

---

# Contents

---

<b>Chapter 1. Biological Removal of Micropollutants</b> . . . . .	1
1.1. Introduction . . . . .	1
1.2. Micropollutant origin . . . . .	2
1.2.1. Trace metal elements (TMEs) . . . . .	2
1.2.2. Organic trace compounds (OTCs) . . . . .	3
1.3. Mechanisms governing the fate of micropollutants in wastewater treatment plants . . . . .	12
1.3.1. Molecular characteristics of micropollutants . . . . .	15
1.3.2. Micropollutant removal mechanisms . . . . .	15
1.4. Effectiveness of biological treatments . . . . .	31
1.4.1. Organic micropollutants . . . . .	32
1.4.2. Activated sludge . . . . .	39
1.5. Biological removal of micropollutants using hybrid systems . . . . .	40
1.5.1. Impact of effluent recirculation . . . . .	44
1.6. Conclusion . . . . .	46
1.7. References . . . . .	47
<b>Chapter 2. Lagoons and Oxidation Lagoons</b> . . . . .	57
2.1. Description . . . . .	58
2.1.1. Aerated lagoons . . . . .	59
2.1.2. Anaerobic lagoons . . . . .	61
2.1.3. Facultative lagoons . . . . .	63
2.2. Design . . . . .	67
2.2.1. Components of a lagoon system . . . . .	68
2.2.2. Lagoon aeration . . . . .	70
2.2.3. Performance . . . . .	71
2.3. Lagoon sizing . . . . .	71
2.3.1. Applied load . . . . .	72

2.3.2. Removal of BOD <sub>5</sub> . . . . .	73
2.3.3. Retention time. . . . .	95
2.3.4. Ammonia removal from facultative lagoons . . . . .	95
2.3.5. Light . . . . .	99
2.3.6. Microbial decontamination. . . . .	99
2.4. Construction of oxidation lagoons . . . . .	100
2.4.1. Implementation . . . . .	100
2.4.2. Sizing and equipment. . . . .	100
2.4.3. Influence of temperature . . . . .	101
2.4.4. Lagoon aeration. . . . .	102
2.4.5. Secondary settling . . . . .	103
2.4.6. Exploitation . . . . .	103
2.5. Conclusion . . . . .	104
2.6. References . . . . .	105
<b>Chapter 3. Sludge Thickening . . . . .</b>	<b>111</b>
3.1. Origin and characteristics of sludge . . . . .	111
3.1.1. Primary sludge . . . . .	111
3.1.2. Biological sludge . . . . .	112
3.2. Principle of sludge thickening . . . . .	113
3.3. Gravity thickening. . . . .	114
3.3.1. Thickener surface area . . . . .	116
3.3.2. Determining the applied load . . . . .	117
3.3.3. Mass loading rate (kg.m <sup>-2</sup> .d <sup>-1</sup> ) . . . . .	121
3.3.4. Total height of a gravity thickener. . . . .	122
3.4. Lamellar thickening . . . . .	123
3.4.1. Thickener surface area . . . . .	125
3.4.2. Sludge layer height . . . . .	125
3.4.3. Retention time. . . . .	125
3.4.4. Harrowing . . . . .	125
3.4.5. Removal of thickened sludge . . . . .	125
3.4.6. Storage of thickened sludge . . . . .	126
3.4.7. Discharge of clarified water . . . . .	126
3.4.8. Laminar cross-sectional layout . . . . .	126
3.5. Flotation thickening . . . . .	128
3.5.1. Principle . . . . .	128
3.5.2. Direct flotation . . . . .	129
3.5.3. Indirect flotation . . . . .	130
3.5.4. Determining the size of a flotation vessel. . . . .	134
3.5.5. Operating parameters. . . . .	135
3.5.6. Modeling the efficiency of a flotation vessel as a function of load . . . . .	136

---

3.6. Comparison of conventional gravity thickeners and flotation thickeners . . . .	137
3.7. Dewatering table. . . . .	138
3.8. Conclusion . . . . .	140
3.9. References . . . . .	141
<b>Chapter 4. Sludge Treatment . . . . .</b>	<b>143</b>
4.1. Sludge origin . . . . .	143
4.2. Sludge quality . . . . .	144
4.3. Composition of the sludge . . . . .	144
4.3.1. General characteristics . . . . .	145
4.3.2. Specific characteristics of the sludge . . . . .	148
4.4. Treatments . . . . .	152
4.4.1. Thickening. . . . .	153
4.4.2. Centrifugation. . . . .	153
4.4.3. Mechanical dewatering. . . . .	157
4.4.4. Sludge drying . . . . .	172
4.4.5. Stabilization and sanitization . . . . .	197
4.4.6. Comparison between the various processes . . . . .	214
4.4.7. Chemical stabilization . . . . .	216
4.5. Sludge reuse . . . . .	219
4.5.1. Energy recovery. . . . .	219
4.5.2. Other byproducts of sludge recovery . . . . .	231
4.5.3. Conclusions on reuse . . . . .	238
4.6. Conclusion . . . . .	240
4.7. References . . . . .	240
<b>Chapter 5. Odor Treatment . . . . .</b>	<b>247</b>
5.1. General summary . . . . .	247
5.2. Choice of deodorization process . . . . .	251
5.3. Strategies for the biological removal of odorous products . . . . .	253
5.3.1. Physicochemical treatment. . . . .	254
5.3.2. Biological treatment . . . . .	264
5.4. References . . . . .	286
<b>Index. . . . .</b>	<b>289</b>