

Index

- A**
- Abiotic degradation, 53–54
 - Abiotic desorption, 191, 211
 - ABS. *See* Acrylonitrile butadiene styrene (ABS)
 - AC. *See* Activated carbon (AC)
 - Acclimation, 49, 56, 57–58, 63, 68, 80, 108, 193–194, 199, 207, 221, 335, 358
 - Acetic acid, 112, 301, 328
 - Acetone, 96
 - Acid Orange II, 111
 - Acid Orange 7, 111
 - Acinetobacter*, 307
 - Acrylonitrile butadiene styrene (ABS), 99
 - Acrylonitrile manufacturing wastewater, 103
 - Activated carbon (AC), 13
 - adsorption, 7–8, 18–19
 - in anaerobic treatment, 81
 - ash content, 15
 - biodegradable and nonbiodegradable organics on, 56
 - biological regeneration of, 59
 - biological sludge properties with, 81–82
 - bioregeneration of, 217–229, 361–363
 - in drinking water treatment, 363
 - in micropollutants, 362
 - carbon activation, 29, 197
 - chemically activated carbon, 21, 29, 193, 202, 257, 259, 269, 360
 - thermally activated carbon, 21, 29, 193, 197, 256, 257, 274, 360
 - characteristics of, 14–15
 - density, 153
 - in drinking water treatment, 4–5
 - enhancement of denitrification by, 80
 - enhancement of nitrification by, 78
 - enhancement of organic carbon removal by, 78
 - in environmental media, 7
 - in environmental pollution, 4
 - grade, 202, 360–361
 - heterogeneity of, 21
 - historical appraisal of, 1–3
 - in industrial wastewater treatment, 6
 - for inorganic species, 80
 - for membrane filtration, 85–86
 - for microbial products, 83–85
 - microcrystallites, 14–15
 - microorganisms
 - attachment and growth of, 59
 - natural organic matter
 - adsorbability of, 255–258
 - desorbability of, 258–259
 - particle size, 15, 16, 85
 - physicochemical regeneration of, 363
 - pollutants, control of, 8–10
 - pore volume, 13, 292
 - porosity, 1, 203
 - preparation of, 13–14
 - raw materials
 - charcoal, 14
 - coal, 14
 - coconut shell, 2, 13, 99
 - coke, 13, 14
 - lignite, 13, 14
 - wood, 13, 14
 - reactivation, 37–39
 - regeneration, 37–39
 - saturation, 204, 213
 - in secondary treatment, 46
 - sorption onto, 53
 - substrates concentration, 58
 - surface area, 1
 - surface functional groups, 15, 21
 - in tertiary treatment, 46–47
 - for toxic and inhibitory substances, 56–58
 - types, 15
 - granular activated carbon (GAC), 16
 - powdered activated carbon (PAC), 15
 - use of, 1, 3–4
 - volatile organic compounds (VOCs) on, 58
 - in wastewater treatment, 5–6
 - in water treatment, 246–247
 - granular activated carbon (GAC) filtration, 247
 - powdered activated carbon (PAC) addition, 246

- Activated carbon adsorption,
 - 6, 18, 43, 127, 177
 - with biological processes, 7
 - in wastewater treatment, 7
 - in water treatment, 8
- Activated carbon
 - manufacturing, 13
 - Bayer, 3
 - Norit, 2–3
 - Purit, 2
- Activated carbon reactors, 30
 - GAC adsorbers, 30
 - breakthrough curves, 34–37
 - operation of, 31–34
 - purpose of use, 30
 - types of, 30–31
 - PAC adsorbers, 30
- Activated sludge process, 70–71
 - conventional, 68, 72, 73, 74, 102, 111, 134
 - Powdered Activated Carbon Treatment (PACT), 7–8, 69, 98, 99, 100–101, 102, 110, 127–128
- Adenosine triphosphate (ATP), 242, 306
- Adsorbability, 255
 - characteristics of, 54
 - of Natural Organic Matter (NOM), 254, 255–258
 - of organic matter
 - in raw and ozonated waters, 255–259
- Adsorbable Organic Xenobiotics (AOX), 10, 62, 112
- Adsorbate, 16
 - aromaticity, 255
 - hydrophobicity, 21
 - physical and chemical characteristics of, 18–19
 - polarity, 19
 - solubility, 17, 18–19
- Adsorbed organics, 59, 87, 190, 215
- Adsorbents, 16
 - abrasion number, 33
 - apparent density, 33
 - iodine number, 33
 - molasses number, 33
 - particle density, 33
 - porosity, 20–21
 - shape, 20, 33
 - size, 20, 33
 - surface area, 33
 - type, 33
- Adsorbers
 - bed area, 33
 - bed volume (BV), 34
 - breakthrough curve, 34–37
 - breakthrough time, 36
 - carbon depth, 31
 - carbon usage rate (CUR), 34
 - contact time, 32–33
 - effective contact time, 33
 - empty bed contact time (EBCT), 32–33
 - filter operation time, 34
 - filter velocities, 33–34
 - hydraulic loading rate (HLR), 31, 33
 - interstitial velocity, 34
 - mass transfer zone (MTZ), 34, 37
 - reactivation, 37–38
 - superficial linear velocity, 33
 - throughput volume, 34
 - void ratio, 160
 - wave front, 35
- Adsorbing media, 153
- Adsorption, 16, 53
 - adsorption energy, 17, 211
 - adsorption enthalpy, 18
 - adsorption equilibrium and isotherms, 24
 - BET (Brunauer, Emmett, Teller), 27
 - Freundlich, 25–27
 - Fritz–Schluender, 228
 - Langmuir, 26–27
 - adsorption kinetics, 18, 22, 36
 - adsorption reversibility. *See* Hysteresis
 - and biological removal, 268–269
 - chemical adsorption, 17, 18
 - chemical bonding, 15, 17
 - competitive adsorption, 28–29
 - coverage, 18
 - equilibrium and isotherms, 24–27
 - factors influencing, 18
 - chemical surface characteristics, 21–22
 - pH value, 19–20
 - physical and chemical characteristics of adsorbate, 18–19
 - porosity of adsorbent, 20–21
 - surface area of adsorbent, 18
 - temperature, 20
 - irreversible adsorption, 29, 196, 197, 198, 200, 202, 204, 205, 208, 211, 222, 259
 - kinetics of, 22
 - adsorption bond, 24
 - bulk solution transport (advection), 22–23
 - external diffusion, 23
 - intraparticle (internal) diffusion, 23
 - mono- and multilayer adsorption, 20
 - multisolute adsorption, 28–30
 - of nonphenolic compound, 197
 - of phenolic compounds, 197
 - physical adsorption, 17, 18, 24
 - reversibility of, 195–198
 - single solute adsorption, 27–28
 - types of, 16–17
- Adsorption and biodegradation
 - characteristics of water, 250–260
 - determination of, 255–259
 - NOM characteristics, ozonation impact on, 250–251
 - adsorbability, change in, 255
 - biodegradability, increase in, 251–254
 - raw water NOM, 250
- Adsorption capacities
 - direct measurement by, 213

- Adsorption-induced acclimation, 193–194
- Adsorption isotherm, 24, 154, 211–212, 256
- Adsorption models
- Ideal Adsorbed Solution (IAS) model, 28
 - Ideal Adsorbed Solution Theory (IAST), 28, 177, 227, 334
 - Improved Simplified Ideal Adsorbed Solution (ISIAS) model, 28
 - Simplified Ideal Adsorbed Solution (SIAS) model, 28, 29
- Advanced Oxidation Processes (AOPs), 47, 97, 118
- Advective transport, 170
- Aerobic PACT, 46
- Aerobic systems, respirometry in, 215
- Afiopia*, 307
- AFLP. *See* Amplified Fragment Length Polymorphism (AFLP)
- Alcaligenes*, 306
- Aldehydes, 252, 273, 302
- Algae, 239, 326–327
- Aliphatics, 6
- aliphatic acids, 6
 - and aromatic hydrocarbons, 5, 288
 - chlorinated aliphatics, 14, 79, 185
 - *cis*-1,2-dichloroethene, 304
 - *trans*-1,2-dichloroethene, 304
 - trichloroethylene (TCE), 54, 105, 215, 290
 - vinyl chloride, 133
- 17 α -Ethinylestradiol (EE2), 52, 53, 55
- α -Proteobacteria, 307
- Amines, 288
- Ammonia in water treatment systems, 278–282
- Ammonia monooxygenase enzyme (AMO), 298
- Ammonia oxidizing bacteria (AOB), 78, 308
- Ammonia removal, 285, 308
- importance of, 285–286
- Ammonium, 78, 79, 238, 301
- AMO. *See* Ammonia monooxygenase enzyme (AMO)
- amoA (ammonia monooxygenase gene), 308
- Amoco refinery, 98
- Amplified Fragment Length Polymorphism (AFLP), 307
- Anaerobic–aerobic PACT, 46
- Anaerobic PACT[®], 46, 74
- Anaerobic systems, bioregeneration in, 216–217
- Anaerobic treatment, activated carbon in, 81
- Aniline, 54, 198, 288
- Anoxic systems, bioregeneration in, 216–217
- Anthracene, 209
- Anthracite, 66, 68, 99, 157, 273
- AOB. *See* Ammonia Oxidizing Bacteria (AOB)
- AOC. *See* Assimilable Organic Carbon (AOC)
- AOCl (Adsorbable Organic Chlorine), 10
- AOC limits, in water distribution, 319–320
- AOPs. *See* Advanced Oxidation Processes (AOPs)
- AOX. *See* Adsorbable Organic Xenobiotics (AOX)
- Aromatics
- aromatic acids
 - benzoic acids, 14, 118
 - benzene, 14, 22, 87, 104, 105, 106, 110, 138, 182, 183
 - chlorinated aromatics, 5, 14, 130
 - benzenes
 - 1,2-dichlorobenzene, 106, 110, 134, 182, 183, 304
 - 1,4-dichlorobenzene, 304
 - trichlorobenzene (TCB), 106, 134, 182, 183, 184
 - phenolics
 - chlorophenol, 29, 50, 87, 107, 108, 134, 194, 199, 205, 207, 209
 - pentachlorophenol (PCP), 108, 110, 206, 217, 327
 - phenol
 - phenolics
 - ethylphenol, 108
 - isopropylphenol, 200
 - methylphenol, 108
 - nitrophenol, 87, 107, 110
 - polynuclear aromatics, 5, 14
 - toluene, 14, 50, 96, 105, 106, 118, 134, 138, 182, 183, 208, 224, 225
- Arthrobacter viscosus*, 108
- Assimilable organic carbon (AOC), 240–242, 252
- modifications in, 242
- ATP. *See* Adenosine triphosphate (ATP)
- Atrazine, 206, 289–290, 291, 321, 346–347
- Azo dyes, 110–111, 210
- B**
- BAC-FBR, 68
- BAC filters. *See* Biological activated carbon (BAC) filters
- BAC filtration. *See* Biological activated carbon (BAC) filtration
- BAC reactors. *See* Biological activated carbon (BAC) reactors
- Bacillus*, 307
- Backwashing, 276
- biomass loss, 276
 - chlorinated water, 276
 - oxidant residuals, 277
- BAC-Sequencing Batch Reactors (BAC-SBR), 112, 227
- BAC sludge, 86–87

