

Index

a

absorption process 139, 195, 223, 226, 228, 353
 acetonitrile extracted lignin (AEL) 201
 acetylated cellulose derivatives 468
 acid EDTA, potentiometric titration 471
 acid hydrolysis 146, 344–345
 acrylamide (AM) 184
 acrylamide-bonded SA hydrogel 394
 acrylamide/GO-bonded SA
 nanocomposite hydrogel 394
 acryloylmorpholine-based polymers 400
 2-(acryloyloxy)ethyl trimethyl ammonium chloride solution (ATAC) 188
 activated carbon 286, 401
 activation energy 221, 469
 adsorption 228, 230
 capacities and mechanisms
 for binding CECs 455–456
 for binding conventional pollutants 452–453
 performances, chitosan-based
 composites 308, 309
 advanced oxidation processes (AOT) 109, 112, 343, 358
 aerogels 214, 217, 218, 235, 240, 241, 244, 290–291, 313, 386, 440
 Ag/CNFs membrane 165
 agricultural food applications 426–427
 alcohol dehydrogenase immobilization 432–433
 algae-derived biopolymers
 alginate 54

carrageenan 54–55
 macroalgae (seaweeds) 52
 microalgae 52
 alginate-coated maghemite, for MB removal 448
 alginates 54, 388, 394
 chemical modification of 391, 392
 alkali commercial lignin 202
 alkali/urea aqueous system 467
 1-allyl-3-methylimidazolium chloride (AMIMCl) 466, 467
 alpha zirconium phosphate nanoparticles (α -ZrP-n) 232
 American Society for Testing and Materials (ASTM) 214, 344
 amidoxime-modified chitosan 380, 385
 amphoteric character, of HEDTA 472
 amylopectin 32, 49, 280, 281, 372, 375
 amylose 49, 280, 288, 372, 375
 animal-derived polymers
 benefits 27, 37
 classification 27
 drawbacks 37
 oils 36, 37
 polysaccharides 30–33
 proteins 33–36
 animal digestive systems 41, 42
 anion exchange membrane (AEM) 310
 anionic lignin-based polymers 185–189
 anionic starches 375–377
 Arrhenius equation 469
 arsenic, in drinking water 110–111
 atomic absorption spectrophotometer 67

atomic force microscopy (AFM) 57–59
attenuated total reflection (ATR) 214
azo dyes 117, 186–188

b

bacterial biopolymers
microbial exopolysaccharides 45–46
nanocellulose 42, 45
polyhydroxyalkanoates (PHAs) 37–42
bacterial celluloses (BCs) 42, 160–161,
217
and composite membranes 169–173
hydrogels 467–469
bacterial cellulose@ZIF-8 aerogel
membrane 172
bacteriophage-mediated lysis systems
41–42
barrier properties 148
BCM@(3-aminopropyl) triethoxysilane
(APTES)-ethylenediaminetetra-
acetic acid (EDTA) composites
membrane 172
beeswax 36
bibliometric analysis
affiliations 5
authors 3–5
countries 5
definition 1
keywords 7–13
methodology 2
publications 6–7, 12–13
sources 2, 4
Bibliometrix R-package 1
bioaccumulation 110
biocatalytic membrane
advantages 421
agricultural food 426–427
definition 421
dopamine in enzyme immobilization
alcohol dehydrogenase 432–433
laccase 432
opportunities and challenges 434
dopamine in membrane modification
membrane antifouling ability
improvement 431

