

# Contents

---

<b>Abbreviations</b>	xiii
<b>List of Contributors</b>	xvii
<b>Preface</b>	xxi

## Chapter 1

<b>Wastewater characterization</b>	1
------------------------------------	---

*M. C. Tomei and D. Mosca Angelucci*

1.1 Introduction	1
1.2 Gross Parameters	2
1.3 Physical Properties	4
1.4 Organic Matter	5
1.5 Inorganic Matter	7
1.6 Micropollutants	8
1.7 Biodegradability	11
1.7.1 COD, Nitrogen and phosphorus fractionation	11
1.7.2 Evaluation methods	14
References	17

## Chapter 2

<b>The microbiology of the activated sludge process</b>	21
---	----

*S. Rossetti, C. Levantesi and V. Tandoi*

2.1 Introduction	21
2.2 Microorganisms in Activated Sludge	22
2.2.1 Bacteria: cell structure	22

2.2.2 Inclusions .....	24
2.3 The Identification of Bacteria .....	24
2.3.1 Conventional taxonomy .....	25
2.3.2 Molecular taxonomy .....	26
2.3.3 Molecular characterization of mixed biomass .....	26
2.4 Filamentous Bacteria .....	28
2.5 Microthrix parvicella .....	36
2.5.1 Identification of <i>M. parvicella</i> .....	38
2.5.2 Physiology of ' <i>Candidatus M. parvicella</i> ' .....	38
2.6 Thiothrix .....	39
2.7 Nostocoida limicola .....	40
2.8 Polyphosphate Accumulating Organisms (PAO) .....	40
2.9 Glycogen Accumulating Organisms (GAO) .....	41
2.10 Nitrifiers .....	42
2.11 Denitrifiers .....	42
References .....	43

## Chapter 3

### **Activated sludge separation problems** ..... 53

J. Wanner

3.1 Introduction .....	53
3.2 'Well-settling' Activated Sludge .....	54
3.2.1 Requirements .....	54
3.2.2 Microscopic features of well settling activated sludge .....	57
3.3 Activated Sludge Separation Problems .....	57
3.3.1 Poor floc microstructure .....	58
3.3.2 Poor floc macrostructure .....	61
3.3.3 Other reasons .....	64
3.4 Summary .....	65
Acknowledgment .....	65
References .....	65

## Chapter 4

### **Aeration tank and secondary clarifier as one system** ..... 67

J. Wanner and M. Torregrossa

4.1 Introduction .....	67
4.2 Aeration Tank and Secondary Clarifier Interactions .....	68
4.2.1 Activated sludge process .....	68
4.2.2 Secondary clarifier .....	69
4.2.3 Separation function .....	76

4.2.4	BOD <sub>5</sub>	76
4.2.5	COD	77
4.2.6	Nitrogen and phosphorus	77
4.3	The Impact of Aeration Basin Equipment and Operation on the Performance of Secondary Clarifiers	77
4.3.1	Mechanical vs. diffused-air aeration	77
4.3.2	Mixed liquor mixing	78
4.3.3	Degasification and reflocculation in aeration tanks	79
4.4	Features of Secondary Clarifier Construction	80
4.4.1	Inlet structure with a flocculation zone	81
4.4.2	Outlet structure	84
4.4.3	Scum baffles	86
4.5	Efficient Scum Removal from the Surface of Secondary Clarifiers	87
4.5.1	Conventional scum boxes	87
4.5.2	'Travelling' scum boxes	88
4.5.3	Pneumatic systems	88
4.6	Removal of Settled and Thickened Sludge	90
4.6.1	Effect on the final effluent quality	90
4.6.2	Mechanical scrapers	90
4.6.3	Vacuum sludge removal	91
4.7	Operation of Aeration Tank – Secondary Clarifier System for Bulking and Foaming Control	91
4.7.1	Use of chemicals in activated sludge process	92
4.7.2	Operation of secondary clarifiers	95
References		96

## Chapter 5

### **Bulking and foaming control methods**

V. Tandoi, M. Majone and S. Rossetti

5.1	Introduction	99
5.1.1	Microscopic characterization of the activated sludge	100
5.1.2	Biological foam	101
5.1.3	Bulking	103
5.1.4	The problem of excess sludge production and its disposal	103
5.2	Specific Control Methods	105
5.2.1	Bulking due to low (F/M) ratio	105
5.2.2	Bulking due to low dissolved oxygen concentrations	117
5.2.3	Bulking due to low nutrient concentration	118
5.2.4	Bulking due to fatty acids in the influent stream: control methods for <i>Microthrix parvicella</i>	120

5.2.5	Microbial and enzymatic preparations . . . . .	121
5.3	Non-specific Control Methods . . . . .	122
5.3.1	Oxidizing agents . . . . .	122
5.3.2	Weighting or flocculating agents . . . . .	126
5.3.3	Specific biocide . . . . .	127
5.4	Control of Non-Filamentous Bulking ('Viscous Bulking') . . . . .	127
5.5	Avoiding Poor Settling Properties: Alternative Separations of Activated Sludge . . . . .	128
	References . . . . .	129

