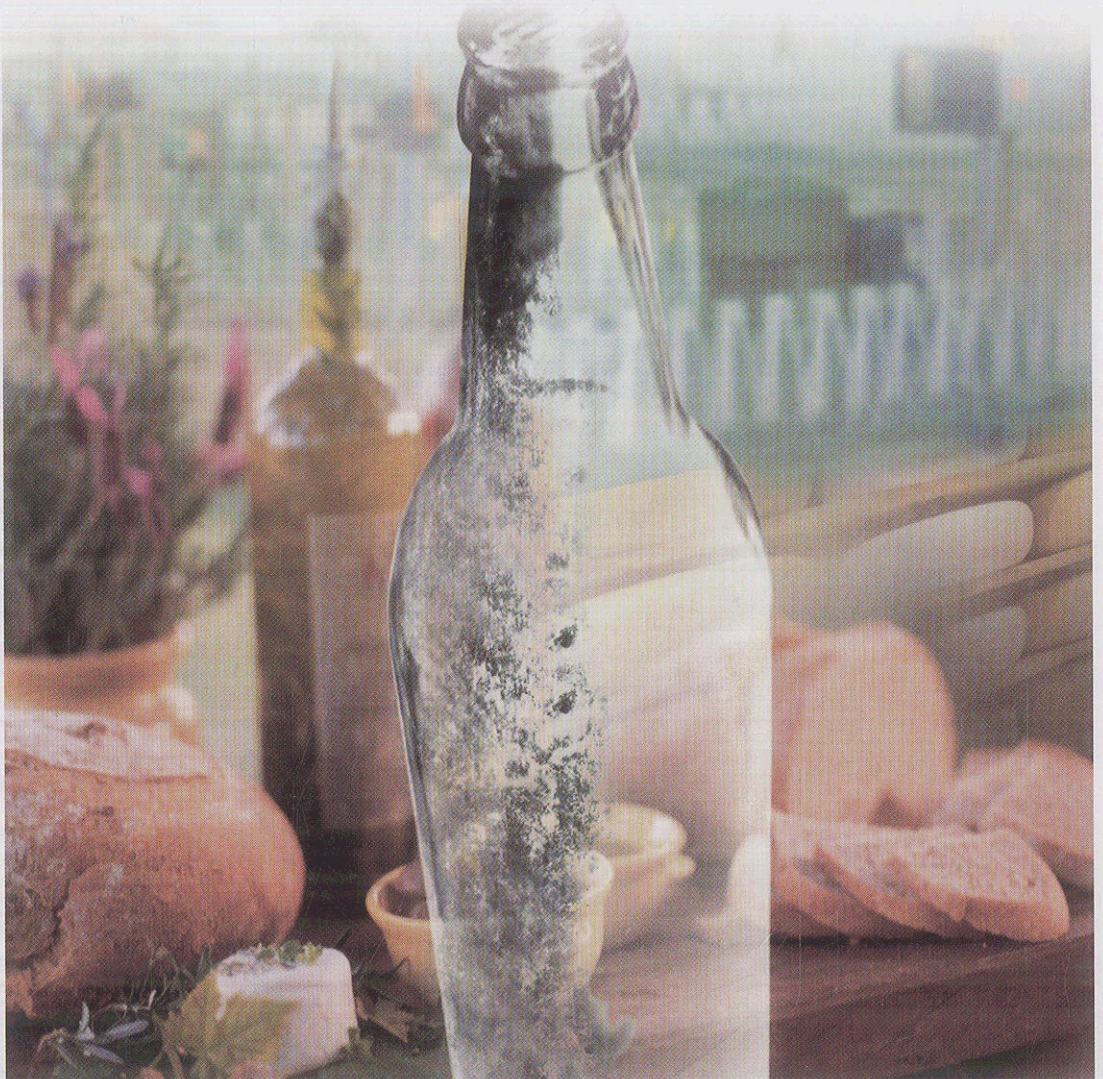


Mario Stanga

 WILEY-VCH

Sanitation

Cleaning and Disinfection in the Food Industry



Contents

Preface *XVII*

Acknowledgments *XXI*

Acronyms *XXIII*

Part One Chemistry and Problems of Industrial Water 1

1	Chemistry of Aqueous Solutions	3
1.1	Variables	5
1.1.1	Water	5
1.1.1.1	Hardness	7
1.1.1.2	Salinity	8
1.1.1.3	Alkalinity	8
1.1.1.4	pH	10
1.1.1.5	Conductivity	11
1.1.1.6	Scaling Tendency or Corrosion Tendency	13
1.1.2	Salts	15
1.1.2.1	Precipitation	16
1.1.2.2	Sequestration	19
1.1.2.3	Flocculation	26
1.1.2.4	Dispersion	27
1.1.2.5	Suspension	28
1.1.2.6	Anti-redeposition	30
1.1.3	Stability Constant	31
1.1.3.1	Theoretical Meaning	31
1.1.3.2	Practical Meaning	32
1.1.4	Critical pH	36
1.1.4.1	Effect on Bicarbonates	39
1.1.4.2	Effect on Phosphates	40
1.1.4.3	Effect on Sequestrants	41
1.2	Inorganic Competitors	43
1.2.1	Bicarbonates	43
1.2.1.1	Chemical Mechanism	43

1.2.1.2	Physical Mechanism	44
1.2.2	Silicates	44
1.2.3	Sulfates	45
1.2.4	Aluminates	49
1.2.5	Phosphates	51
1.3	Organic Competitors	53
1.3.1	Proteins	53
1.3.2	Starches	58
1.3.3	Fatty Acids	60
1.3.4	Other Carboxylic Compounds	63
1.3.5	Humic Substances	65
1.4	Self-Protected Contamination	67
1.5	Modifiers Affecting Deposits	68
1.5.1	Heating	69
1.5.1.1	Caramelization	70
1.5.1.2	Carbonization	70
1.5.2	Dehydration	71
1.5.3	Polymerization	72
	References	73
2	Chemical-Physical Treatment	77