membrane hydrophilicity
enhancement 431
dopamine properties
adsorption 430
Michael and Schiff reaction 429
oxidizing capacity 429
reducibility 429–430
enzymes
catalase 424
laccase 423
tyrosinase 423–424
examples of 422
medicine application 427
preparation method
covalent bonding 425–426
cross-linking method 425
entrapment method 424–425
physical adsorption method 426
seawater treatment 427–429
biochar-alginate composite 394
biochar/pectin/alginate hydrogel beads
402
biodegradable biopolymers 25
biodegradable plastics 26
bio-extraction methods 41
biological contaminants 114–115
biological glue 429
biomaterials 147, 223, 224, 468
bioplastics 439
commercial application areas 26, 29
manufacturing capacity 26–28
biopolymer-coated nanoparticles
characterization
thermogravimetric analysis 444
XRD analysis 443–444
iron oxide nanoparticle synthesis
440–442
metal oxide nanoparticle synthesis
442, 443
in water treatment
Acid Green 25 dye removal 449
anionic reactive black 5 dye removal
449
CECs removal 449–457
heavy metal removal 444–447

- methylene blue dye removal 447–449
 Rhodamine B dye removal 448
 biopolymer pectin-GO nanocomposite 401
 biopolymers 276
 advantages 26
 characteristics 26
 characterization 55, 56, 439–440
 atomic absorption spectrometry 67
 atomic force microscopy 57–59
 CHNS/O analyzers 70
 differential scanning calorimetry 62–63
 Fourier transform infrared spectroscopy 63–65
 nuclear magnetic resonance 65–67
 optical microscopy 56
 Raman spectrum 64–66
 scanning electron microscopy 56–58
 thermogravimetric analysis 60, 62
 transmission electron microscopy 58–60
 X-ray diffraction 68–69
 commercializing natural biopolymer 26
 conventional and nonconventional extraction techniques 71
 definition 1, 25, 26, 93
 drawbacks 72
 mechanical properties 70–71
 source and types 93–94
 water pollution treatment 94–105
 biopolymers/biodegradable polymers 439
 bisphenol-A (BPA) removal 450
 Brunauer–Emmett–Teller technique (BET) 103, 218
 1-butyl-3-methylimidazolium chloride (BMIMCl) 466, 467
- C**
Calligonum polygonoides biomass-based AC/alginate beads 394
- capacitive deionization (CDI) 308
 capsular polysaccharides (CPSs) 46
 carbon-based adsorbents 351
 carbon-dot hydrogels 479
 carbon nanotubes (CNTs) 196, 306–307
 carboxymethylated cellulose fiber (CMF) 241
 carboxymethyl chitosan-coated magnetic silica, for cobalt removal 446
 carboxymethyl starch (CMS) 376
 carrageenans 54–55, 93, 388
 cassava starch (CS) 289–290
 catalase 424, 425, 427
 cation exchange membrane (CEM) 310
 cation exchange resin (CER) method 45
 cationic lignin-based polymers 183–185
 cationic starches 283, 375, 376
 CB@NF/PVA/starch composites 379
 cellulose 46–49, 147, 439
 chemical and hierarchical structure 158, 159
 definition 145
 extraction using acid hydrolysis method 146
 fibres 146
 in plant microfibril membrane 145, 146
 property of 145
 cellulose acetate 468
 hydrogels derived from 469–474
 cellulose acetate/lignocellulose
 nanofibrils (CA/LCNFs) composite membranes 165
 cellulose-coated magnetic nanoparticles 441
 cellulose-derived hydrogels 465
 applications 475–476
 contaminated water
 metal and radioactive compounds removal 477–478
 organic contaminants, oils and dye removal from 478–480
 cellulose dissolution systems
 alkali/urea or thiourea aqueous system 467

