

CONTENTS

PREFACE

PRINCIPLES AND PERSPECTIVES 1

Chapter 1	THE ENVIRONMENT AND POLLUTION	3
	Introduction	3
	Metal smelting: an example of point source pollution	6
	Non-point source pollution	10
	Ecological considerations	11
	Environmental law	15
	Integrated pollution control and national agencies	15
	UNITED STATES	16
	UNITED KINGDOM	16
	Concepts underlying the establishment of discharge limits	17
	UNITED KINGDOM	17
	UNITED STATES	18
	International law and environmental protection	18
	References	19
	Further reading	20

Chapter 2	ASSESSING THE ENVIRONMENTAL FATE AND POTENTIAL IMPACT OF POLLUTANTS	21
	Introduction	21
	Predicting the environmental fate of pollutants	24
	Qualitative predictions	24
	Quantitative predictions	26
	Biological models	34
	The relationship between exposure and the amount of pollutant accumulated by an organism	37

	Application of bioconcentration and bioaccumulation factors	39
	Biomagnification	41
	The effects of accumulated pollutant on individual organisms	43
	Impacts at the ecosystem level	44
	References	45
	Further reading	47
Chapter 3	TREATMENT TECHNOLOGIES	48
	Traditional approaches to pollution control	48
	Landfill	49
	Incineration	49
	Other technologies	50
	Evaluation of waste management options	52
	Biotreatment technologies for pollution control	54
	References	58
	Further reading	58
Chapter 4	BIOCATALYST SELECTION AND GENETIC MODIFICATION	59
	Enrichment and screening strategies	59
	Design of enrichment strategies relating to the environmental source	60
	Microbiological techniques for enrichment and selection	63
	<i>In situ</i> enrichment prior to isolation	63
	Laboratory microcosms and soil columns	64
	Laboratory-based liquid culture techniques	65
	Genetic approaches to the isolation of biocatalysts for environmental biotechnologies	68
	Genetically engineered microbes	70
	GEMs for the treatment of toxic environmental chemicals	72
	Natural versus genetically engineered biocatalysts for pollution control	75
	Further reading	75
	ORGANIC POLLUTANTS	77
Chapter 5	THE CARBON CYCLE AND XENOBIOTIC COMPOUNDS	79
	Exogenous organic matter entering the environment	81

The role of natural microbial communities	83
The fate of organic xenobiotic compounds in the environment	85
Biodegradation	88
Haloorganic compounds in the natural environment	93
References	95
Further reading	95

Chapter 6	BIODEGRADATION OF ORGANIC COMPOUNDS	96
	Biodegradation of xenobiotic compounds	100
	The biochemistry of carbon-halogen bond cleavage	101
	Microbial dehalogenases	102
	OXYGENOLYTIC DEHALOGENATION	103
	REDUCTIVE DEHALOGENATION	106
	HYDROLYTIC DEHALOGENATION	106
	HALOALCOHOL DEGRADATION	111
	LIGNINASES	112
	The biochemistry of organomercurial detoxification	114
	Exploitation of the biochemical versatility of microorganisms	115
	References	115

Chapter 7	APPLICATION OF BIOTECHNOLOGIES TO THE TREATMENT OF ORGANIC POLLUTANTS	118
	Introduction	118
	Biotechnologies for the prevention of environmental pollution by toxic organic compounds	118
	Municipal wastewater treatment	119
	Biotechnologies for the cure of environmental pollution by toxic organic compounds	122
	Soil remediation	122
	Groundwater remediation	127
	Air remediation	131
	References	132
	Further reading	132

NITRATE AND PHOSPHATE POLLUTION	133
Chapter 8	
NITROGEN AND PHOSPHORUS IN THE ENVIRONMENT	135
The environmental behaviour of nitrogen and phosphate	135
Environmental concerns	139
Eutrophication	139
Nitrate and drinking water supply	145
METHAEMOGLOBINAEMIA (BLUE-BABY SYNDROME)	146
CANCER	146
Sources and loads	148
Sewage	149
Agricultural inputs	151
LOSSES FROM GRASSLANDS	151
LOSSES FROM ARABLE SYSTEMS	153
Relative importance of nitrogen and phosphate sources	154
References	155
Further reading	157
Chapter 9	
MICROBIAL REMOVAL OF NITRATES	158
Introduction	158
Microbial removal of nitrate from wastes and groundwater: biocatalysts and mechanisms	159
Denitrifying bacteria and denitrification	160
REACTION AND ENZYME SYSTEMS	160
HETEROTROPHIC DENITRIFICATION	161
CHEMOLITHOTROPHIC DENITRIFIERS	161
DISSIMILATORY NITRATE REDUCTION	162
Factors affecting denitrification	162
OXYGEN	162
ENERGY SOURCE: CARBON AND INORGANIC COMPOUNDS	162
TEMPERATURE AND pH	163
INHIBITORY SUBSTANCES	164
Treatment technologies	164
Wastewater denitrification treatment technologies	164
CONVENTIONAL TREATMENT	164
BACTERIAL ADSORPTION AND ENTRAPMENT	165
LAND TREATMENT SYSTEMS	166
BACTERIAL COMMUNITIES AND DENITRIFICATION	166