2.1	Softening	77
2.2	Deionization	79
2.3	Dealkalinization	80
2.4	Reverse Osmosis	81
	Reference	82
3	Sequestrants	83
3.1	Definition	83
3.2	Coordination Groups	90
3.3	Sequestration Data	91
3.4	Food Cleaning Sequestrants	93
3.4.1	(Poly)phosphates	93
3.4.1.1	Hexametaphosphate (HEMP)	97
3.4.1.2	Pyrophosphate	98
3.4.1.3	Monomeric Phosphates	99
3.4.1.4	Tripolyphosphate	99
3.4.2	Phosphonates	100
3.4.2.1	Phosphonates and pH	103
3.4.2.2	Stability of Phosphonates	105
3.4.2.3	Phosphonates and Corrosion Inhibition	106
3.4.3	Hydroxy Acids	109
3.4.4	Poly(co-poly)acrylates	118
3.4.5	Aminopolycarboxylic Acids	131
3.4.6	Polysaccharides and Bentonites	143
	References	145

Part Two Characterization of Chemicals Used in the Sanitation Process 149

- 4 Laboratory Tests 151**
 - 4.1 Turbidimetric Tests 151
 - 4.1.1 Sequestration Test (Oxalate) 152
 - 4.1.2 Nephelometric Titration 153
 - 4.1.3 Sequestration Test (Hampshire) 153
 - 4.2 Suspension Test 154
 - 4.3 Dispersion Test 155
 - 4.4 Static Test of Scale Forming 155
 - 4.5 Dynamic Test of Scale Formation 156
 - 4.6 Static Test of Scale/Soil Dissolution 157
 - 4.7 Dynamic Test of the Dissolution of Scale/Soil 157
 - 4.8 Chemical Stability Test 157
 - 4.9 Solution Stability 158
 - 4.10 Sequestrant Stability 159
 - 4.11 EDTA and Calcium Titration 159
 - 4.11.1 Titration of EDTA 159
 - 4.11.2 Titration of Calcium Salts 160
 - References 160