- cellulose dissolution systems (*contd.*)
 bacterial cellulose hydrogels 467–469
 ionic liquids 467
N-methylmorpholine-*N*-oxide 466
- cellulose–lignin membranes 200
- cellulose membrane 146, 201, 245
 process characteristics 150, 151
- cellulose–metallothionein biosorbent 104
- cellulose micelles 160
- cellulose nanocrystals (CNCs) 58, 60, 158, 160, 166–169
- cellulose nanofibrils (CNFs) 158, 160
 composite membrane 162–166
- cellulosic materials (CMs)
 adsorption yields, in
 percentage/concentrations 243
- characteristic functional groups 214
- characterization and evolution 242–243
- chemical composition 214
- classification 213
- devices manufactured with 241–242
- dye/colorants extraction and type of 225–227
- heavy metals and industrial dyes,
 absorption of 232–233
- heavy metals purification 224–225
- morphological characteristics 240–241
- morphology and crystalline structure 214, 216–218
- oil/hydrocarbon 228, 230–231, 234–235
- organic and inorganic compounds 227–229, 233–234
- physical and chemical modifications 235–240
- physical-mechanical properties 218–220
- physicomechanical properties 219
- selection stage of water treatment 243–244
- structural and functional properties 213
- TAPPI standards 216
- thermal properties 220–222
- ceramic membranes 137, 211, 426
- ceramics 158
- chemical contamination
 inorganic contaminants
 metallic contaminants 115, 116
 non-metallic contaminants 115
- organic contaminants
 dyes 117
 oil and grease 118
 pesticides 116, 117
 phenolic compounds 118
 polycyclic aromatic hydrocarbons (PAHs) 118
 volatile organic compounds (VOC) 117
- chemical extraction methods 40
- chemically modified chitosan composites, for contaminant adsorption 381–382
- chemical precipitation process 278
- chemisorption 280, 319, 352, 387, 403, 444
- chitin
 alkaline hydrolysis 301, 302
 and chitosan 31
 isolation process 379
- chitin coated nickel oxide nanoparticles 442
- chitin material development
- nanoobjects
 acid hydrolysis 344–345
 deep eutectic solvents 346
 high pressure 346–347
 ionic liquid 345–346
 solvent casting 347
 TEMPO-mediated oxidation method 345
- nanoparticle and nanostructured composite production 343–344
- nanostructured materials
 $\text{CaCl}_2/\text{methanol}$ 349
 DMAc/LiCl 349–350

- electrospinning method 348
 ionic liquids 348–349
 NaOH/urea 350
 solvent casting 350
 pollutant removal by adsorption process 350–358
 pollutant removal by adsorption processes 358
 pollutant removal by degradation processes 358–361
chitosan 301, 379
 action toward Gram-positive and Gram-negative bacteria 303
 advantages and drawbacks 303
 applications 303, 304
 bactericidal effects 303
 with carbon-based nanomaterials 304, 305
 chemical modification 384
 ionic crosslinking 383
 N-substitution and O-substitution reactions 380
 Schiff base reaction 380
 self-crosslinking 383
 chemical structure 379, 380
 and chitin 31
 composites membranes 322–324
in situ polymerization modification 383
 IPN and gel 318–322
 metal-chelating ability 303
 molecular weight 301, 302
 polymer blends 315–318
 structure, chemical modification of 303
chitosan (β -(1-4)-D-glucosamine) 341
 chitosan and quinoa polysaccharide composite aerogel 386
 chitosan-based composites 383–387
 chitosan-based gel bead 320, 321
 chitosan-based nanoadsorbent 446
 chitosan biopolymer 94, 96, 105, 439
 chitosan/cellulose acetate 386
 chitosan–cellulose composite hydrogel 386
chitosan/cellulose sulfate aerogel 386
chitosan/CNTs composites 306, 312
 adsorption properties 307, 309
 electrosorption 308
 membrane separation processes 308, 310
microbial desalination cells (MDCs) 310
 organic dyes 311
 pH values 308
 preparation 307
 removal of pollutants 308
 SWCNTs or MWCNTs 306–307
chitosan-coated copper oxide
 nanoparticles, XRD patterns of 443
chitosan-coated maghemite 445
chitosan-coated magnetite hydroxyapatite 443
chitosan-coated magnetite nanoparticles 440
chitosan-coated magnetite, XRD patterns of 443
chitosan-coated nanoparticles stability 442
chitosan/Fe₃O₄/attapulgite gel beads 386
chitosan-G (GO) composites
 adsorption 312
 aerogels 313
 desalination processes 313
 fibers 312
 hydrogels 313
 and reduced graphene oxide (rGO) 312
 removal of heavy metals 315
 separation by magnetism 314
chitosan/TiO₂/attapulgite composite 386
chitosan-water treatment residual
 particulate adsorbent, adsorption capacity of 386