	Denitrification of drinking water	167
	<i>In situ</i> denitrification of groundwater	168
	References	171
	Further reading	173
Chapter 10	MACROPHYTE SYSTEMS FOR NITRATE AND PHOSPHATE REMOVAL	174
	Introduction	174
	The concept and processes of pollutant removal	177
	Plant accumulation of pollutant	177
	Bacteria mediated decomposition	178
	ORGANIC CARBON	178
	NITROGEN	179
	Physical-chemical processes	180
	PHOSPHATE	180
	PATHOGENS	180
	Design and management of artificial wetlands	180
	Choice of plant species	181
	Substrate	181
	Area of reed bed	182
	The nature, loading and distribution of effluent	183
	PRE-TREATMENT	183
	LOADING AND DISTRIBUTION OF EFFLUENT	183
	Subsequent management	184
	Evaluation of artificial reed beds	185
	References	187
	Further reading	189
	SULPHUR AND NITROGEN OXIDES	191
Chapter 11	ENVIRONMENTAL IMPACTS OF SULPHUR AND NITROGEN OXIDES	193
	Introduction	193
	Chemistry of acid precipitation	194
	Sources	196
	Plant sensitivity to SO₂ and NO_x	197
	Primary sites of pollutant action	197
	Effects of SO ₂ on plant growth	198
	Acid precipitation, soil acidification and plant-soil interaction	200
	Forest decline	202

	Acidification of surface waters	203
	References	206
	Further reading	208
Chapter 12	DESULPHURIZATION OF COAL AND OILS	209
	Introduction	209
	Composition and structure of coal	210
	Composition and structure of oil	211
	Microbial removal of inorganic sulphur from coal and oil : organisms and mechanisms	212
	Mechanisms of inorganic sulphur oxidation by <i>Thiobacillus</i>	212
	Chemolithotrophic bacteria and inorganic sulphur oxidation	214
	Heterotrophic microorganisms and inorganic sulphur oxidation	215
	General considerations on microbial inorganic sulphur removal	217
	Microbial removal of organic sulphur from coal and oil	217
	Aerobic organic sulphur removal	218
	Anaerobic organic sulphur removal	220
	General considerations on microbial organic sulphur removal	220
	Factors affecting the removal of inorganic sulphur from coal	221
	Coal type, pulp density and particle size	221
	Environmental and nutrient conditions	222
	Factors affecting the removal of organic sulphur from coal and oil	223
	Available reaction surface	223
	Environmental and nutrient conditions	223
	Desulphurization process technology	225
	References	227
	Further reading	229
	METAL AND RADIONUCLIDE POLLUTANTS	231
Chapter 13	ENVIRONMENTAL FATE AND EFFECTS OF METALS AND RADIONUCLIDES	233
	Definitions	233
	Environmental chemistry	234
	Classification of metallic elements	235
	PERIODIC TABLE CLASSIFICATION	235

TYPE-A AND TYPE-B METAL CATIONS	236
Interactions of metals with particles	239
Formation of carbon complexes	239
Metals in the atmosphere	240
Metals in water	242
ACCUMULATED ELEMENTS	245
RECYCLED ELEMENTS	245
SCAVENGED ELEMENTS	248
METALS IN SOILS AND THEIR MOBILITY	251
Metal toxicity	255
The environmental cycling and sources of metals	258
References	260

Chapter 14	METAL AND RADIONUCLIDE BIOTREATMENT	263
	Introduction	263
	Precipitation of heavy metals and radionuclides	264
	Biotransformations of heavy metals and radionuclides	265
	Oxidation reactions	265
	Reduction reactions	267
	Alkylation reactions	269
	Intracellular accumulation	269
	Extracellular accumulation	273
	Biopolymer accumulation	282
	POLYSACCHARIDE BIOPOLYMERS	283
	POLYPHENOLIC BIOPOLYMERS	285
	METAL-BINDING PROTEINS	285
	EXOPRODUCT BINDING	286
	References	286
	Further reading	288

Chapter 15	BIOTECHNOLOGY FOR METAL AND RADIONUCLIDE REMOVAL AND RECOVERY	290
	Introduction	290
	Non-living biological processes for metal effluent treatment	291
	Process technologies: microbial and algal biosorbents	291
	Efficiency of non-living microbial biosorbents	297
	Process technology: biopolymers and exoproduct sorption	298

Living biological processes for metal effluent treatment	299
Engineered microbial living systems	299
IMMOBILIZED GROWING OR RESTING CELLS	300
BIOLOGICAL SEWAGE TREATMENT	303
Engineered and natural ecosystems	304
References	308
Further reading	310

Chapter 16 FUTURE PROSPECTS	311
------------------------------------	-----