- 5 Surfactants, Caustics, and Acids 161**
 - 5.1 Surfactants 161
 - 5.1.1 HLB 162
 - 5.1.2 Grouping of Surfactants 164
 - 5.1.2.1 Anionic Surfactants 165
 - 5.1.2.2 Nonionic Surfactants 166
 - 5.1.2.3 Cationic Surfactants 167
 - 5.1.2.4 Amphoteric Surfactants 167
 - 5.1.3 Defoamers 168
 - 5.1.4 Wetting Agents 169
 - 5.1.5 Cleaning Agents 172
 - 5.1.6 Disinfectants 172
 - 5.1.7 Structural Boosters 174
 - 5.1.8 Biodegradability and Toxicity 174
 - 5.1.9 BPD and REACH 175
 - 5.2 Caustics 176
 - 5.3 Acids 179
 - References 181

Part Three Application to the Food Industry 183

- 6 Bottlewashing 185**
 - 6.1 Pre-washing 189
 - 6.2 Caustic Zone 189

6.2.1	Modifications Induced by Alkalinity	190
6.2.2	Label Removal	194
6.2.3	Self-Adhesive Labels	201
6.2.4	Ceramic Labels	202
6.2.5	Mold Removal	204
6.2.6	Plastic Bottles	207
6.2.6.1	Procedure for Testing for Stress Cracking due to Cleaning Solutions	211
6.2.6.2	Procedure for Testing for Haze Suppression	212
6.2.6.3	Procedure for Screening Defoamer Rinsability	212
6.2.7	Exhausted Solution	213
6.2.8	Sequestrants in Washing	214
6.2.8.1	Polyphosphates and Phosphates	215
6.2.8.2	Gluconate and Gluconic Acid	215
6.2.8.3	Phosphonates	216
6.2.8.4	Phosphono-Carboxylate Polymers	217
6.2.8.5	Acrylic Polymers	217
6.2.8.6	EDTA and NTA	217
6.2.8.7	Polysaccharides and Bentonites	219
6.3	Rinse Section	219
6.3.1	Rinse Design and Chemicals Application	221
6.3.1.1	Second Rinse	223
6.3.2	Sequestrants of Rinse	224
6.3.3	Inlet Position	227
6.4	Environmental Impact from Labels	228
6.5	Outcoming Bottles	228
6.5.1	Non-homogeneous Coating of Water on the Bottles	229
6.5.2	Bottles React with Phenolphthalein	229
6.5.3	Bottles Dry Leaving Whitish Streaks or Foggy Glass	230
6.5.4	Homogeneous White Scale Covers Bottles	230
6.5.5	External Non-homogeneous Deposit on the Bottle	230
6.5.6	Bottles Contain Residues	231
6.5.7	Bottles Drain Leaving More than 2 Drops of Water	231
6.5.8	Bottles Sparkling when Just Filled	232
6.5.9	Just-Filled Bottles Contain Micro-Bodies (or Some Time After Filling)	232
6.6	Microbiological Condition of a Bottlewasher	232
6.7	What Can or Cannot Be Cleaned	234
6.7.1	Removable Organic Soils	235
6.7.2	Inorganic Soil Removable with Acids	236
6.8	Concepts of Problem Solving in Cleaning Bottles	236
6.8.1	Glass Bottles	236
6.8.2	Plastic Bottles (PET, PEN)	237
6.8.3	Plastic Bottles (PC-HOD)	238
6.9	Cold Aseptic Filling (CAF)	238

- 6.9.1 CAF Technology 239
- 6.9.2 Microbiological Sensitiveness 241
- 6.9.3 Cleaning Programs 242
- References 244