chitosan/xylan coated magnetite
nanocomposite 451
chlorination process 143–144
3-chloro-2-hydroxypropansulfonic acid
sodium salt (CHPSS) 190
chloryrifos (CPF) 233
CHNS/O analyzers 70
ciprofloxacin (CIP) removal 450
CN-TFNC membranes 162–164
coagulation efficiency 278
coalescence 230, 231
(chitosan-2-hydroxy-1-naphthaldehyde)-
coated magnetite, for chromium
sorption 444
cobalt ferric nanoparticles (CoFe_2O_4)
442
collagen
drawbacks 34
sources of 33, 34
structure of 33
coniferyl 182
contaminant absorption mechanism
231–235
Contaminants of Emerging Concern
(CECs)
description 449
removal 449–457
conventional and nonconventional
extraction methods 27
copolymerization 184, 189, 324
coprecipitation method 314, 440
covalent bonding method 425–426
crosslinked gum ghatti (with poly(acrylic
acid-*co*-acrylamide))-coated
magnetite 443
cross-linked polyvinyl alcohol (PVA) RO
membranes with triblock
copolymers 169
cross-linking method 425
crystalline cellulose 214, 220
CS-carbon-based nanomaterials
removal of pollutants 305, 306
water treatment 304
CTA-modified starch-based flocculant
376

d

decoloration 379
deep eutectic solvents (DESs) 346
degrees of substitution (DS) 468, 469
demineralization 379
deproteinization 379
depth filters 139
diatomite 394–395
diclofenac (DCF) 449, 450
Diels–Alder reaction 307
diethylenetriaminepentaacetic acid
(DTPA) functionalized
chitosan-coated magnetic silica
445
differential scanning calorimetry (DSC)
62–63, 220, 221
diffusion coefficients, of hydrogels 469
dimethyl diallyl ammonium chloride
(DADMAC) 184
diphenylamine 391
4,4'-diphenylmethane diisocyanate (MDI)
473
direct coating method 164
CNFs membranes preparation 162
distillation 142–143
dopamine properties
adsorption 430
Michael and Schiff reaction 429
oxidizing capacity 429
reducibility 429
drinking water treatment plants (DWTP)
7, 112
Dubinin–Radushkevich models 305, 450
dynamic mechanical analysis (DMA)
219

e

EDAX 214
electrical double-layer (EDL) formation
308
electrospinning method 201, 226, 313,
348
engineered nanomaterials (ENMs) 112
entrainment method 424–425
enzymatic extraction methods 40

enzymatic hydrolysis lignin (EHL) 185
 esterification 42, 148, 197, 237
 etherification 238
 eutrophication 91
 extracellular matrices (ECMs) 30
 extracellular polymeric substances/
 exopolysaccharides (EPS) 45–46

f

fast sulphon black (FSB) dye 361
 Fe_2O_3 NPs-starch nanocomposite 377
 fibrous tunicate cellulose nanocrystals
 (TCNCs) 167
 field emission scanning electron
 microscope (FESEM) 98, 240
 film-like BCs/cyclodextrin oligomer
 composites 172
 filtration process 139, 140
 flax fibers-CNF (FF-CNF), oil/water
 separation composite membrane of
 164
 flocculation 278, 282–283, 376
 flotation process 279
 forced hydrolysis method 171
 Fourier transform infrared spectroscopy
 (FTIR) 63–65, 214
 Freundlich isotherm models 305, 315,
 354, 395