- Bacteria
 - ammonia oxidizing bacteria (AOB), 78, 308
 - autotrophic bacteria, 78, 103
 - cocci-shaped, 216
 - filamentous, 216
 - heterotrophic bacteria, 78, 80, 304
 - nitrite oxidizing bacteria (NOB), 78, 308
- Bacterial re-growth/aftergrowth, definition of, 238
- BAF. *See* Biological Aerated Filter (BAF)
- BAR. *See* Biofilm annular reactor (BAR)
- BASM. *See* Biodegradation/adsorption–screening model (BASM)
- BDOC. *See* Biodegradable Dissolved Organic Carbon (BDOC)
- Bed configurations
 - expanded bed, 31, 63, 69, 346
 - fixed bed, 31, 175
 - fluidized bed, 31, 68
 - moving bed, 31, 347
 - packed bed, 23, 166
- Bed Volume (BV), 34
- Bentazon, 291, 347
- Bentonite, 111
- Benzene, 87, 105, 110, 134, 182, 183, 210, 289, 304
- Benzoic acids, removal of, 118
- BET (Brunauer, Emmett, and Teller) isotherm, 25, 27
- 17 β -Estradiol (E2), 55, 109
- β -Proteobacteria, 307
- Bezafibrate, 52
- BFAC model. *See* Biofilm on activated carbon (BFAC) model
- BFR. *See* Biofilm Formation Rate (BFR)
- BGAC. *See* Biological granular activated carbon (BGAC)
- Bioavailability, 48
- Biocarbonate, 68
- Biocides, 101, 288
- Biodegradability, 199–200, 252–254
- Biodegradable Dissolved Organic Carbon (BDOC), 240, 251, 265, 284
 - modifications in, 242
 - in water distribution, 319–320
- Biodegradable fraction, 48, 78, 96, 114
 - measurement of, in NOM, 239–243
- Biodegradable organic compounds, 225, 358
- Biodegradable organic matter (BOM), 48, 78, 199, 238, 265, 274, 332
 - assimilable organic carbon (AOC), 240–242
 - biodegradable dissolved organic carbon (BDOC), 240, 251, 265, 284
- Biodegradation, 48, 293
 - abiotic degradation/removal, 53–54
 - biological removal
 - of micropollutants, 50–52
 - of organic substrates, 49
 - characteristics of, 54
 - cometabolism, 50, 208
 - and concurrent adsorption
 - bioregeneration in, 218–219
 - fractionation of organic matter in wastewater, 48
 - models
 - first-order, 168, 228–229
 - Haldane, 228
 - Monod, 151, 183, 334
 - organic substrates, biomass, and activation carbon, 54
 - primary substrate, 49, 50
 - reductive dechlorination, 105
 - secondary substrate utilization, 49–50
 - sorption onto activated carbon, 53
 - sorption onto sludge, 52–53
- Biodegradation/adsorption–screening model (BASM), 225, 227
- Biodegradation products, measurement of, 214–215
- Biofilm
 - backwashing, 276, 308
 - biofilm-carbon boundary, 67, 154, 172
 - biofilm density, 155
 - biofilm kinetics, 146, 151
 - biofilm loss, 164
 - biofilm thickness, 154–155, 161, 171, 174, 204, 220, 346
 - detachment, 157
 - dispersion coefficient, 33, 160, 163, 170, 171
 - growth, 65, 154–155, 175, 223, 225, 304, 346
 - mass transfer coefficient, 148, 166, 171, 224, 337
 - models, 221, 222
 - BFAC model, 174, 175, 219, 223
 - MDBA model, 227
 - molecular diffusivity, 148, 149, 151, 338
 - substrate utilization, 151, 181
- Biofilm annular reactor (BAR), 243
- Biofilm–carbon system, dimensionless numbers in, 169–173
- Biofilm formation, 57, 59
- Biofilm Formation Rate (BFR), 243
- Biofilm growth and loss, 154–155
- Biofilm growth control, in BAC filters, 305
- Biofilm on activated carbon (BFAC) model, 174, 175, 219, 223
- Biofilters
 - anthracite-sand filters, 276
 - GAC-sand filters, 273, 276
 - sand biofilter, 307, 308
- BIOFILT model, 339–340
- Biofouling, 8, 75–76, 195
- Biological activated carbon (BAC), conversion of GAC into, 64–65
 - advantages of BAC process, 66

- BAC versus GAC operation, 66
- removal mechanisms and biofilm formation in BAC operation, 65–66
- Biological activated carbon (BAC) filters, 100, 108, 141, 142, 146, 269, 283–285, 291, 293, 297, 299, 303, 304, 305
- adsorption and biodegradation, 269–270
- biofilm growth control, 305
- biomass and microbial activity determination in, 305
- bioregeneration of, 272–273
- DBP precursors removal in, 295
- haloacetic acids (HAAs) removal in, 297
- heterotrophic biomass and activity in, 306–308
- microbial ecology of, 303
- microbiological safety, of finished water, 309
- nitrifying biomass and activity in, 308–309
- nutrient removal in, 285
- ammonia removal, 285–286
- denitrification, 286–287
- nitrification, factors affecting, 285–286
- organics removal in, 277
- preozonation, relevance of, 284–285
- trihalomethanes (THMs) removal in, 297
- Biological activated carbon (BAC) filtration, 8, 109, 127, 140, 237, 238, 244, 247, 273, 297, 331, 354–355, 359
- adsorption and biological processes, models integrating, 342–345
- adsorptive and biological removal, 334
- adsorptive removal only, 333–334
- BDOC and AOC limits, in water distribution, 319–320
- BIOFILT model, 339–340
- biological processes in, 334–342
- biological removal in, 334
- bromate removal in, 298–301
- CHABROL model, 335
- current use of, in water treatment, 249–250
- domestic and industrial wastewaters reclamation for nonpotable uses, 141–142
- domestic wastewater reclamation for drinking purposes, 140–141
- empirical models, 333
- empty-bed contact time (EBCT), 274–276, 338–339
- filter backwashing, 276
- in full-scale groundwater treatment, 327–329
- in full-scale surface water treatment, 320–326
- Granular Activated Carbon (GAC), 273
- activation, 274
- biomass attachment, 273
- characteristics effects, on adsorption, 290
- coal- and wood-based GAC, 274
- removal performance, 273
- haloacetic acids (HAAs) removal, in BAC filters, 297
- cometabolic removal, 297–298
- metabolic removal, 297
- history of, in water treatment, 247–249
- hydraulic loading rate (HLR), 274–276
- initial models in, 334–335
- ionic pollutants removal, 298
- micropollutants removal, models describing, 346–348
- multiple species inside drinking water biofilters, 341–342
- nitrate removal in, 298
- organic micropollutant groups in, 291
- Disinfection By-Products (DBP) precursors removal, 294, 295
- geosmin and MIB, 292
- microcystins, 293
- pesticides, 291
- pharmaceuticals and endocrine disrupting compounds (EDCs), 291
- organic micropollutants in water, 288
- NOM and, 288–290
- adsorption onto preloaded GAC, 290
- oxidant residuals, effect of, 277
- ozonation and, 249, 327
- perchlorate removal in, 301
- physicochemical regeneration of, 363–364
- process-based models, 333
- sewage treatment for reuse in agriculture, 140
- temperature, effect of, 276
- trihalomethanes (THMs) removal, 297
- cometabolic removal, 297
- metabolic removal, 297
- Uhl's model, 335–337
- Wang and Summers, model of, 337–338
- Biological Activated Carbon (BAC) process, 8, 44
- Biological activated carbon (BAC) reactors, 44, 99, 100, 105, 111
- carbon properties, in modeling, 177–178
- characterization, by dimensionless numbers, 164–173
- biofilm–carbon system, 169–173
- dimensionless parameters, 165
- first-order kinetics inside biofilm, 168–169

- Biological activated carbon (BAC) reactors"
 - (continued)
 - mass transfer equations, 165–166
 - reactor mass balance, 166–167
 - zero-order kinetics inside biofilm, 167–168
 - high substrate concentrations, 175–176
 - initial steps in modeling, 173
 - integration of adsorption into models, 174–175
 - landfill leachate treatment in, 118–120
 - substrate removal and biofilm formation, 173–174
 - three-phase fluidized bed reactor, 177
 - very low substrate conditions, 176–177
- Biological activated carbon (BAC) systems, concurrent bioregeneration in, 195
- Biological aerated filter (BAF), 68, 100
- Biological granular activated carbon (BGAC), 237
- Biologically treated water, 256, 258, 259
- Biological Membrane Assisted Carbon Filtration (BioMAC), 76
- Biological nitrogen removal, 250
- Biological processes, in water treatment, 238
- Biological rapid sand filtration (BSF), 249
- Biological regeneration of activated carbon, 59
- Biological removal of micropollutants, 50–52
- Biological sludge, properties of, 81
 - dewaterability of sludge, 82
 - sludge settling and thickening, 81
- Biological stability/instability, 238
 - AOC, 10, 240–242, 251
 - BDOC, 240, 251, 265, 284
- BioMAC. *See* Biological Membrane Assisted Carbon Filtration (BioMAC)
- Biomass
 - acclimated, 51, 193–194, 199, 214, 301, 328
 - activity
 - ATP measurement, 306
 - heterotrophic biomass, 306–308
 - nitrifying biomass, 308–309
 - attachment, 273
 - concentration, 68, 205–206, 242, 344
 - configuration
 - fixed-growth, attached-growth (biofilm), 44, 66
 - hybrid, 81
 - suspended-growth, 44
 - and microbial activity determination, in BAC filters, 305
 - nonacclimated, 108, 199
- Biomass respiration method (BRP), 306
- Biomembrane operation assisted by PAC and GAC, 74
 - membrane-assisted biological GAC filtration, 76
 - membrane bioreactors (MBRs), 74
 - PAC-MBR process, 75
- Biopolymers, 244, 268, 323
- Bioregenerated carbon, 107, 195, 208, 360
- Bioregeneration, 59, 189, 211, 219, 361
 - anaerobic/anoxic systems, 216–217
 - bioregeneration conditions, 362–363
 - concurrent bioregeneration, 195
 - definition of, 189
 - determination of, 209–216
 - adsorption capacities, direct measurement by, 213
 - adsorption isotherms, use of, 211–212
 - biodegradation products, measurement of, 214–215
 - quantification, 213–214
 - respirometry, in aerobic systems, 215
 - reversible adsorption, extent of, 211
 - scanning electron microscopy (SEM), 216
 - solvent extraction, direct measurement by, 213
 - in drinking water treatment, 363
 - *ex-situ*, 138
 - factors affecting, 198–209
 - biodegradability, 199–200
 - biomass concentration, 205–206
 - carbon activation type, 202
 - carbon particle size, 200–201
 - carbon porosity, 201–202
 - concentration gradient and carbon saturation, 204–205
 - desorption kinetics, 203
 - dissolved oxygen concentration, 206
 - microorganism type, 206–207
 - multiple substrates, presence of, 208–209
 - physical surface properties, of carbon, 202–203
 - substrate, chemical properties of, 200
 - substrate and biomass associated products, 207–208
 - substrate–carbon contact time, 203–204
 - groundwater, 7, 50, 250, 273, 300, 303–304, 355
 - *in-situ*, 218
 - mechanisms of, 189–194
 - acclimation of biomass, 193–194
 - concentration gradient, 189–191