- 7 Lubrication 247**
- 7.1 Theory of Lubrication 247
- 7.1.1 Friction 248
- 7.1.2 Lubricity 250
- 7.1.3 Variables of Lubrication 253
- 7.1.3.1 Quantity of Solution on the Track 254
- 7.1.3.2 Quantity of Lubricant on the Track 254
- 7.1.3.3 Speed of the Track 255
- 7.1.3.4 Temperature of the Track 256
- 7.1.3.5 Friction and Micro-friction 256
- 7.1.3.6 Dry Tracks 257
- 7.1.3.7 Bottles, Cans, and Composite Containers (Cartons) 257
- 7.1.3.8 Type of Beverage 259
- 7.2 Soap-based Lubrication 260
- 7.2.1 Buffering Power and Alkalinity Donors 261
- 7.2.2 Types of Fatty Acids and their Concentration 263
- 7.2.3 Sequestrants 265
- 7.2.4 Keeping Tracks Clean 266
- 7.2.5 Fluidifying and Antigelling 267
- 7.2.6 Foam Control 268
- 7.3 Amine-Based Lubricants 269
- 7.3.1 Types of Lubricating Molecules 270
- 7.3.2 Anionic Interference 272
- 7.3.3 Sequestrants 274
- 7.3.3.1 Glycine 276
- 7.3.3.2 Lauryldimethylamine [$\text{CH}_2(\text{lauryl})\text{CH}_2\text{-N}(\text{CH}_3)_2$] (LDMA) 277
- 7.3.3.3 Fatty Alcohol Ethoxy Carboxylate (FAEC) 278
- 7.3.4 Cleaning and Microbial Control 279
- 7.3.5 Biofouling in the Delivery Plant 281
- 7.3.6 Chlorine Dioxide in Preventing Biofouling 283
- 7.3.7 Foam Control 284
- 7.4 Imidazoline-Based Lubrication 285
- 7.5 Lubrication Based on Fatty Quaternary Ammonium Compounds (FQACs) 286
- 7.6 Silicone-Based Lubricant 288
- 7.7 Dry Lubrication 290
- 7.8 Stress Cracking 294
- 7.9 Concepts of Problem Solving in Lubrication 297
- References 299

- 8 CIP (Cleaning in Place) 301**
 - 8.1 CIP Classification 302
 - 8.1.1 Total Loss CIP 302
 - 8.1.2 Partial Recovery CIP 303
 - 8.1.3 Total Recovery CIP 304
 - 8.2 CIP Parameters 304
 - 8.2.1 Flow Velocity 306
 - 8.2.2 Flow Rate 307
 - 8.2.3 Temperature 309
 - 8.3 Dairy 310
 - 8.3.1 Treatment with Heat Exchange 311
 - 8.3.1.1 Conversion of Stainless Steel Oxides 316
 - 8.3.2 Raw Milk Line 316
 - 8.3.3 Separator 318
 - 8.3.4 Churning 319
 - 8.3.5 Curdmaking Process 320
 - 8.4 Processed Food 324
 - 8.4.1 Evaporator 326
 - 8.4.2 Dough-Kneading Machine and Extruder 328
 - 8.4.3 Pasteurizer and Sterilizer 328
 - 8.4.4 Cooking, Baking, and Frying 332
 - 8.4.5 Smoke Chambers 335
 - 8.4.6 Blanching 336
 - 8.4.7 High-Temperature Scraped Sterilizer 338
 - 8.4.8 Fresh Cut Produce (4th Gamme) 339
 - 8.4.8.1 Cleaning and Disinfection Procedures 344
 - 8.4.9 Mechanical Cleaning of Equipment 347
 - 8.5 Winery 349
 - 8.5.1 Cleaning in the Cellar 349
 - 8.5.2 Stabilization of Wine 351
 - 8.5.3 Cleaning and Disinfection of Wooden Barrels 352
 - 8.5.3.1 Disinfection of Wood 353
 - 8.6 Enzymatic Cleaning in Food Detergency 355
 - 8.6.1 Protease 357
 - 8.6.2 Lipase 358
 - 8.6.3 Amylase 358
 - 8.7 Chemicals for Cleaning Tenacious Contamination 358
 - References 360
- 9 Acidic Cleaning 363**
 - 9.1 Infinite Dilution 364
 - 9.2 Sequestrants 364
 - 9.3 Cleaning of Molds 366
 - 9.4 Cleaning of Chocolate Molds 368
 - 9.5 Acidic Cleaning in a Brewery 370