g

gelatin 34–35
 gelatin–beta cyclodextrin fiber adsorbent
 100
 gelatin-coated magnetite, thermal
 stability of 444
 gelatin infused with chitosan/
 polyethyleneimine 100–101
 gel-based chitosan 321–322
 glutaraldehyde (GA) 105, 199, 203
 glycidyl methacrylate (GMA) 233, 238
 glycidyltrimethylammonium chloride
 (GTMAC) 190
 glycogen 27, 32–33
 GO@CNFs composite membrane, oil/
 water separation efficiency of 165

graft copolymerization 238–240, 397
 green biopolymer synthesis techniques
 71–72
 guar gum (GG) 123, 396
 gum-acacia (GA) integrated Fe_3O_4
 nanoparticles composite hydrogel
 478
 gum arabic 98–100
 gum ghatti crosslinked with poly(acrylic
 acid-co-acrylamide)-coated
 magnetite 448
 gum polysaccharides
 chemical structure 396
 properties 396

h

halogenation 237–238
 hardwood lignin (HL) 182, 185
 heavy metals (HMs) 224–225
 and industrial dyes, absorption of
 232–233
 HEDTA
 before and after immersion in CuSO_4
 solution 473
 hydrogel
 neutralization 470, 471
 synthesis 470
 potentiometric titration 472
 hemicellulose 212, 216, 221, 236
 heparin 32
 high-performance liquid chromatography
 (HPLC) 214
 Hummers method 312
 hyaluronan (HA) (hyaluronic acid or
 hyaluronate)
 animal tissues 30
 GAG uronic acid 30
 market value 30
 molecular weight 30
 restrictions 30
 hydrogels 288–290
 applications 474
 from cellulose acetate 469–474
 classification 465

- hydrogels (*contd.*)
 in evaporators and hydrogen production applications 480–481
 hydrogen bond donor (HBD) 346
 hydrolysis lignin (HL) 182
 hydrophobic double network hydrogel 288
 hydrophobicity 226, 234, 288, 310
- i**
 immersion precipitation phase inversion (IPPI) 165
 impregnation method 165
 inorganic contaminants
 metallic contaminants 115, 116
 non-metallic contaminants 115
 interfacial polymerization (IP) method 166
 interfacial solar-driven evaporators 378
 International Organization for Standardization (ISO) 214, 344
 International Union of Pure and Applied Chemistry (IUPAC) 26, 344
 interpenetrating polymer networks (IPNs) 318–319
 ion exchange process 279
 ionic liquids (ILs) 48, 64, 69, 236, 345–346, 348–349, 467
 IPN-based chitosan 321–322
 3-isocyanatopropyltriethoxysilane (ICPTES) 441
 itaconic acid grafted poly(acrylic acid-co-aniline) (ItA-g-poly(AA-*co*-Ani)) hydrogel 479
- k**
 kappa carrageenan–graphene oxide composite 101–102
 κ-carrageenan siliceous hybrid coated magnetite, for paraquat removal 451
 keratin 35–36, 62–64, 67, 69
 kraft lignin (KL) 51, 182, 190
 kraft process 51
- l**
 laccase 423–425, 427, 432
 Langmuir isotherm models 305, 311, 315, 385–387, 445
 lignin 50–52
 anionic lignin-based polymers 185–189
 application of 181
 cationic lignin-based polymers 183–185
 lignin-based hydrogels 202–203
 lignin-based membranes 199–202
 lignin-based polymers with dual action 189–191
 microparticles 196
 nanoparticles 195–199
 structure 182, 183
 thermoplastics 191–195
 lignin-based polymers with dual action 189–191
 lignin-grafted cationic polyacrylamide (L-CPA) 185
 lignin hydrogel-based solar driven evaporator 480
 lignin–nanoparticles (L-NP) 198
 lignosulfonate 51, 182, 187
 lignosulfonate modified PS (SLPS) 191
 Linde Type A (LTA) zeolite particles 385
 lysozyme/TEMPO-oxidized cellulose nanofibers (LYS/TOCNs)
 composite membrane 164
- m**
 macroalgae (seaweeds) 52, 54
 magnetic-based adsorbents 445
 magnetic–carboxylated cellulose/starch composite 104–105
 magnetite-coated nanoparticles 440
 mechanical disruption 40
 mechanical filtration 139
 media filters 139
 medicine application 427
 medium-released polysaccharides (MRPs) 46