- exoenzymatic reactions, 191–193
- in micropollutants, 362
- modeling/models, 217–229
- biodegradation/adsorption-screening model (BASM), 225, 227
- biofilm model, 221, 222
- biofilm on activated carbon (BFAC) model, 174, 175, 219, 223
- concurrent adsorption and biodegradation, 218–219
- kinetics, 228–229
- multicomponent systems, 225–227
- multi-solute MDBA model, 218
- offline bioregeneration, 228
- one-liquid film model, 221, 222
- single solute systems, 220–225
- two-liquid film model, 221–222
- offline bioregeneration, 194–195
- reversibility of adsorption, 195–198
- schematic representation of, 190
- Bioremediation, groundwater, 50, 303–304
- Bioremediation, soil, 7, 50
- Biosorption, 100
 - characterization of, 54
 - NOM, 335
 - potential, 52
 - sorption onto sludge, 47
- Biot number, 166, 172, 173
- Biotransformation, 47, 48, 71, 156
- Bis (2-ethylhexyl) phthalate, 111, 294
- Bisphenol A (BPA), 53, 55, 109, 292
- BKME. *See* Bleached kraft pulp mill effluent (BKME)
- Bleached kraft pulp mill effluent (BKME), 98
- BOD (biochemical oxygen demand), 8, 48, 113, 215, 240, 353
- BOD₅/COD ratio, in landfill leachate, 81, 99, 100, 113
- BOM. *See* Biodegradable Organic Matter (BOM)
- Bosea*, 308
- Bound EPS, 83
- Bradyrhizobiaceae*, 308
- Bradyrhizobium*, 308
- Breakthrough curve, 36, 162, 265
 - initial stage of operation, 265
 - intermediate and later stages of operation, 266
- Breakthrough point, 36, 223
- Bromate, 301
 - bromide in water, 295
 - brominated organic compounds, 298
 - ozonation effects, 249
 - removal of, 298–301
- Bromide ion, 295, 298
- Brominated flame retardants, 43
- 4-Bromo-3-chloroaniline, 111
- Bromoform, 295, 298
- Bromophenol, 107, 294
- BRP. *See* Biomass respiration method (BRP)
- BSF. *See* Biological rapid sand filtration (BSF)
- BTEX (Benzene, Toluene, Ethylbenzene, Xylene), 99, 104, 138
- BTX (Benzene, Toluene, *p*-Xylene), 104, 105
- Bulk organic matter, 47, 48, 56
- Burkholderiales*, 308
- Bussy, 2
- Butyl cellosolve, 102
- BV. *See* Bed Volume (BV)
- C
- CAA. *See* Chloroacetaldehyde (CAA)
- Caffeine, 292
- CAgran, 202, 257, 258, 259, 269
- Candida*, 206
- Carbamazepine, 75
- Carbamazepine (CBZ), 52, 55, 109, 290, 291, 358, 362
- Carbon, physical surface properties of, 202–203
- Carbon activation type, 29, 202
- Carbonization process, 13
- Carbon particle size, 200–201
- Carbon porosity, 201–202
- Carbon properties' consideration in modeling, 177–178
- Carbon saturation
 - concentration gradient and, 204–205
- Carbon tetrachloride, 14, 105, 134, 209, 210
- Carbon usage rate (CUR), 33, 34
- Carbonyl oxygen, 15
- Carboxylic acids, 241, 253
- Carcinogen, 244, 295, 299, 354
- Carman–Kozeny equation, 85
- Castlemaine plant, 326
- Cationic polyelectrolyte, 71
- Caulobacter*, 307
- Caustic hydrolysate wastewater, 101
- CB. *See* Chlorobenzene (CB)
- CBZ. *See* Carbamazepine (CBZ)
- CDOC. *See* Chromatographic DOC (CDOC)
- CHABROL model, 335
- Chambers Works PACT[®] system, 134
- Characteristics of activated carbon, 14–15
- Charcoal, 1, 2, 14
- Chemical adsorption (chemisorption). *See* Adsorption
- Chemical bonding, 15, 17
- Chemically activated PAC, 201, 202
- Chemical oxygen demand (COD)
 - soluble chemical oxygen demand, (SCOD), 115
 - total chemical oxygen demand (TCOD), 115

- Chemical surface
 - characteristics, 21–22
 - 'Chemische Werke', 2
 - Chemisorption, 17, 196
 - oxygen, 15, 272, 302, 306
 - perchlorate reduction, 301
 - Chloramine, 276
 - Chlorinated compounds, 50, 105, 215, 297
 - Chlorinated hydrocarbons, 129, 182
 - Chlorinated organic compounds (AOC), 10, 215
 - Chlorinated phenols, 50, 108
 - Chlorine, 4, 112, 248, 276, 277, 285, 294, 297, 327
 - Chlorine dioxide, 277, 323
 - Chloroacetaldehyde (CAA), 110, 217
 - Chlorobenzene (CB), 14, 87, 110, 134, 183, 304
 - 3-Chlorobenzoic acid, 197, 200, 202, 210
 - Chlorobenzoic acids,
 - removal of, 118, 200, 202
 - Chloroform, 96, 134, 138, 185, 295, 298, 348
 - Chlorophenols, 4, 87, 108
 - 2-Chlorophenol (2-CP), 29, 50, 87, 108, 134, 194, 199, 200, 207, 208, 210
 - 4-Chlorophenol (4-CP), 107–108, 205, 207, 209, 210, 215
 - Chromatographic DOC (CDOC), 244
 - Chromium compounds, 113
 - Clofibric acid, 290
 - Clogging, 31, 47, 63, 68, 69, 305
 - Closed-loop offline
 - bioregeneration system, 194
 - COD. *See* Chemical oxygen demand (COD)
 - Coke plant wastewaters, 102, 103
 - Coliform bacteria, 309, 319
 - Color, 62, 70, 78, 98, 100, 102, 114, 128, 130, 133, 239, 251, 289, 326, *Comamonadaceae*, 308
 - Cometabolic removal of substrate, 50
 - Cometabolism, 50, 208, 356
 - ammonia, 78, 103, 133, 135, 248, 285
 - AMO enzyme, 359
 - chlorinated benzenes, 199
 - chlorinated phenols, 50, 95, 108
 - cometabolic regeneration, 362
 - cometabolic substrate, 50, 356
 - Complexing agents, 109, 357
 - Concentration gradient
 - bioregeneration due to, 189–191
 - and carbon saturation, 204–205
 - Concurrent adsorption and biodegradation
 - bioregeneration in, 218–219
 - Contaminated groundwater,
 - remediation of, 7
 - Contaminated groundwaters, PACT for, 138–139
 - Contaminated surface runoff waters, PACT for, 139–140
 - Continuous-flow (CF)
 - activated sludges, 115
 - Continuous-flow stirred tank reactor (CSTR), 70, 103, 177
 - Conventional water treatment, NOM removal
 - in, 244–246
 - extent of, 245–246
 - rationale for, 244–245
 - Co-treatment, 82, 96, 136
 - Cresols, 108
 - Cryptosporidium*, 326
 - CSTR. *See* Continuous-flow stirred tank reactor (CSTR)
 - CUR. *See* Carbon usage rate (CUR)
 - Cyanide
 - biodegradation of, 112
 - biological removal of, 102, 103
 - Cyanobacterial toxins
 - 1,3-Cyclohexanediamine, 111
 - Cytostatics, 55
 - Cytarabine (CytR), 53, 55
- ## D
- DAF. *See* Dissolved air flotation (DAF)
 - Damköhler number of type I, 170, 172
 - Damköhler number of type II, 170, 172
 - DBAA. *See* Dibromoacetic acid (DBAA)
 - DBPs. *See* Disinfection By-Products (DBPs)
 - DCAA. *See* Dichloroacetic acid (DCAA)
 - DCF. *See* Diclofenac (DCF)
 - DCM. *See* Dichloromethane (DCM)
 - de Cavaillon, Joseph, 2
 - Dechlorination, 105, 215
 - of chlorinated water, 4
 - Denitrification, 49, 286
 - enhancement of, by activated carbon, 80
 - GAC-FBR configuration, 80
 - groundwater, 238, 297
 - nitrogen removal, 286–288
 - surface water, 288, 298
 - wastewater, 135, 141
 - Desorbability, of NOM
 - from activated carbon, 258–260
 - in raw and ozonated waters, 254–260
 - Desorption, 53, 196
 - abiotic desorption, 191, 211
 - of biodegradable organics, 53, 65, 255
 - desorption isotherm, 211, 258, 260, 360
 - kinetics, 203
 - of organic matter, 191
 - Detachment rate, 155, 157
 - Dewatering, 73, 82, 137
 - Diazepam (DZP), 55, 109
 - Dibromoacetic acid (DBAA), 295
 - Dibutyl phthalate, 111
 - Dichloroacetic acid (DCAA), 295
 - 2,4-Dichloro-benzenamine, 111

- Dichlorobenzene, 134
 1,2-Dichlorobenzene, 110, 183
 Dichloroethane (1,2-DCE), 105, 110, 328
 Dichloromethane (DCM), 105
 Dichlorophenol, 84, 107, 197, 200, 227, 229
 1,4-Dichlorophenol, 134
 2,4-Dichlorophenol, 107, 110, 197, 200, 208, 210, 227, 229
 3,5-Dichlorophenol, 84, 106, 107
 2,4-Dichlorophenoxyacetate (2,4-D), 60
 Diclofenac (DCF), 52, 55, 109, 290
 Diethylene triamine pentaacetic acid (DTPA), 109
 Diffusion
 – biofilm diffusivity, 171
 – intraparticle diffusivity, 171, 201
 – of substrate in water, 171
 Dimensionless Empty Bed Contact Time, 338–339
 Dimensionless numbers
 – Biot number, 166, 172, 173
 – Damköhler number Type I, 170, 172
 – Damköhler number Type II, 170, 172
 – modified Stanton number, 169, 170
 – Peclet number, 167, 170
 – Sherwood number, 165, 170
 – solute distribution parameter, 167, 170
 – Stanton number, 169, 170
 Dimensionless parameters, definition of, 165
 Dimensionless separation factor, 26
 3,5-Dimethoxyacetophenone, 111
N,N-dimethyl acetamide, 96
N,N-dimethyl formamide, 96
 Di-*n*-butyl phthalate, 294
 Dinitrophenol, 107, 110, 134
 Dinitrotoluene, 110, 134, 294
 1,4-Dioxane, 130
 Disinfection
 – chlorine, 4, 5, 294, 320, 322, 323
 – UV/H₂O₂, 249
 Disinfection By-Products (DBPs), 5, 10, 243, 244, 270, 294–295
 – bromate, 298, 299
 – brominated organic compounds, 298
 – haloacetic acids (HAAs), 10, 244, 294–295, 297
 – total trihalomethanes (TTHM), 295
 – trihalomethane formation potential (THMFP), 10, 295, 303
 – trihalomethanes (THMs), 10, 244, 294, 297, 348, 359
 Dissociation constant, 19
 Dissolved air flotation (DAF), 4, 6, 73, 138, 141
 Dissolved Organic Carbon (DOC), 239, 265
 – Biodegradable Dissolved Organic Carbon (BDOC), 240, 270
 – mineralization of, 253–254
 – Nonbiodegradable Dissolved Organic Carbon (NBDOC), 243
 Dissolved Organic Matter (DOM), 85, 239, 303
 Dissolved oxygen (DO), 70, 194, 266
 Dissolved oxygen concentration, 206
 Diuron, 291
 DO. *See* Dissolved oxygen (DO)
 DOC. *See* Dissolved Organic Carbon (DOC)
 Dohne water works, 248
 DOM. *See* Dissolved Organic Matter (DOM)
 Domestic and industrial wastewaters, PACT for, 136
 Domestic wastewaters reuse, PACT for, 139
 Domestic wastewater treatment, 83, 354
 Draft tube gas–liquid–solid fluidized bed bioreactor (DTFB), 177
 Drinking water BAC filtration, 273, 275, 332, 359, 363
 Drinking water treatment, 237, 358–359
 – activated carbon in, 4–5, 246–247
 – granular activated carbon (GAC) filtration, 247
 – powdered activated carbon (PAC) addition, 246
 – adsorption and biodegradation characteristics of water, 250–259
 – determination of, 254–259
 – NOM characteristics, ozonation impact on, 250–254
 – raw water NOM, 250
 – biological activated carbon (BAC) filtration, 247
 – adsorption and biological processes, 342–345
 – biological processes in biofilters, 334–342
 – current use of, 249–250
 – history of, 247–249
 – micropollutants removal, 346–348
 – and ozonation, 249
 – substrate removal and biofilm formation, 331–333
 – biological processes in, 238
 – bioregeneration of activated carbon in, 363
 – NOM removal, in conventional water treatment, 244–246
 – extent of, 245–246
 – rationale for, 244–245
 – organic matter in, 238–244
 – biodegradable fraction, in NOM, 239–243
 – expression, in terms of organic carbon, 239