- 9.5.1 Acids 372
- 9.5.2 Sequestrants 372
- 9.5.3 Surfactants 373
- References 373

10 Open Aqueous Systems Exchanging Heat 375

- 10.1 Tunnel Pasteurizers 375
 - 10.1.1 Deposition and Scale 377
 - 10.1.2 Microbiology 378
 - 10.1.3 Corrosion 378
 - 10.1.4 Dome Staining 381
 - 10.1.5 Chemical Treatments 382
 - 10.1.5.1 Scale and Biofouling 382
 - 10.1.5.2 Corrosion 383
 - 10.1.5.3 Packaging Damage 383
- 10.2 Cooling Tower 383
- References 385

11 Foam and Gel Cleaning 387

- 11.1 Foam 388
- 11.2 Gel 390
- 11.3 Foam-Gel Synergism 390
- 11.4 Body Structure 393
- 11.5 Sequestrants 394
- 11.6 Foam/Gel Free OPC 396
- 11.7 Practical Problem Solving in OPC 396
 - 11.7.1 Bluish Stains 396
 - 11.7.2 Yellowish-White Stain 397
 - 11.7.3 Fat Removal in Patches 397
- 11.8 Equipment for Pressure Washing 398
 - 11.8.1 Centralized Equipment 399
 - 11.8.2 Decentralized Equipment 399
 - 11.8.3 Loss in Pressure 400
 - 11.8.4 Loss in Temperature 400
 - 11.8.5 Generation of Aerosol 402
- References 402

12 Membrane Cleaning (Crossflow Filtration) 403

- 12.1 Membrane 406
- 12.2 Module 410
 - 12.2.1 Plate and Frame 410
 - 12.2.2 Hollow Fibers 411
 - 12.2.3 Tubular 412
 - 12.2.4 Spiral Wound (SW) 413
 - 12.2.5 Pleated 414

12.2.6	Modules	414
12.3	Diafiltration and Chromatography	416
12.4	Electrodialysis	418
12.5	Ultrasound Applied to Membrane Processings	419
12.6	Fields of Application	419
12.7	Cleaning	420
12.7.1	Alkalinity	421
12.7.2	Sequestrants	422
12.7.3	Surfactants	423
12.7.4	Enzymatic Systems	423
12.7.5	Acids	424
12.8	Cleaning Procedures	425
	References	427
13	Milk Production	429
13.1	Mastitis	429
13.2	Cow and Milk	431
13.3	Milking CIP	434
13.4	Bulk Milk Tanks	438
13.5	Raw Milk Quality Standards	439
	Reference	440
14	Biofilm	441
14.1	Microbiological Background	441
14.2	Formation and Growth of Biofilm	445
14.2.1	Surface Condition	447
14.2.2	Environmental Conditions	448
14.3	Practical Significance	448
14.4	Cleaning and Disinfection	451
14.4.1	Alkaline Cleaning	452
14.4.2	Acidic Cleaning	452
14.4.3	Disinfection	452
	References	457
15	Environmental Sanitation	459
15.1	Environmental Particles	459
15.2	Physical Control	462
15.2.1	Air Filtration and Clean Rooms	462
15.2.2	Ultraviolet Radiation	464
15.3	Control by Chemicals	467
15.3.1	Atomization and Aerosolization	467
15.3.2	Chemicals	468
15.3.2.1	Aldehydes	469
15.3.2.2	Nitrogen Derivatives	469