- Meldrum's acid modified CNF-based
PVDF membrane 164
- melt blending 316
- membrane filtration 149–150
- membrane hydrophilicity enhancement 431
- membrane processing 150–151
- membrane technology 148–149, 241
- mercaptoacetic acid locking imine (MALI) reaction 307
- mercerization (alkaline treatment) process 214, 216
- mesoporous silica grafting 395
- metallic contaminants 115, 116
- metal–organic framework (MOF) 172, 323, 349, 352, 356–357, 378, 402, 403
- 2-(methacryloyloxy) ethyl trimethylammonium chloride (METAC) 187
- 2-(methacryloyloxy) ethyl trimethylammonium methyl sulfate (METAM) 188
- methyl methacrylate (MMA) 186
- Michael and Schiff reaction 429
- microalgae 52
- microbial desalination cells (MDCs) 310, 311
- microfibrils 218, 219
- mixed cellulose ester (MCE) membrane 167
- modified starch composites 377–378
- monolignols 182, 183
- multifunctional limestone-AC-SA nanocomposite absorbent 394
- multifunctional rhodamine-modified chitosan hydrogel 384
- multiple correspondence analysis (MCA) method 10
- n**
- nanocellulose 42, 45, 158, 160, 161
- nanocellulose membranes 161, 174
- nanocomposite hydrogels 289, 400
- nanofibers 240, 344, 345, 347, 348
- nanofibrils 218. *see also* cellulose nanofibrils (CNFs)
- nanofiltration process 139–140, 322–323
- nanoparticle, defined 344
- nanoporous starch 286
- natural fibers (NFs) 211, 212
- adsorption yields, in percentage/concentrations 243
- characteristic functional groups 214
- characterization and evolution 242–243
- chemical composition 214
- classification 213
- components of 212
- devices manufactured with 241–242
- dye/colorants extraction and type of 225–227
- global production 212
- heavy metals and industrial dyes, absorption of 232–233
- heavy metals purification 224–225
- morphological characteristics 240–241
- morphology and crystalline structure 214, 216–218
- oil/hydrocarbon 228, 230–231, 234–235
- organic and inorganic compounds 227–229, 233–234
- physical and chemical modifications 235–240
- physical-mechanical properties 218–220
- selection stage of water treatment 243–244
- structural and functional properties 213
- TAPPI standards 216
- thermal properties 220–222
- natural gum polysaccharides 396
- natural polysaccharides 371
- natural rubber (NR) 52, 53
- NBC/ANF membranes (BAFM) 172
- nephelometric turbidity units (NTU) 114

neutron diffraction analyses 217
N-methylmorpholine-*N*-oxide (NMMO) system 466
N,N-dimethylacetamide(DMAC)/LiCl 349–350
 non-metallic contaminants 115
 non-PHA cellular materials (NPCM) 38–39
 nuclear magnetic resonance (NMR) 65–67, 214

O

oil
 beeswax 36
 and grease 118
 oil/water separation composite membrane, of flax fibers-CNF (FF-CNF) 164
 optical microscopy (OM) 56
 organic contaminants
 dyes 117
 oil and grease 118
 pesticides 116, 117
 phenolic compounds 118
 polycyclic aromatic hydrocarbons (PAHs) 118
 volatile organic compounds (VOC) 117
 organic pollutants 227, 342
 organosolv 51, 52, 182
 oxidation 237
 TEMPO-mediated 345
 oxidizing capacity 429