- Drinking water treatment (*continued*)
 - fractionation, of NOM, 243–244
 - nonbiodegradable dissolved organic carbon (NBD OC), 243
- DTFB. *See* Draft tube gas–liquid–solid fluidized bed bioreactor (DTFB)
- DTPA. *See* Diethylene triamine pentaacetic acid (DTPA)
- DuPont, 70, 101
- DuPont's Chambers Works, 128, 134
- Dyes
 - acid dye, 100, 214
 - Acid Orange, 111
 - anthraquinone dye, 100, 214
 - azo dye, 100, 110, 111, 214
 - indigo carmine, 14
 - methylene blue, 14, 111
 - polymeric dye, 111
 - Reactive Black, 110
 - removal of, 110–111
 - soluble organic dyes, 6, 14
- DZP. *See* Diazepam (DZP)
- E
- E2 (17 β -Estradiol), 55
- E3 (Estriol), 55
- EBCT. *See* Empty-bed contact time (EBCT)
- EC. *See* Expanded clay (EC)
- EOCl. *See* Extractable organic chlorine (EOCl)
- EDCs. *See* Endocrine disrupting compounds (EDCs)
- EDTA (Ethylene diamine tetraacetic acid), 109
- EE2 (17 α -Ethinylestradiol), 52, 53, 55
- EEM (Excitation-Emission Matrix), 325
- Effective contact time, 33
- Electrochemical oxidation, 101
- Emerging substances, 5
- Empty-bed contact time (EBCT), 32–33, 204, 274–276, 284, 338–339
- Endocrine disrupters, 55
- Endocrine disrupting compounds (EDCs), 5, 109, 288, 291–292
 - bisphenol A, 53, 55, 109
 - nonylphenol, 109, 290, 292
- Endogenous respiration, 49
- Engineered/mechanical treatment systems, 248–249
- Envirex[®], 68
- Environmental media, activated carbon in, 7
- Environmental pollution, activated carbon in, 4–10
 - activated carbon adsorption, with biological processes, 7
 - in wastewater treatment, 7–8
 - in water treatment, 8
 - drinking water treatment, 4–5
 - environmental media, 7
 - flue gases, treatment of, 7
 - groundwater contamination, remediation of, 7
 - soil contamination, remediation of, 7
 - water preparation, for industrial purposes, 7
 - pollutants control, 8–10
 - wastewater treatment, 5–6
- Environmental Scanning Electron Microscopy (ESEM), 216
- Enzymes, 50
 - ammonia monooxygenase. *See* Ammonia monooxygenase enzyme (AMO)
 - extracellular enzymes (Exoenzymes), 191, 193
- Eponit[®], 2
- EPS. *See* Extracellular polymeric substances (EPS)
- Erythromycin, 292
- Escherichia coli*, 308
- Escherichia fergusonii*, 308
- ESEM. *See* Environmental Scanning Electron Microscopy (ESEM)
- Estradiol, 292
- Estriol (E3), 55
- Estrone, 52
- Ethanol, 96, 108, 195, 301
- Ethyl acetate, 96
- Ethylbenzene, 134, 182
- Ethylene diamine tetraacetic acid. *See* EDTA (Ethylene diamine tetraacetic acid)
- Excitation-Emission Matrix. *See* EEM (Excitation-Emission Matrix)
- Exhausted GAC, 205, 293
- Exoenzymatic reactions
 - bioregeneration due to, 191–193
 - validity of, 361–362
- Exopolymers. *See* Extracellular polymeric substances (EPS)
- Expanded and fluidized-bed BAC reactors, 68–69
- Expanded clay (EC), 105
- Extracellular enzymes, 191
- Extracellular polymeric substances (EPS), 77
 - characteristics/definition, 83
 - composition, 82–83
 - effect on dewaterability, 83, 358
 - retention by PAC, 84
- Extractable organic chlorine (EOCl), 103
- F
- FA. *See* Free ammonia (FA)
- FB. *See* Fluidized bed (FB)
- FBR. *See* Fluidized bed reactor (FBR)
- Fenoprofen, 290
- Fick's law, 148, 149
- Filter backwashing, 276
- Filter operation time, 34
- Filter velocities, 33–34
- Finished water
 - microbiological safety, 309
 - re-growth potential, 242–243
- Firmicutes, 308
- First-order kinetics, 228, 229
 - inside biofilm, 168–169
- Five haloacetic acids (HAA5), 295

- Fixed-bed BAC reactors, 67–68, 110–111, 112
- Fixed-bed carbon adsorbers, 31
- Flame retardants, 43, 109, 357
- Flavobacterium*, 207, 307
- Flue gases
 - treatment of, 7
- Fluidized bed (FB)
- Fluidized bed reactor (FBR), 31, 68, 300
- Fluorescence spectroscopy, 243
- Fluorobenzene, 210, 215
- 2-Fluorobenzoate (2-FB), 105
- 5-Fluorouacil (5-Fu), 53, 55
- FNA. *See* Free nitrous acid (FNA)
- Food-to-microorganism (F/M) ratio, 70, 71
- Formaldehyde, 274
- Fouling, 75
 - *See also* Biofouling;
 - Membrane fouling;
 - Microbial fouling
- Free ammonia (FA), 79
- Free nitrous acid (FNA), 79
- Freundlich adsorption, 227
- Freundlich isotherm, 25, 26, 27, 154, 220, 225, 256, 258
- Freundlich parameters, 29
- Full-scale drinking water treatment plants
 - BAC filtration in, 319–329
- Full-scale PACT systems, 127
 - for contaminated groundwaters, 138–139
 - for contaminated surface runoff waters, 139–140
 - for domestic and industrial wastewaters co-treatment, 136
 - for domestic wastewaters reuse, 139
 - for industrial effluents
 - organic chemicals production industry, 128–130
 - pharmaceutical wastewaters, treatment of, 135–136
 - priority pollutants, treatment of, 134
 - propylene oxide/styrene monomer (PO/SM) production wastewater, 130–131
 - refinery and petrochemical wastewaters, 131–134
 - synthetic fiber manufacturing industry, 130
 - for landfill leachates, 136–138
- Full-scale surface water treatment, BAC filtration in, 320–326
 - Bendigo, Castlemaine & Kyneton, 326–327
 - Leiden plant, 320–322
 - Mülheim plants, 320
 - Ste Rose plant in Quebec, 323
 - suburbs of Paris, plants in, 322–323
 - Weesperkarspel plant, 324–326, 327
 - Zürich-Lengg, plant in, 323–324
- G**
- Gabapentin, 292
- GAC. *See* Granular activated carbon (GAC)
- GAC-SBR, 112
- GAC-Sequencing Batch Biofilm Reactor (GAC-SBBR), 68
- Gas masks, 3
- Gemfibrozil, 290
- Geosmin, 292–293
- Giardia* contamination, 326
- Gibbs free energy, 190, 198, 200
- Glyoxal, 273, 274
- Granular activated carbon (GAC), 3, 4, 6, 13, 16, 39, 97, 105
 - BAC reactors, main processes in, 66
 - biomass attachment, 273
 - coal-based, 274
 - conversion of, into BAC, 64–65
 - BAC process, advantages of, 66
 - removal mechanisms and biofilm formation in BAC operation, 65–66
 - versus BAC operation, 66
 - expanded and fluidized-bed BAC reactors, 68
 - filtration, 145, 247, 265, 331
 - fixed-bed BAC reactors, 67–68
 - GAC upflow anaerobic sludge blanket reactor (GAC-UASB), 81
 - integration into groundwater bioremediation, 303–304
 - positioning, in wastewater treatment, 59–63
 - recognition of biological activity, 63–64
 - removal performance, 273
 - secondary treatment of wastewaters, 45
 - tertiary treatment of wastewaters, 45
 - wood-based, 274
- Granular activated carbon (GAC) adsorbers, 30, 145
 - breakthrough curves, 34–37
 - integrated adsorption and biological removal, benefits of, 155–158
 - modeling approaches in GAC/BAC reactors, 158
 - BAC reactors' characterization, by dimensionless numbers, 164–173
 - biomass balance in reactor, 164
 - substrate mass balance in liquid phase of reactor, 159–164
 - models in BAC reactors involving adsorption and biodegradation, 173
 - carbon properties, in modeling, 177–178
 - high substrate concentrations, 175–176

- Granular activated carbon (GAC) adsorbers (*continued*)
 - initial steps in modeling, 173
 - integration of adsorption into models, 174–175
 - substrate removal and biofilm formation, 173–174
 - three-phase fluidized bed reactor, 177
 - very low substrate (fasting) conditions, 176–177
 - operation of, 31–34
 - bed volume (BV), 34
 - carbon usage rate (CUR), 34
 - effective contact time, 33
 - empty-bed contact time (EBCT), 32
 - filter operation time, 34
 - filter velocities, 33–34
 - throughput volume, 34
 - processes around carbon particle surrounded by biofilm, 146
 - adsorption isotherms, 154
 - biofilm growth and loss, 154–155
 - diffusion and removal of substrate within biofilm, 149–152
 - diffusion into activated carbon pores and adsorption, 152–154
 - related to biomass and activated carbon, 146
 - related to substrate transport and removal, 146
 - transport of substrate to surface of biofilm, 148
 - purpose of use, 30
 - types of, 30–31
- Granular activated carbon (GAC) reactors
 - GAC/BAC, 158–173, 177, 267–268, 331
 - GAC-FBR, 68, 99, 104, 118, 119, 120, 138, 208, 327
 - GAC-MBR, 209
 - GAC-SBBR, 68
 - GAC-UASB, 81
 - GAC-UFBR, 105
- Granular Activated Carbon-Fluidized Bed Reactor (GAC-FBR) system, 68, 99, 104, 118, 119, 120, 138, 208, 327
- Groundwater
 - bioremediation, 303–304
- Groundwater recharge, 248
- Gum arabic powder, 111
- H**
- HAA. *See* Haloacetic Acids (HAA)
- HAA5. *See* Five haloacetic acids (HAA5)
- HAAFP, 10, 295
- Haloacetic Acids (HAA), 10, 244, 294–295, 297
 - HAA5, 295, 297
 - HAAFP (HAA Formation Potential), 295
- Halogenated hydrocarbons, 288
- HD 4000, 256, 258
- Heavy metals, 80
 - cadmium (Cd), 58, 80
 - chromium (Cr), 58, 113
 - copper (Cu), 58, 80
 - nickel (Ni), 58, 80
 - zinc (Zn), 58, 81
 - *See also* Organic pollutants
- Henry constant, 54, 184
- Heterogeneity of activated carbon, 21
- Heterotrophic plate count (HPC), 238, 305
- Hexavalent chromium (Cr (VI)), 80
- High substrate concentrations, modeling in, 175–176
- Historical appraisal of activated carbon, 1–3
- History of activated carbon
 - Bussy, 2
 - Hunter, 2
 - Joseph de Cavaillon, 2
 - Kayser, 2
 - Lipscombe, 2
 - Lowitz, 2
 - Schatten, 2
 - Scheele, 2
 - Stenhouse, 2
 - von Ostrejko, 2
- HLR. *See* Hydraulic loading rate (HLR)
- HMX (High Melting explosive), 195
- Homogeneous surface diffusion model, 152
- HPC. *See* Heterotrophic Plate Count (HPC)
- Hubele model, 342
- Hueco Bolson aquifer, 139
- Humic acids, 64, 114, 254, 342, 343
- Humic substances, 196, 240, 244, 338
 - humic acid, 64, 111, 114, 254, 342, 343
- Hunter, 2
- Hydraulic loading rate (HLR), 33, 35, 72, 274–276
- Hydraulic regime
 - completely mixed, 146, 173
 - dispersed plug flow, 146, 173
 - plug flow, 173
- Hydraulic residence time, 246
- Hydrocarbons
 - aliphatic and aromatic, 5, 288
 - chlorinated, 129, 182
 - halogenated, 288
 - high molecular weight hydrocarbons, 14
 - polycyclic aromatic hydrocarbon (PAH), 99, 138, 209
 - total volatile hydrocarbon (TVH), 99
- Hydrogenophaga*, 307
- Hydrogen peroxide, 196, 277, 328
- Hydrogen sulfide (H₂S)
 - biodegradation of, 112
- Hydrolysis, 48, 83, 149, 335
- Hydrophilicity, 15, 290
- Hydrophobicity, 21, 239, 291
- Hydrophobic nonylphenol, 290