## Chapter 6

### *Experiences in various countries* . . . . . 139

6.1	Introduction . . . . .	139
6.2	Australia . . . . .	140

*H. Stratton, M. Christie, P. Griffiths and R.J. Seviour*

6.2.1	General situation . . . . .	140
6.2.2	What do we know of these filamentous bacteria? . . . . .	142
6.2.3	Bulking and foaming filamentous bacteria in Australian activated-sludge plants . . . . .	143
6.2.4	Do filamentous bacteria populations in the same treatment plant change over time and can we control them? . . . . .	147
6.2.5	The future . . . . .	151

6.3	Austria . . . . .	151
-----	-------------------	-----

*N. Kreuzinger and N. Matsché*

6.3.1	Intention of the investigation . . . . .	151
6.3.2	Organization of the assessment . . . . .	152
6.3.3	Methodology . . . . .	155
6.3.4	Results . . . . .	157
6.3.5	Summary and conclusion . . . . .	164

6.4	Belgium . . . . .	165
-----	-------------------	-----

*A. Fenu, J. Deurinck and S. Van Damme*

6.4.1	General situation . . . . .	165
6.4.2	The <i>M. parvicella</i> problem . . . . .	166
6.4.3	Polyaluminium chloride to tackle <i>M. parvicella</i> . . . . .	168
6.4.4	<i>Microthrix parvicella</i> monitoring: a revised methodology . . . . .	171
6.4.5	Conclusion . . . . .	174

6.5	China . . . . .	174
-----	-----------------	-----

*M. Yang, R. Qi and J. Wang*

6.5.1	Introduction . . . . .	174
-------	------------------------	-----

6.5.2	Distribution of filamentous bacteria in activated sludge . . . . .	176
6.5.3	Studies on sludge bulking processes and control strategy . . . . .	177
6.6	Czech Republic . . . . .	180
<i>I. Ruzickova, O. Krhutkova and J. Wanner</i>		
6.6.1	Separation problems – situation up to the 1980s . . . . .	180
6.6.2	Separation problems – situation up to the mid-1990s . . . . .	181
6.6.3	WWTPs screening – 1995–2000 . . . . .	181
6.6.4	Results of separation problems and filamentous microorganisms screening . . . . .	182
6.6.5	Development of filamentous population in Czech activated sludge plants between 1997 and 1998 . . . . .	184
6.6.6	Screening of eight nutrient removal plants in 2000 . . . . .	187
6.6.7	Foam control strategies . . . . .	189
6.6.8	Development in the last decade . . . . .	193
6.7	Denmark . . . . .	197
<i>M. Nierychlo and P. H. Nielsen</i>		
6.7.1	General situation . . . . .	197
6.7.2	MiDAS: large-scale survey of the microbiology of Danish WWTPs . . . . .	198
6.7.3	Wastewater and WWTP characteristics . . . . .	199
6.7.4	Settling properties in Danish nutrient removal plants . . . . .	199
6.7.5	Filamentous community composition . . . . .	202
6.7.6	The future: surveillance and control by DNA analyses . . . . .	208
6.8	France . . . . .	209
<i>N.Durban, L. Juzan, Y. Fayolle and S. Gillot</i>		
6.8.1	General situation . . . . .	209
6.8.2	Current settling and foaming problems and control measures (2012 survey) . . . . .	211
6.8.3	A case study: metallic salt addition in an industrial size pilot-plant subject to <i>M. parvicella</i> bulking and foaming . . . . .	215
6.8.4	Conclusions . . . . .	217
6.8.5	Acknowledgments . . . . .	218
6.9	Greece . . . . .	218
<i>A. Andreadakis, D. Mamais and C. Noutsopoulos</i>		
6.9.1	General situation . . . . .	218
6.9.2	Reason for dysfunctions and filamentous bacteria identified . . . . .	218
6.9.3	Solution adopted . . . . .	221
6.9.4	A Greek case study . . . . .	222

6.10 Italy .....	225
<i>S. Badoer, C. Davoli and V. Tandoi</i>	
6.10.1 General situation .....	225
6.10.2 Characterizing the activated sludge and the qualification circuit .....	225
6.10.3 Filament surveys .....	226
6.10.4 Control methods .....	227
6.11 Malaysia .....	233
<i>N. Syamimi Zaidi, K. Muda, J. Sohaili and M. Sillanpää</i>	
6.11.1 General situation .....	233
6.11.2 Causes of plant dysfunction .....	235
6.11.3 Implemented control strategies of filamentous sludge bulking in Malaysia .....	237
6.11.4 Future scenario of sludge bulking occurrences in Malaysia .....	238
6.12 South Africa .....	239
<i>N. Deepnarain, S. Kumari and F. Bux</i>	
6.12.1 General situation .....	239
6.12.2 Overview of filamentous bulking and foaming in South African wastewater treatment works .....	241
6.12.3 Case study .....	241
6.12.4 Remedial methods to control filamentous bulking and foaming in South Africa .....	247
6.13 Spain .....	248
<i>F. Estevez, E. Rodríguez and E. Reina</i>	
6.13.1 General situation .....	248
6.13.2 Separation problems and control methods applied .....	252
6.13.3 Spain case study .....	257
6.13.4 Acknowledgement .....	263
6.14 USA .....	263
<i>T. G. Daigger and D. Jenkins</i>	
6.14.1 General situations .....	263
6.14.2 Control of filaments in activated sludge systems .....	264
6.14.3 Other solid separation problems .....	270
6.14.4 Foaming .....	270
6.14.5 Viscous bulking and dispersed growth .....	271
6.14.6 Conclusions .....	275
References .....	275
<b>Index .....</b>	<b>293</b>