatment of Diseases	770
		13.6.1	Viral Diseases	770
		13.6.2	Bacterial Diseases	773
		13.6.3	Fungal Diseases	787
		13.6.4	Diseases Caused by Protozoa	792
		13.6.5	Diseases Caused by Helminths	795
	13.7	Exampl	les of Strategies for Control of Zoonotic Diseases	
		Transm	hission and Infection	799
	13.8	Public 1	Health Measures to Prevent Infections	
		with Pa	thogens	801
		13.8.1	Vaccination	801
		13.8.2	Safe Water Supply	802
		13.8.3	Mitigation Measures in Agricultural Practice	804
		13.8.4	Protection of the Public from Foodborne	
			Infections	806
		13.8.5	Information and Education	810
	Refer	ences .		810
			······································	-

14	Soil a	is an En	vironmental Reservoir of Prion Diseases	829
	14.1	Overvie	ew of Prion Diseases	831
		14.1.1	Prion Diseases in Humans	832
		14.1.2	Prion Diseases in Animals	834
	14.2	Prions i	in the Environment	835
		14.2.1	Major Factors Affecting Spatial Distribution	
			of Prions	838
		14.2.2	Prions in Soils	838
		14.2.3	Prions in Wastewater Treatment Systems	843
	14.3	Prion T	ransmission	844
		14.3.1	In Vivo Dissemination	845
		14.3.2	Excretion/Secretion of Prions	845
	14.4	Clinica	l Features of Human TSEs	848
		14.4.1	Spread of Prions Within Organisms	848
		14.4.2	Pathogenesis	849
		14.4.3	Therapeutic Strategies	852
	14.5	Public	Health Management	852
		14.5.1	Avoidance of latrogenic Transmission	
			of Prions	853
		14.5.2	Minimizing Risks of BSE Transmission	
			from Cattle to Humans	853
		14.5.3	Depopulation of Herds Affected by TSE-Infected	
			Animals	854
		14.5.4	Landfilling	854
	14.6	Method	is for Treatment of Environmental Material	
		Infecte	d with TSEs	854
		14.6.1	Aerobic Treatment	855
		14.6.2	Anaerobic Treatment	855
		14.6.3	Thermal and Chemical Procedures	856
	14.7	Method	is for Treatment of Wastewater	857
	Refer	ences		857
Ind	ex	• • • • • •		865