- 4-Hydroxyacetophenone, 109
- Hysteresis, 196, 201, 208, 211, 362
- I**
- IAS model. *See* Ideal Adsorbed Solution (IAS) model
- IAST. *See* Ideal Adsorbed Solution Theory (IAST)
- IBP. *See* Ibuprofen (IBP)
- IBPCT. *See* Integrated Biological-Physicochemical Treatment (IBPCT)
- Ibuprofen (IBP), 52, 55, 290, 292
- IC₅₀, 106
- Ideal Adsorbed Solution (IAS) model, 28
- Ideal Adsorbed Solution Theory (IAST), 28, 177, 227
- iMBRs. *See* Immersed MBRs (iMBRs)
- Immersed MBRs (iMBRs), 74–75
- Improved Simplified Ideal Adsorbed Solution (ISIAS) model, 28, 29
- Indomethacin, 290
- Industrial wastewater treatment, 6, 95, 100–104
- paper and pulp wastewaters, 97–98
 - petroleum refinery and petrochemical wastewaters, 98–99
 - pharmaceutical wastewaters, 95–97
 - textile wastewaters, 99–100
- Infrared spectroscopy, 243
- Inhibition
- competitive, 56, 61
 - noncompetitive, 56, 61
 - substrate, 56, 60
- Inhibitory compound, 108
- Inorganic pollutants, 10, 79, 145, 359
- Inorganic species, activated carbon in, 80
- Instrumental analysis
- Excitation-Emission Matrix (EEM), 325
 - Gas Chromatography-Mass Spectrometry (GC-MS), 243
 - Nuclear Magnetic Resonance (NMR), 243, 244
 - Organic Carbon Detection (OCD), 243
 - Organic Nitrogen Detection (OND), 243
 - Size Exclusion Chromatography (SEC), 243, 244
 - spectral measurements, 239
- Integrated adsorption and biological removal, 47
- benefits of, 155–158
 - biodegradation/biotransformation, 48
 - abiotic degradation/removal, 53–54
 - micropollutants, 50–52
 - organic matter fractionation, in wastewater, 48
 - organic substrates, 49
 - sorption onto activated carbon, 53
 - sorption onto sludge, 52–53
 - biological regeneration of activation carbon, 59
 - organic substrates, biomass, and activation carbon
 - interactions between, 54
 - organic substrates, main removal mechanisms for, 47
 - substrates, behavior and removal of, 59
 - surface of activation carbon
 - biodegradable and nonbiodegradable organics retention on, 56
 - microorganisms, attachment and growth of, 59
 - substrates concentration on, 58
 - toxic and inhibitory substances retention on, 56–58
 - volatile organic compounds (VOCs) retention on, 58
- Integrated Biological-Physicochemical Treatment (IBPCT), 173
- Integrated systems, observed benefits of, 76
- anaerobic treatment, 81
 - biological sludge in presence of activated carbon, 81
 - dewaterability of sludge, 82
 - sludge settling and thickening, 81
 - denitrification, enhancement of, 80
 - inorganic species, activated carbon addition on, 80–81
 - membrane bioreactors (MBRs), effect of PAC on, 87
 - membrane filtration, effect of activated carbon on, 85
 - microbial products, effect of activated carbon on, 83
 - microbial products, importance of, 82
 - nitrification, enhancement of, 78–80
 - organic carbon removal, enhancement of, 78
- Ion exchange, 300, 302
- Iopromide, 52
- Irreversible adsorption, 29, 196, 197, 198, 200, 202, 204, 205, 208, 211, 222, 259
- Irreversible fouling resistance, 85, 86
- ISIAS model. *See* Improved Simplified Ideal Adsorbed Solution (ISIAS) model
- Isopropyl alcohol, 96
- Isopropyl ether, 96
- Isothiazolinones, 101
- K**
- Kaolin, 111
- KATOX, 63
- Kayser, 2
- Ketoprofen, 290

- Kinetics
 – adsorption, 22, 34, 36, 162, 169
 – of bioregeneration, 228–229
 – desorption, 203
 Kyneton plant, 326
- L**
 Laboratory-Scale PACT reactors, 114–118
 Lake Zurich, 294, 323, 324
 Landfill leachate treatment
 – BAC filtration, 118–120
 – PAC-MBR process, 118
 – PACT, 114–118, 136–138
 Langmuir isotherm, 25, 26, 154
 LC₅₀ tests, 101
 LCC. *See* Life cycle cost (LCC)
 LDF model. *See* Linear Driving Force (LDF) model
 Leiden plant, 320–322
 LHAAP. *See* Longhorn Army Ammunition Plant (LHAAP)
 Life cycle assessment (LCA), 327
 Life cycle cost (LCC), 327
 Lignin, 13
 Lignin sulfonate, 111
 Lindane, 110, 182, 183
 Linear Driving Force (LDF) model, 153
 Lipscombe, 2
 Liquid chromatography with online organic carbon detection (LC-OCD), 325
 Liquid film-biofilm boundary
 LMW organics. *See* Low-molecular-weight (LMW) organics
 Longhorn Army Ammunition Plant (LHAAP), 327, 328
 Lowitz, 2
 Low-molecular-weight (LMW) organics, 244
 Lyophobic character of solute, 17
- M**
 Macropores, 20, 21, 23, 152, 193, 203, 216, 257
 MAP. *See* Microbially available phosphorus (MAP)
 Mass balance
 – biofilm, 149
 – liquid phase, 159–164
 – in PACT process, 178–180
 – reactor, 164
 – solid phase, 158
 Mass transfer coefficient, 148
 Mass transfer equations, 165–166
 Mass transfer zone (MTZ), 34, 37
 Mass transport, 36, 145, 165, 171–172, 222
 Maturation pond, 140
 MBAA. *See* Monobromoacetic acid (MBAA)
 MBRs. *See* Membrane bioreactors (MBRs)
 MCAA. *See* Monochloroacetic acid (MCAA)
 MDBA. *See* Multiple-Component Biofilm Diffusion Biodegradation and Adsorption model (MDBA)
 Membrane-assisted biological GAC filtration (BioMAC process), 76
 Membrane bioreactors (MBRs), 8, 74, 302–303
 – biofouling, 75
 – biological membrane assisted carbon filtration (BIOMAC), 76
 – effect of PAC on, 82–86
 – extracellular polymeric substances (EPS), 82–83, 84
 – fouling, 75, 84
 – GAC-MBR (GAC added membrane bioreactor), 209, 355
 – immersed membrane bioreactor (iMBR), 74
 – membrane flux, 84, 86
 – microfiltration, 75
 – PAC-MBR, 75–76
 – permeability, 75, 76
 – soluble microbial products (SMP), 358
 – submerged membrane bioreactor (sMBR), 74, 303
 – transmembrane pressure (TMP), 75, 85
 – ultrafiltration, 75
 Membrane filtration, activated carbon in, 85–86
 Membrane fouling, 75, 245
 MEP. *See* Metabolic end products (MEP)
 Mesopores, 20, 21, 152, 192, 193, 201
 Metabolic end products (MEP), 83, 84
 Methanol, 96
 2-Methyl-1-dioxolane, 130, 131
 Methyl chloride, 134
 Methylene chloride, 96, 213
 Methyl ethyl ketone, 102
 Methylphenols, 108
 Methyl-tert-butylether (MTBE), 288, 294
 MF. *See* Microfiltration (MF)
 MIB (2-Methylisoborneol), 245, 292–293
 Michigan Adsorption Design and Applications Model (MADAM) program, 173
 Microbial ecology, 362–363
 – of BAC filters, 304–305
 Microbial fouling, 228
 Microbially available phosphorus (MAP), 305
 Microbial products, activated carbon on, 83–85
 Microcrystallites, 14–15
 Microcystins, 288, 293, 348
 Microfiltration (MF), 74, 302
 – continuous microfiltration (CMF), 326
 – continuous microfiltration-submerged (CMF-S), 326
 Microorganisms
 – attachment and growth of, on surface of activated carbon, 59

- and bioregeneration, 206–207
- determination, 306
- heterotrophic biomass and activity, 306–308
- nitrifying biomass and activity, 308–309
- Micropollutants
 - adsorption and biodegradation of, 362
 - removal from drinking water in BAC systems, 288–298
 - in wastewaters, 55
- Micropores, 14, 20, 21, 23, 27, 152, 192, 193, 201, 202, 203, 216
- Microtox[®] test, 101
- Mixed liquor (volatile) suspended solids (MLSS/MLVSS), 70, 133, 180
- M-nitrophenol (MNP), 107
- MNP. *See* M-nitrophenol (MNP)
- Modeling, 145
 - adsorption, 145, 152, 158, 173, 174–175, 177
 - biofilm detachment, 155
 - biological removal
 - attached-growth, 66
 - suspended-growth, 145, 157
 - bioregeneration, 217–229
 - diffusion, 152
 - drinking water biofiltration, 331, 341
 - GAC adsorbers, 145
 - GAC/BAC reactors, modeling approaches in, 158–173
 - integrated adsorption and biological removal, benefits of, 155–158
 - prevalent models in BAC reactors involving adsorption and biodegradation, 173–178
 - processes around carbon particle surrounded by biofilm, 146–155
 - PACT process, modeling of, 178
 - mass balance for PAC in, 178–180
 - mass balances in, 178
 - models describing substrate removal in, 181–185
- Models
 - biodegradation/adsorption –screening model (BASM), 225
 - biofilm on activated carbon (BFAC) model, 174, 175, 223
 - BIOFILT model, 339–340
 - homogeneous surface diffusion model (HSDM), 174, 347
 - ideal adsorbed solution (IAS) model, 28
 - improved simplified ideal adsorbed solution (ISIAS) model, 28
 - michigan adsorption design and applications model (MADAM), 173
 - model of Wang and Summers, 337–338
 - models involving bioregeneration, 217–229
 - Multiple-Component Biofilm Diffusion Biodegradation and Adsorption model (MDBA), 227
 - plug flow stationary solid phase column (PSSPC) model, 345
 - Pore Diffusion Model (PDM), 152
 - S_{min} model, 334, 336
 - Simplified Ideal Adsorbed Solution (SIAS) model, 28, 29,
 - Uhl's Model, 335–337
- Modified Biot number, 170, 173
- Modified Stanton number, 169, 170
- Molecular tools
 - Amplified Fragment Length Polymorphism (AFLP), 307
 - Polymerase Chain Reaction (PCR), 308
 - terminal-restriction fragment length polymorphism (T-RFLP), 308
- Molinate, 202, 203, 210
- Monobromoacetic acid (MBAA), 295
- Monochloramine, 277
- Monochloroacetic acid (MCAA), 295
- Monod model, 151, 183
- MTBE. *See* Methyl-tert-butylether (MTBE)
- MTZ. *See* Mass transfer zone (MTZ)
- Mülheim process, 247–248, 320, 321
- Multicomponent systems, bioregeneration modeling in, 225–227
- Multiple-Component Biofilm Diffusion Biodegradation and Adsorption model (MDBA), 227
- Multisolute Fritz–Schlunder isotherm, 228
- Multi-solute MDBA model, 218
- Municipal wastewater treatment, 6
- N**
 - Naphthalene, 21, 118
 - Naproxen (NPX), 52, 55, 290
 - National Pollutant Discharge Elimination System (NPDES), 132
 - Natural Organic Matter (NOM), 5, 30, 200, 237, 363
 - acidity, 255, 267
 - adsorbability of, 255, 255–258
 - aromaticity, 251, 255
 - BAC filtration, 288–289
 - biodegradability, 251, 253–254
 - biodegradable fraction in, 239–243
 - biological removal of, 331, 332, 344–345
 - desorbability of, 258–260
 - fractionation of, 243–244, 255
 - fractions removal, 267