P

PAA/gum hydrogels 397
 PAA/pectin gum hydrogels, adsorption capacity of 400
 PAA/pectin hydrogels 397
 PA-CNFs composite membrane 166
 Paraquat® herbicide, adsorption and controlled release of 469
 Pb²⁺-adsorbing nanocomposite material 383
p-coumaryl 182, 183

PDA-coated cellulose, thermal stability of 444
 PDA-coated magnetite, for MB removal 448
 PDA functionalized GO/carboxymethyl chitosan composite aerogels 386
 pectin-based nanoadsorbent 446
 pectin/chitosan/magnetite nanorods composites 441
 pectin-coated iron oxide, for cobalt removal 446
 pectin-coated magnetite, for CIP removal 450
 pectin-coated silica magnetite, for CIP removal 450
 pectin/gum polysaccharides
 chemical modification 397–401
 composite formulation 398–399
 gum composites 401–403
 pectins 395
 chemical structure 396
 pesticides 111, 112, 116, 117, 324, 451
 petrochemical polymers 157, 158
 petroleum-based polymers 25, 359, 439
 phase separation process 165
 phenol absorption 234
 phenolic compounds 118, 233
 photothermally-active reduced graphene oxide/BNCs composites (RGO/BNCs) 172
 physical adsorption method 236, 280, 426
 physical contaminants 114
 physisorption 279–280
 phytoremediation 279
 plant-derived biopolymers
 cellulose 46–49
 lignin 50–52
 natural rubber 52, 53
 starch 49–50
 types 46
 plant extracts as natural coagulant 378
 plastic materials 25
 plastic pollution 25

- PMDA cross-linked cellulose acetate hydrogels 469
- polyacrylamide (PAM) 183, 185, 278, 289
- polyamine-*co*-melamine crosslinked chitosan derivatives 384
- polyaniline (PANI) for Acid Black-234 removal 378
as dye adsorbent 378
- polycyclic aromatic hydrocarbons (PAHs) 118, 322
- poly dimethyl diallyl ammonium chloride (PDADMAC) 183
- polyethersulfone (PES) 199
- polyethyleneimine (PEI) 101, 105, 191
- poly-glutamic acid-magnetite 441
- poly(acrylic acid-*co*-aniline) grafted itaconic acid hydrogel 479
- poly(acrylamide-*co*-sodium acrylate) hydrogels 480
- poly(gellan gum-*co*-acrylamide-*co*-acrylic acid) hydrogel 400
- poly(acrylamide-*co*-acrylonitrile) hydrogels 480
- polyhydroxyalkanoates (PHAs) 26
bio-extraction methods 41
animal digestive systems 42
bacteriophage-mediated lysis systems 41–42
predator bacteria extraction system 41
- conventional extraction 38
chemical extraction methods 40
enzymatic extraction methods 40
mechanical disruption 40
solvent-based extraction 38–40
- extraction methods 42–44
- NPCM 38–39
production price 37–38
storage 37
- polylactic acids (PLAs) 26, 218
- polymer blending 315
adsorbent membranes 316
melt blending 316
preparation of hydrogels 317, 318
properties 316
- solution blending 316
- polymers 145
definition 144
- polysaccharides 288. *see also* starch
chitin and chitosan 31–32
glycogen 32–34
heparin 32
hyaluronan (HA) (hyaluronic acid or hyaluronate) 30
- poly(2-methacryloyloxyethyl)trimethyl ammonium chloride-grafted starch 375
- polyvinyl alcohol (PVA)/chitosan-coated magnetic beads 446
- porous starch 378
- porous TiO₂ nanoparticles 232
- predator bacteria extraction system 41
- proteins
collagen 33–34
gelatin 34–35
keratin 35–36
- q**
- quality measure for water
biological contaminants 114–115
chemical contamination
inorganic contaminants 115, 116
organic contaminants 116, 118
physical contaminants 114
radioactive contamination 118
- quartz crystal microbalance (QCM) 186
- r**
- radioactive contamination 118
- Raman spectroscopy 64–66
- reverse osmosis (RO) 141–142
desalination membranes 166
- reversible addition-fragmentation
chain-transfer (RAFT) approach 235
- Rhodamine B degradation efficiency 171
- s**
- SA-g-terpolymers hydrogel 391
- scanning electron microscopy (SEM) 56–58, 240