- 15.4 Mold Control and Prevention 469
 - References 471

- 16 Ultrasound Cleaning 473**
 - References 476

- 17 Corrosion and Corrosion Inhibition 477**
 - 17.1 Calculation and Monitoring of Corrosion 477
 - 17.1.1 Intensity and Rate 478
 - 17.1.2 Electrochemistry 479
 - 17.2 Stainless Steel and Chloride 484
 - 17.3 Chromium and Chemicals 486
 - 17.4 Aluminium and Caustics/Acids 488
 - 17.5 Copper and its Alloys 489
 - 17.6 Zinc (Galvanized Steel) 490
 - 17.7 Biofilm 491
 - 17.8 Reliability of Supply 491
 - 17.9 Post-Installation Treatment of Stainless Steel 493
 - 17.9.1 Procedures and Recommendations 495
 - 17.9.2 Example of Complete Program 495
 - 17.9.3 Example of Simplified Program 496
 - 17.9.4 Gaskets 496
 - References 497

- 18 Disinfectants and Sanitation Technology 499**
 - 18.1 Water 500
 - 18.2 Manufacturing Environment and Types of Microorganisms 502
 - 18.3 Disinfectants 504
 - 18.3.1 Main Disinfectants for the Food Industry 506
 - 18.3.2 Biocides from the Haber-Willstätter Reaction 506
 - 18.3.3 How to Choose a Disinfectant 512
 - 18.3.3.1 Basic Behavior Typifying the Application of Disinfectants 514
 - 18.4 Physical Disinfection 521
 - 18.4.1 Disinfection by Heating 521
 - 18.4.2 Disinfection by UV Radiation 524
 - 18.4.3 Disinfection by Filtration 525
 - 18.4.4 Disinfection by Electrolyzed Water 527
 - 18.4.5 Disinfection by Cold Plasma 529
 - 18.4.6 Disinfection by High Pressure 531
 - 18.4.7 Disinfection by Pulsed Electric Field 532
 - 18.5 Regularity and Perseverance in Sanitation 534
 - 18.6 Sanitation Plan 536
 - 18.6.1 Early Stage 536
 - 18.6.2 Planning 537

18.6.3	Validation	537
18.6.4	Application	537
18.6.4.1	Assessment of the Sanitation Result	538
18.7	Rapid Controls of Sanitation	539
18.7.1	Bioluminometer	540
18.7.2	Proteins Test	540
18.8	European (EN) Microbiological Tests	541
18.8.1	Bactericidal Activity	542
18.8.1.1	EN 1040	542
18.8.1.2	EN 1276	543
18.8.1.3	EN 1656	543
18.8.1.4	EN 13727	543
18.8.2	Fungicidal Activity	543
18.8.2.1	EN 1275	543
18.8.2.2	EN 1650	543
18.8.2.3	EN 1657	544
18.8.2.4	EN 13624	544
18.8.3	Sporicidal Activity	544
18.8.3.1	EN 14347	544
18.8.3.2	EN 13704	544
18.8.4	Main Tests Methodology	544
18.8.4.1	NF EN 1276 Procedure	544
18.8.4.2	NF EN 1650 Procedure	545
18.8.4.3	NF EN 13697 Procedure	546
18.8.4.4	NF EN 13704 Procedure	547
18.9	Hand Washing and Disinfection	547
18.9.1	Handwashing Products Structure	549
18.9.2	Handwashing Disinfectants	550
18.9.2.1	Products Performing Cleaning and Disinfection	551
18.9.2.2	Products for Terminal Disinfection after Washing	552
	References	552

19 Waste Water Treatment 555

19.1	Understanding Terms	555
19.2	Purification Process	557
19.2.1	Preliminary Treatments	557
19.2.2	Chemical Treatment	558
19.2.3	Settling, Concentration, and Dewatering	559
19.2.4	Biological Treatment	561
19.2.5	Final Treatments	563
	References	564

20 Boiler Treatment 565

20.1	Deaeration and the Generation of Noncorrosive Steam	565
20.1.1	Generation of Noncorrosive Steam	567

20.2	Scale Prevention	568
20.3	Chemical Treatments	571
20.4	Chemical Cleaning	571
	References	573
21	Due Diligence (HACCP)	575
	Index	577