- Natural Organic Matter (NOM) (*continued*)
- molecular size distribution of, 243
 - ozonation effects, 248, 250–254
 - polarity, 250, 255
 - raw water NOM, 250
 - removal in conventional water treatment, 244–246
 - structure and composition, 251
 - *see also* Organic matter
- Natural treatment systems, 248
- N-butanol, 102
- NDMA. *See* N-nitrosodimethylamine (NDMA)
- Neutrals, definition of, 244
- Nitrate, 238
- removal, 298
 - role in bromate reduction, 300
 - role in perchlorate reduction, 301
- Nitrification, 78–79, 285
- affecting factors, 285–286
 - BAC filtration, 285–286
 - drinking water, 359
 - enhancement, by activated carbon, 78
 - inhibition of, 79
 - nitrifiers in BAC filtration, 285, 286
 - PAC addition, 79–80
 - wastewater treatment, 78–80
- Nitrifiers, 285
- ammonia oxidizing bacteria (AOB), 78, 308–309
 - molecular microbiology, 308–309
 - nitrite oxidizing bacteria (NOB), 78, 308
- Nitrifying biomass, 308
- Nitrite Oxidizing Bacteria (NOB). *See* Nitrifiers
- Nitrobenzene, 110, 134
- Nitrophenol, 87, 107, 197, 200, 362
- 2-Nitrophenol (2-NP), 58, 108, 200, 207, 210
- 4-Nitrophenol (4-NP), 107, 110, 134, 198
- N-nitrosodimethylamine (NDMA), 288
- Nitrosomonas* sp., 308
- Nitrospira* sp., 308
- NMR spectroscopy. *See* Nuclear Magnetic Resonance (NMR) spectroscopy
- NOM. *See* Natural Organic Matter (NOM)
- Nonadsorbing media, 168, 334
- Nonbiodegradable dissolved organic carbon (NBDOC), 243, 265
- Nonbiodegradable organics, 56, 97, 111, 255, 256, 258, 259
- Nongrowth substrate. *See* Cometabolism: cometabolic substrate
- Nonsingularity, 196
- Nonylphenol, 290, 292
- Nonylphenol ethoxylates (NPEs), 101
- Norit 1240, 258, 259, 260, 268, 270
- Norit[®], 2, 3
- NPDES. *See* National Pollutant Discharge Elimination System (NPDES)
- NPEs. *See* Nonylphenol ethoxylates (NPEs)
- NPX. *See* Naproxen (NPX)
- Nuclear Magnetic Resonance (NMR) spectroscopy, 243, 244
- O**
- OCPSF. *See* Organic chemicals, plastics and synthetic fiber (OCPSF)
- o*-cresol, 108, 177, 197, 200, 202, 210
- 9-Octadecenamide, 111
- Octanol-water partition coefficient, 52, 54, 110
- relation to adsorption, 53
 - sorption to biological sludge, 52
- Offline bioregeneration, 194–195, 204, 207, 228
- Oil and grease, 98, 99, 140
- Oilfield wastewater, treatment of, 99
- ‘One-liquid film’ model, 221, 222
- Orange II, 110, 111
- Organic carbon
- assimilable organic carbon (AOC), 240–242, 253
 - biodegradable organic carbon (BDOC), 242
 - dissolved organic carbon (DOC), 239
 - nonbiodegradable organic carbon (non-BDOC or NBDOC), 243
 - particulate organic carbon (POC), 239, 251
 - total organic carbon (TOC), 239
- Organic carbon removal, enhancement of
- by activated carbon, 78
- Organic chemicals, plastics and synthetic fiber (OCPSF), 127
- Organic chemicals production industry, full-scale PACT for, 128–130
- Organic matter
- biodegradable organic matter (BOM), 48, 78, 199, 205, 238, 274, 293
 - dissolved organic matter (DOM), 85, 239, 303, 308
 - fractionation, in wastewater, 48
 - natural organic matter (NOM), 5, 30, 200, 237
 - particulate organic matter (POM), 48, 67, 303, 335
 - in water treatment, 238–244
 - biodegradable fraction, 239–243
 - expression of, 239
 - fractionation of, 243–244
 - nonbiodegradable dissolved organic carbon (NBDOC), 243
- Organic matter, removal of, 265

- BAC filters, bioregeneration of, 272–273
 - breakthrough curves, 265
 - initial stage of operation, 265
 - intermediate and later stages of operation, 266–268
 - main mechanisms, 265
 - Organic micropollutants, 43, 48
 - adsorption of, onto preloaded GAC, 290
 - in BAC filtration, 291
 - biodegradation of, 356
 - NOM and, 288–290
 - in water, 288
 - Organic Nitrogen Detection (OND). *See* Instrumental analysis
 - Organic pollutants, 79
 - in secondary effluents, 111
 - OUR. *See* Oxygen uptake rate (OUR)
 - Oxidant residuals, effect of, 277
 - Oxidative coupling, 196, 197, 200
 - of phenolic compounds, 197
 - Oxidative polymerization, 197
 - Oxygenase enzyme
 - dioxygenase, 359
 - monooxygenase, 298
 - Oxygen uptake rate (OUR), 80, 96, 185, 358
 - Ozonated and biologically treated water, 256, 258
 - Ozonation, 62–63, 97, 118, 140–141, 294
 - and BAC filtration, 249, 327
 - intermediate ozonation, 267
 - NOM characteristics, impact on, 250–255
 - postozonation, 295
 - preozonation, 63, 141, 251, 253, 283–285, 287, 292, 295, 297, 309
 - Ozone dose, 249, 250–251, 254
- P**
- PAC. *See* Powdered activated carbon (PAC)
 - PAC added membrane bioreactor (PAC-MBR) process, 44, 75–76, 101, 104, 111, 118, 157, 355
 - Packed Bed Reactor (PBR), 300
 - Packing media, 32, 345
 - GAC, 66, 345
 - plastics, 66, 129
 - sand, 214, 242, 273, 293, 300
 - PACT process. *See* Powdered activated carbon treatment (PACT) process
 - PAE. *See* Phthalate ester (PAE)
 - PAH. *See* Polycyclic aromatic hydrocarbon (PAH)
 - Paint wastewater, 102
 - Paper and pulp wastewaters, treatment of, 97–98
 - Paracetamol, 291
 - Partially exhausted GAC, 205
 - Partial penetration, 151
 - Particle size, 15, 16, 85
 - Particulate Organic Carbon (POC), 239, 251
 - Particulate organic matter (POM), 48, 67, 303, 335
 - Partition ratio, 24
 - PCBs. *See* Polychlorinated biphenyls (PCBs)
 - PCE. *See* Perchloroethylene (tetrachloroethylene) (PCE)
 - PCPs. *See* Personal care products (PCPs)
 - PCR. *See* Polymerase Chain Reaction (PCR)
 - p*-cresol, 228
 - PDM. *See* Pore diffusion model (PDM)
 - Peclet number (Pe), 167, 170
 - Pentachlorophenol, 108, 110, 206, 217, 327
 - Perchlorate, 8, 274, 298, 299, 301, 347–348
 - contamination, 327–328
 - removal, 301–302
 - Perchloroethylene (tetrachloroethylene) (PCE), 105, 110, 134, 217
 - Persistent Organic Pollutant (POP), 294
 - Personal care products (PCPs), 43, 288
 - Pesticides, 288, 291
 - BAC filtration, 247, 249
 - chlorinated pesticides, 109
 - drinking water, 5, 6, 107, 112, 140
 - herbicides, 346
 - alachlor, 346
 - atrazine, 346–347
 - bentazon, 347
 - insecticides, 6, 182
 - lindane, 110, 182, 183, 184
 - organic pesticides, 100–101
 - organophosphate pesticides, 109
 - organosulfur pesticides, 109
 - Pesticides and polychlorinated biphenyls (PCBs), removal of, 109
 - p*-ethylphenol, 200, 210
 - Petrochemical wastewaters, 98–99
 - PACT treatment of, 131–134
 - PFR. *See* Plug flow reactor (PFR)
 - pH values, 19–20, 70, 78, 79, 100, 115, 119, 135, 299, 305
 - Pharmaceutical and Personal Care Products (PPCPs), 109, 288, 356, 362
 - Pharmaceuticals, 96
 - 5-fluorouracil, 53, 55
 - antibiotics, 76, 357
 - BAC filtration, 291, 292
 - biological rate constant, 291
 - caffeine, 292
 - carbamazepine, 52, 55, 109, 290, 357, 358, 362
 - clofibric acid, 290
 - diclofenac, 52, 55, 109, 290

- Pharmaceuticals (*continued*)
- and endocrine disrupting compounds (EDCs), 109, 291
 - estradiol, 292
 - fenoprofen, 290
 - gemfibrozil, 290
 - ibuprofen, 52, 109, 290, 292, 358
 - indomethacin, 290
 - ketoprofen, 290
 - naproxen, 52, 55, 109, 290
 - octanol-water partitioning, 52, 54, 110, 291
 - propyphenazone, 290
 - salicylic acid, 291, 292
 - sorption to sludge, 55
 - trovafloxin mesylate, 292
 - wastewater treatment, 95–97, 135
 - water treatment, 44, 52
- Pharmaceutical wastewaters, treatment of, 95–97, 135–136
- Phenol, 5, 20, 21, 29, 50, 59, 87, 111, 134, 200, 208, 210, 217, 220, 224, 227, 228, 229, 288, 294
- removal of, 106–108, 110, 118
- Phenolic compounds
- adsorption of, 197
 - chlorophenol, 4, 87, 107
 - nitrophenol, 87, 107, 110, 134, 197, 200, 362
 - oxidative coupling of, 197
 - oxidative polymerization of, 196
 - wastewaters, 101
- Phenol molecules (PhOH), 196
- Phenoxy radicals (PhO^{*}), 196, 197
- Phosphorus, 70, 140, 198, 254, 304
- Phragmitis communis*, 207
- Phthalate ester (PAE), 294
- Phthalates, 294
- Physical adsorption (Physisorption). *See* Adsorption
- Physicochemically regenerated carbon, 360
- Physicochemical regeneration of activated carbon, 363
- Physisorption, 17, 193, 196
- Pilot reactors, 102
- Pilot-scale GAC-FBR, leachate treatment in, 119–120
- p*-isopropylphenol, 200, 210
- Plane of zero gradient (PZG), 190
- Plants in suburbs, of Paris, 322–323
- Plug flow reactor (PFR), 70, 170, 177, 242, 335, 338
- Plug flow stationary solid phase column (PSSPC) model. *See* Models
- p*-methylphenol, 195, 200, 210
- p*-nitrophenol (PNP), 107, 200, 210, 220, 221, 224, 229
- PNP. *See p*-Nitrophenol (PNP)
- POC. *See* Particulate Organic Carbon (POC)
- Polarity, 21, 65, 250
- of adsorbate, 19
- Polaromonas*, 307
- Pollutants
- biodegradation of, 49
 - control of, 8–10
- Pollutants and wastewaters, biological treatment of, 95
- industrial wastewaters, treatment of, 95, 100–104
 - paper and pulp wastewaters, 97–98
 - petroleum refinery and petrochemical wastewaters, 98–99
 - pharmaceutical wastewaters, 95–97
 - textile wastewaters, 99–100
 - landfill leachate treatment, 113
 - in biological activated carbon (BAC) media, 118–120
 - in PAC-added activated sludge systems, 114–118
 - using PAC-MBR process, 118
 - removal of specific chemicals, 104, 112–113
 - dyes, 110–111
 - organic pollutants, in secondary effluents, 111
 - pesticides and polychlorinated biphenyls (PCBs), 109
 - pharmaceuticals and endocrine-disrupting compounds, 109
 - phenols, 106–108
 - priority pollutants, 109–110
 - volatile organic compounds (VOCs), 104–106
- Polychlorinated biphenyls (PCBs), 109
- Polycyclic aromatic hydrocarbon (PAH), 99, 138, 209
- Polyelectrolyte, 71
- Polymerase Chain Reaction (PCR), 308
- Polyoxyethylen, 210
- Poly S119, 111
- Polysaccharide, 84
- POM. *See* Particulate organic matter (POM)
- POP. *See* Persistent Organic Pollutant (POP)
- Pore blockage, 347
- Pore diffusion model (PDM), 152
- ‘Pore diffusion’, 23
- Pore-filling, 21
- Pores, 14
- macropores, 20, 21, 152, 193, 203, 216, 257
 - mesopores, 20, 21, 152, 192, 193, 201
 - micropores, 14, 20, 21, 27, 152, 192, 193, 201, 202, 203, 216
 - pore blockage, 347
- Pore volume, 13, 21, 193, 202, 257, 292
- Porosity, 1, 203
- Postchlorination, 308
- Potable water, 139, 194

- POTW. *See* Publicly Owned Treatment Works (POTW)
- Powdered activated carbon (PAC), 2, 4, 13, 15, 96, 97, 99, 106, 109, 111, 129, 302, 347, 354, 355, 358
- addition, 246
 - adsorbers, 30
 - anaerobic PACT process, 74
 - integration into biological wastewater treatment, 70–73
 - sequencing batch PACT reactors, 73
 - single-stage continuous-flow aerobic PACTs process, 70
 - activated sludge process, basic features of, 70
 - characteristics of, 72
 - development of, 70
 - process parameters in, 72
- Powdered Activated Carbon Treatment (PACT) process, 7, 44, 69, 100, 101, 102, 109, 114, 127, 145, 157, 195, 199, 207, 209
- aerobic PACT, 46
 - anaerobic PACT, 46, 74, 81, 86, 114, 157
 - and BAC systems, 353–355
 - concurrent bioregeneration in, 195
 - for contaminated groundwaters, 138–139
 - for contaminated surface runoff waters, 139–140
 - for domestic and industrial wastewaters co-treatment, 136
 - full-scale PACT systems, 127
 - for contaminated groundwaters, 138–139
 - for contaminated surface runoff waters, 139–140
 - for co-treatment of domestic and industrial wastewaters, 136
 - for domestic wastewaters reuse, 139
 - for industrial effluents, 128–136
 - for landfill leachates, 136–138
 - general process diagram, 71
 - for landfill leachates, 136–138
 - mass balance for PAC in, 178, 180–181
 - models describing substrate removal in, 181–185
 - operation process parameters, 72
 - PAC-MBR, 44, 75–76, 101, 104, 111, 118, 157, 355
 - PACT[®], 70–74, 87, 128, 131–132, 134
 - PACT sludge, 70, 73, 81, 85, 87, 106, 139, 180, 363–364
 - PACT/WAR, 87, 132, 136, 139
 - for reuse of domestic wastewaters, 139
 - SBR-PACT, 74, 135, 137
 - typical conditions in, 72
- PPCPs. *See* Pharmaceutical and Personal Care Products (PPCPs)
- Prechlorination, 308
- Precursors, 295
- DBP formation, 5, 244, 270, 285, 295, 303
 - humic substances, 196, 240, 244, 245
- Preozonation, 141, 249, 251, 273, 283, 288, 291, 294, 295, 309, 323, 327, 333, 344–345
- Preparation of activated carbon, 13–14
- Pressure swing adsorption, 38
- Primary substrate, removal as, 49, 108, 293, 356
- Priority pollutants, 70, 76, 87
- removal of, 109–110
 - treatment of, 134
- Propylene oxide/styrene monomer (PO/SM) production wastewater, 130–131
- Propyphenazone, 290
- Pseudomonas*, 206, 306
- Pseudomonas chrysosporium*, 206
- Pseudomonas fluorescens*, 112
- Pseudomonas fluorescens* P17, 241
- Pseudomonas putida* ATCC 70047, 107
- Pseudomonas* strains, 207
- Publicly Owned Treatment Works (POTW), 43, 56, 101, 127, 135, 137
- Purit[®], 2–3
- Pyrolysis/GC-MS, 243
- PZG. *See* Plane of zero gradient (PZG)
- R**
- Radiolabeled carbon, 214–215
- Radiolabeled phenol, 215
- Rapid sand filtration, 248, 249, 307, 320, 322, 323
- Rate-limiting step, 16, 24, 199, 201, 337–338
- Raw and ozonated waters, 250, 253, 267, 286–287
- adsorbability and desorbability of organic matter in, 255–259
- Raw water, 5, 245, 255, 258, 285, 291, 302, 303, 323, 325, 326
- NOM, 250
- RBF. *See* River bank filtration (RBF)
- RDX. *See* Royal Demolition Explosive (RDX)
- Reactivation, of activated carbon, 37–39
- Reactive Black 5, 110
- Reactor mass balance, 220
- dimensionless form of, 166–167
 - total dimensionless expression of, 168–169
- Reactors
- BAC, 37, 44, 56, 59, 64, 66, 67, 99, 110, 142, 155, 157, 164–173, 307, 328
 - BAC-SBR, 227
 - biomass balance in, 164

- Reactors (*continued*)
- FBR, 68, 69
 - GAC-FBR (Fluidized Bed Reactor packed with Granular Activated Carbon), 119, 327
 - GAC-MBR (GAC added Membrane Bioreactor), 209, 355
 - GAC-SBBR (GAC Reactor operated as a Sequencing Batch Biofilm Reactor), 68
 - GAC-UASB (Upflow Anaerobic Sludge Blanket packed with Granular Activated Carbon), 81, 100
 - GAC-UFBR (Upflow Fixed Bed Reactors packed with GAC), 105
 - MBR (Membrane Bioreactor), 74–75, 86
 - PAC-MBR, 111, 302
 - PACT, 73–74, 101, 114, 129, 132, 137
 - substrate mass balance in liquid phase of, 159–164
- Reclamation
- BAC filtration, 141
 - domestic wastewater, 140–141
 - industrial wastewater, 141–142
 - nonpotable use, 141–142
 - ozonation, 140
- Recycle fluidized bed (RFB), 175
- Reductive dechlorination, 105
- Refinery wastewaters, PACT treatment of, 98, 131–134
- Regeneration
- of activated carbon, 360
 - activated carbon grade, importance of, 360–361
 - biological activated carbon, 363–364
 - bioregeneration of activated carbon, 361–363
 - bioregeneration
 - of PACT and BAC sludges, 86
 - frequency, 327, 328
 - thermal, 39
 - wet air oxidation (WAO), 38, 86, 103, 130, 131, 139, 363–364
 - wet air regeneration (WAR), 71, 87, 128, 131, 363
- Reichs Ford Road landfill, 137
- Remediation, 7, 8
- Removal mechanisms and micropollutant elimination, 355
- drinking water treatment, 358–359
 - wastewater treatment, 355–358
- Repsol Tarragona wastewater treatment plant, 131
- Respirometry, 215
- OUR, 80, 96, 103, 106, 117, 185
 - SOUR, 58
- Reversible adsorption, 196
- bioregeneration on, 195–198
 - extent of, 211
- RFB. *See* Recycle fluidized bed (RFB)
- Rheinisch–Westfälische Wasserwerksgesellschaft (RWV), 247–248
- Rhodococcus rhodochrous*, 206
- Ribosomal RNA genes, 308
- River bank filtration (RBF), 248
- Row Supra, 256, 257, 258, 259
- Royal Demolition Explosive (RDX), 195
- RWV. *See* Rheinisch–Westfälische Wasserwerksgesellschaft (RWV)
- S**
- Salicylic acid, 291, 292
- Sand biofiltration, 277, 291
- Sand filtration/filters, 5, 46, 137, 237, 238, 242, 266, 273, 275, 276, 286, 287, 291, 295, 297, 304, 307, 308, 322, 323, 327
- Sandwich™ filter, 273
- SAT. *See* Soil aquifer treatment (SAT)
- SBR. *See* Sequencing batch reactor (SBR)
- SBR-PACT, 74, 135, 137
- Scale
- full-scale, 10, 74, 76, 97, 101, 127, 132–134, 141, 248, 255, 274, 286, 300, 319, 320, 321, 323, 327, 331, 340, 348, 360, 363, 364
 - laboratory-scale, 80, 97, 101, 103, 112, 114, 119, 141, 269, 275, 300
 - pilot-scale, 98, 102, 104, 109, 119, 133, 152, 268, 276, 277, 283, 284, 286, 293, 300, 308, 343, 344, 345
- Scanning Electron Micrographs, 207, 217
- Scanning Electron Microscopy (SEM), 64, 207, 216, 305
- Scattered surface growth, meaning of, 222
- SCFB. *See* Semi-Continuously Fed Batch (Reactor) (SCFB)
- Schatten, 2
- Scheele, 2
- SCR. *See* Specific Cake Resistance (SCR)
- SEC. *See* Instrumental analysis
- Secondary substrate, 49–50, 356
- Secondary treatment, activated carbon in, 46
- GAC, 46
 - PAC, 46
- SEM. *See* Scanning Electron Microscopy (SEM)
- Semi-Continuously Fed Batch (Reactor) (SCFB), 115–116
- Semi-volatile organic compounds (SVOCs), 294
- Sequencing batch reactor (SBR), 73, 81, 103, 106, 195
- BAC-SBR, 112, 227
 - GAC-SBBR, 68

- SBR-PACT system, 74, 135, 137
- sequencing batch biofilm reactor (SBBR), 68, 194, 195
- Sequential adsorption–biodegradation approach, 215
- Settling, 81–82, 103, 129, 322, 323, 354, 358
- Sewage treatment plants (STPs), 43–44, 62, 114, 140
- Sherwood number. *See* Dimensionless numbers
- Shigella* sp., 308
- SIAS. *See* Simplified Ideal Adsorbed Solution (SIAS)
- Siemens
- Simplified Ideal Adsorbed Solution (SIAS), 28, 29
- Single solute adsorption, 27–28, 37
- Single solute systems, bioregeneration in, 220–225
- Single-stage continuous-flow aerobic PACT[®] process, 30
 - activated sludge process, basic features of, 70–71
 - characteristics of, 71
 - development of, 70
 - process parameters in, 72–73
- Size Exclusion Liquid Chromatography coupled to Organic Carbon Detection (SEC-OCD), 243
- Slow sand filtration (SSF), 249, 320, 323
- Sludge, biological
 - dewaterability, 78, 82, 83, 87, 358
 - mean floc size, 85
 - settleability, 82, 84, 97, 181
 - sludge volume index (SVI), 82, 97, 129
 - specific cake resistance (SCR), 85–86
 - specific resistance to filtration (SRF), 82, 83
- Sludge age. *See* Sludge retention time (SRT)
- Sludge retention time (SRT), 47, 52, 66, 68, 70, 72, 75, 85, 157, 179
- Sludge-water partition coefficient, 54
- sMBRs. *See* Submerged membrane bioreactors (sMBRs)
- SMP. *See* Soluble microbial products (SMP)
- SOC. *See* Synthetic Organic Compounds (SOC)
- Sodium-2-(diisopropylamino) ethylthiolate, 101
- Sodium ethylmethyl phosphonate, 101
- Soil aquifer treatment (SAT), 248–249
- Soil contamination, remediation of, 7
- Solid–water partition coefficient, 52
- Solubility, 18–19, 48, 113
- Soluble EPS, 83
- Soluble microbial products (SMP), 77, 83, 208, 304, 341
 - biomass associated products (BAP), 341
 - drinking water biofiltration, 341
 - membrane bioreactors, 302
 - utilization associated products (UAP), 341
- Solute, 16, 17, 18, 158
 - bisolute, 29, 37, 208, 209
 - multisolute, 27, 28–30, 37
 - single solute, 27–28, 37, 220–225, 342
- Solute distribution parameter. *See* Dimensionless numbers
- Solvent, 96, 102, 103, 112, 138, 182, 213, 300
 - solvent extraction, 213
- Sontheimer, 248, 342, 343
- Sorption, 21, 47, 52, 53, 69, 104, 184, 185, 203, 357, 362
 - biosorption, 47, 52, 54, 100, 183, 335
 - onto activated carbon, 53
 - adsorption, 3, 8, 10, 16–39, 43, 96, 97, 112, 145, 189, 237, 265, 342, 347, 348, 353, 354, 357, 358, 360–363
- ion exchange, 66, 300, 302
- SOUR. *See* Specific Oxygen Uptake Rate (SOUR)
- South Caboolture Water Reclamation Plant, 141, 142
- Speciation, 79, 113, 295
- Specific Cake Resistance (SCR), 85–86
- Specific Oxygen Uptake Rate (SOUR), 58
- Specific ozone dose, 251, 253
- Specific Resistance to Filtration (SRF), 82, 83
- Specific surface area, 18, 20–21, 27, 273, 338
- Specific Ultraviolet Absorbance (SUVA), 239, 245, 250, 252, 253, 272, 302, 323
- Spectral measurements, organic matter expression by, 239
- Speitel, 205, 220, 221, 227
- Sphingomonas*, 109, 307
- Spirillum* sp. strain NOX, 241
- SRF. *See* Specific Resistance to Filtration (SRF)
- SRT. *See* Sludge retention time (SRT)
- SSF. *See* Slow sand filtration (SSF)
- Stanton number. *See* Dimensionless numbers
- Stenhouse, 2
- Ste Rose treatment plant, in Quebec, 323
- Stewartby Landfill Site, 138
- Stripping, 7, 54, 96, 102, 134, 184, 185
- STPs. *See* Sewage treatment plants (STPs)
- Styrum-East Water Works, 320
- Submerged membrane bioreactors (sMBRs), 74, 303
- Substituent groups, 19, 200
- Substrate and biomass associated products, of biodegradation, 207–208

- Substrate–carbon contact time, 203–204
- Substrate concentration, 65, 67, 149, 151, 160, 161, 174, 185, 190, 201, 215, 218, 223, 307, 339
- Substrate removal and biofilm formation, 173–174, 331–333
- Substrates, 149, 159, 173–174, 177–178, 193, 208, 223, 225, 305, 307, 323, 332, 339, 340, 345, 356, 359, 361, 362
 - behavior and removal of, 59, 60–61
 - chemical properties of, 200
- Substrates' concentration on the surface of activated carbon, 58
- Sulfate, 15, 135, 300, 301
- Sulfonol, 210
- Surface acidity, 21, 203, 290
- Surface diffusion, 23
- Surface diffusion coefficient, 153, 166, 178, 221
- Surface functional groups, 15, 20, 21, 196
- Surface loading rate, 33
- Surface runoff waters, 139–140, 285
- Surfactants, 5–6, 128, 195, 200
- Surfactants mixture, 210
- SUVA. *See* Specific Ultraviolet Absorbance (SUVA)
- SVOCs. *See* Semi-volatile organic compounds (SVOCs)
- Synthetic carbonaceous adsorbent, 66
- Synthetic fiber manufacturing industry, wastewater of, 130
- Synthetic organic compounds (SOC), 5, 30, 175, 209, 237, 331
- T**
- Tannic acid, 111
- Taste and odor, 3, 4, 5, 238, 245, 246, 247, 288, 292, 320, 326–327
- TCA. *See* Trichloroethane (TCA)
- TCAA. *See* Trichloroacetic acid (TCAA)
- TCB. *See* Trichlorobenzene (TCB)
- TCE. *See* Trichloroethylene (TCE)
- TDS. *See* Total dissolved solids (TDS)
- Temperature, 15, 17, 20, 22, 38, 70, 79, 87, 119, 138, 197, 215, 248, 274, 276–277, 284, 286, 305, 323, 335, 340, 345
- Tensides, 109, 288, 357
- Terminal-restriction fragment length polymorphism (T-RFLP), 308
- Terminal-restriction fragments (T-RFs), 308
- Tert*-butyldimethylsilanol, 111
- Tertiary treatment, activated carbon in, 46
 - GAC, 47
 - PAC, 46–47
- Tetrachloroethylene (PCE), 105, 110, 134, 138, 210, 217
- Tetrahydrofuran, 96
- Textile wastewaters, treatment of, 99–100, 111
- Thermally activated PACs, 202
- Thermal volatilization, 38
- Thiocyanate, biological removal of, 102, 103
- THMs. *See* Trihalomethanes (THMs)
- THMFP, 10, 295, 303
- Three-phase fluidized bed reactor, modeling step input of substrate in, 177
- Throughput volume, 34
- TiO₂/UV/O₃, 111
- TKN. *See* Total Kjeldahl Nitrogen (TKN)
- TMP. *See* Transmembrane pressure (TMP)
- TN. *See* Total Nitrogen (TN)
- TOC. *See* Total Organic Carbon (TOC)
- Toluene, 50, 96, 102, 104, 105, 118, 134, 138, 182, 183, 202, 210, 224, 225, 289
- Total dissolved solids (TDS), 135
- Total Kjeldahl Nitrogen (TKN), 96, 139
- Total Nitrogen (TN), 100, 141, 287, 288
- Total Organic Carbon (TOC), 239, 243
- Total THM (TTHM), 295, 297, 348
- Total volatile hydrocarbons (TVH), 99
- Toxic algal metabolites, 288, 293
- Trace organics, 47, 347
- Transient-state, multiple-species biofilm model (TSMSBM), 341–342
- Transmembrane pressure (TMP), 75, 85
- Transport mechanisms
 - adsorption, 24
 - boundary layer, 22–23
 - bulk solution transport (Advection), 22–23
 - external diffusion, 23
 - external film, 23
 - intraparticle (internal) diffusion, 23
 - liquid film, 23
 - molecular diffusion, 23
 - pore diffusion, 23
 - surface diffusion, 23
- T-RFLP. *See* Terminal-restriction fragment length polymorphism (T-RFLP)
- T-RFs. *See* Terminal-restriction fragments (T-RFs)
- Trichloroacetic acid (TCAA), 295, 297
- Trichlorobenzene (TCB), 134, 182, 290
- Trichloroethane (TCA), 112
- Trichloroethylene (TCE), 54, 105, 134, 138, 208, 210, 215, 290, 304
- Trihalomethanes (THMs), 10, 244, 294–295, 297, 348

- bromodichloromethane, 298, 348
- cometabolism
- nitrifiers, 298
- dibromochloromethane, 298, 348
- trihalomethane formation potential (THMFP), 10, 295, 303
- Trovaflxin mesylate, 292
- TSMSBM. *See* Transient-state, multiple-species biofilm model (TSMSBM)
- TTHM. *See* Total THM (TTHM)
- TVH. *See* Total volatile hydrocarbons (TVH)
- 'Two-liquid film' model, 221–222
- U**
- UASB. *See* Upflow anaerobic sludge blanket (UASB)
- UF. *See* Ultrafiltration (UF)
- Uhl's model, 335–337
- Ultrafiltration (UF), 74, 75, 85, 118, 302, 323
- Upflow anaerobic sludge blanket (UASB), 81, 100
- Upflow fixed-bed reactors packed with GAC (GAC-UFBR), 105
- Use of activated carbon, 1, 3–4
- UV absorbance, 8, 239, 251, 295
- BAC filtration, 277
- specific ultraviolet absorbance (SUVA), 239, 245, 250, 252, 253, 272, 283, 295, 302, 323, 325
- UV₂₅₄, 96, 141, 239, 253, 255, 277, 303, 325
- UV₂₈₀, 96, 111
- V**
- Valeric acid, 173, 218, 219
- van der Kooij, 241, 306
- van der Waals forces, 15, 17, 21, 27, 196
- Very low substrate (fasting) conditions, modeling the case of, 176–177, 336
- Vinyl chloride-containing wastewater, 133
- Virgin GAC, 177, 205, 208
- VOCs. *See* Volatile organic compounds (VOCs)
- Void ratio, 160, 164
- Volatile organic compounds (VOCs), 7, 38, 58, 96, 102, 104–106, 128, 135, 185, 294
- Volatility, 54, 59, 104
- Henry constant, 54, 184
- Volatilization, 38, 54, 183
- von Ostrejko, 2
- W**
- Wang and Summers, model of, 337–338
- WAO. *See* Wet air oxidation (WAO)
- WAR. *See* Wet Air Regeneration (WAR)
- Warburg's apparatus, 215
- Wastewaters
- hazardous landfill leachates, 6, 8, 43, 50, 69, 127
- industrial
- acrylonitrile manufacturing, 103
- alcohol distillery wastewater, 104
- bactericide wastewater, 101
- caustic hydrolysate wastewater, 101
- coke oven plant wastewater, 103
- dyes and pigments processing wastewater, 102
- metal finishing industry wastewater, 112
- mining industry wastewater, 112
- organic chemicals production industry wastewater, 5, 8, 19, 127, 128, 129, 130, 134, 136, 182, 242
- paint and ink industry wastewater, 112
- paper and pulp wastewater, 97–98
- pesticide manufacturing wastewater, 107, 128
- petrochemical wastewater, 131–134
- petroleum refinery wastewater, 98–99
- pharmaceutical wastewater, 95–97, 135–136
- phenolic wastewater, 101, 358
- propylene oxide/styrene monomer (PO/SM) production wastewater, 130–131
- steel mill coke plant wastewater, 102
- synthetic fiber manufacturing industry wastewater, 130
- tannery wastewater, 101
- textile industry wastewater, 63, 214
- municipal, domestic, 50, 63
- reuse, 6, 50, 76, 127, 139
- sanitary landfill leachates, 80, 82, 113
- treatment, 355–358
- activated carbon adsorption in, 7
- activated carbon in, 5–6
- advanced, 141
- biological, 59, 60, 69, 127, 355, 358, 363
- industrial, 6, 31, 43, 46, 47, 50, 56, 62, 63, 68, 74, 76, 95, 99
- municipal, 6, 43, 63, 79, 354, 356, 357
- physicochemical, 6, 30, 62, 110, 238
- primary, 44, 45, 46, 76
- secondary, 43–45, 46
- tertiary, 43–45, 46
- Wastewater treatment plants (WWTPs), 6, 52, 75, 76, 101, 185, 354
- Water preparation, for industrial purposes, 7
- Water treatment
- activated carbon adsorption in, 8
- activated carbon in, 246–247

- BAC filtration, 8, 76, 109, 118, 127, 140, 195, 197, 237, 247, 249, 250, 251, 260, 265, 274, 284, 286, 288, 291, 294, 295, 297, 300, 303, 307, 309, 319, 321, 326, 327, 331, 333, 358, 359, 363
 - biofiltration, 247, 250, 265, 283, 291, 295, 320, 321, 334, 337, 341
 - coagulation, 6, 30, 101, 118, 141, 237, 245, 249, 277, 292, 295, 308, 324, 326
 - disinfection, 4, 140, 141, 237, 244, 248, 285, 309, 322, 324
 - double layer filtration, 248, 321
 - filtration, 8, 85, 86, 100, 104, 108, 138, 140, 195, 237, 245, 247–249, 254, 284, 291, 297, 300, 303, 306, 319, 323, 326, 327, 333, 344, 354, 355, 359, 363
 - flocculation, 63, 237, 245, 246, 248, 277, 292, 322, 323
 - infiltration for groundwater recharge, 248, 321
 - Mülheim process, 5, 247–248, 320
 - sand filtration, 5, 46, 138, 140, 237, 248, 249, 266, 286, 291, 307, 308, 309, 320, 323
 - sedimentation, 63, 139, 140, 245, 248, 277, 292, 308, 324
 - water distribution, 238, 242–243, 245, 248, 284, 285, 295, 319, 324
 - plants
 - Bendigo, Castlemaine & Kyneton (Victoria, Australia), 326–327
 - Leiden Plant (the Netherlands), 320–322
 - Mülheim (Germany), 320
 - Ste Rose Plant (Quebec, Canada), 323
 - suburbs of Paris, 322–323
 - Weesperkarspel (the Netherlands), 324–326, 327
 - Zürich-Lengg (Switzerland), 323–324
 - Weber, 63, 64, 69, 173, 174, 182, 221, 222
 - Weesperkarspel Plant, 276, 283, 324–326, 327
 - Wet air oxidation (WAO), 38, 86, 103, 130, 363–364
 - Wet Air Regeneration (WAR), 71, 87, 128, 131, 363, 364
 - WWTPs. *See* Wastewater treatment plants (WWTPs)
- X**
- Xenobiotic organic compounds (XOCs), 43, 208, 288
 - brominated flame retardants, 43
 - endocrine disrupting compounds (EDCs), 5, 53, 76, 109, 140, 288, 290, 291, 354
 - hormones, 43, 62, 354, 356, 359, 362
 - personal care products (PCPs), 43, 109, 110, 206, 217, 288
 - pesticides, 5, 43, 100, 103, 107, 109, 112, 128, 140, 288, 291, 320, 321, 346, 347
 - pharmaceuticals, 43, 52, 75, 76, 95–97, 109, 135, 288, 290, 354, 357, 358
 - pharmaceuticals and personal care products (PPCPs), 109, 288, 356, 359, 362
 - Xenobiotics, 43, 49, 207, 208, 288, 354
 - XOCs. *See* Xenobiotic organic compounds (XOCs)
 - Xylenols, 108
- Z**
- Zernel Road Municipal Solid Waste Landfill, 137
 - Zero-order kinetics inside biofilm, 167–168
 - Zimpro® WAR, 70, 87
 - Zürich-Lengg, plant in, 323–324