- Schiff base reaction 380
 seawater desalination 165
 seawater treatment 427–429
 seaweed-derived carbohydrate hydrocolloids 388
 seaweed-derived polysaccharide-based adsorbents 389–390
 seaweed-derived polysaccharide composites 394–395
 seaweed-derived polysaccharides 388–395
 chemical modification 391–393
 selenide–chitosan microsphere 94–95
 self-crosslinked chitosan/cationic guar gum hydrogel 383
 semi-IPN hydrogel 319, 320
 sequential IPN 319
 sewage treatment technology 157
 shell-to-core binding mechanism 442
 sieving, definition 139
 siliceous hybrids 441
 silicious hybrid-coated magnetite, CIP removal 450
 simultaneous IPN 319
 sinapyl alcohols 182
 Sips isotherm model 305
 soda lignin 182
 softwood lignin 182
 solution blending 316
 solvent-based extraction, PHA recovery 38–40
 sorption mechanism 291
 starch 49–50
 amylose and amylopectin 372
 botanical sources 372
 chemically modified derivatives and composites 373–374
 chemically modified, for water treatment and purification 372
 contaminants flocculation 282–283
 membranes 283–285
 physically modified starch 372
 physical treatment 372
 sorbents 285–287
 water treatment applications 280
 chemical modification 281
 starch granule, representation of 280, 281
 starch-based biopolymers
 anthropological activities 275
 properties 276
 water contamination 276–277
 water treatment 275, 278–280
 adsorption 279
 benefits and challenges 280
 chemical precipitation 278
 coagulation 278
 flocculation 278
 flotation process 279
 ion exchange process 279
 phytoremediation 279
 starch-based flocculants 376
 starch–chitosan hydrogel microspheres 289
 starch-coated magnetic nanoparticles 441
 starch-g-(acrylic acid-co-acrylamide) 377
 starch-g-PAA/CNF hydrogel 376
 starch–graphene oxide nanofiltration membranes 285
 starch nanocrystals (SNC) 287–288
 starch nanoparticles (SNP) 287
 sugarcane bagasse powder 244
 sulfamethoxazole (SMX) removal 450
 sulfonated kraft lignin (SKL) 199
 sulfonated lignin-based hydrogels (SLG) 203
 superabsorbent hydrogels 289, 469
 super hydrophilic/underwater superoleophobic TCNCs membrane 167
 surface filter 139
 surface modification method 164, 165
 suspended particulate matter (SPM) 114
 Sustainable Development Goals (SDGs) 283
 synchrotron X-ray diffraction analyses 217
 synthetic polymers 144

t

TCNCs/palygorskite (PGS) composite membrane 167
 Technical Association of Pulp and Paper Industry (TAPPI) standards 214
 TEMPO-mediated oxidation method 345
 2,2,6,6-tetramethylpiperidine-1-oxy radical (TEMPO) oxidation 160
 TFNC membranes 162
 thermogravimetric analysis (TGA) 60, 62, 220
 thin film nanocomposite (TFN)
 nanofiltration membrane (NFM) 169
 thiourea aqueous system 467
 three-dimensional poly(vinyl alcohol) (PVA)/starch hydrogel nanofiber membrane 379
 TiO₂ nanoparticles in-situ coated bacterial cellulose membrane (TiO₂@BCM) 170–171
 tissue engineering 32, 55, 144, 147, 217
 toluene diisocyanate (TDI) 473
 toxic pollutants 112, 181
 transmission electron microscopy (TEM) 58–61
 trimethoprim (TMP) 356
 tyrosinase 423–424

u

ultrafiltration 140–141
 ultrafiltration nanofiber composite membrane 162
 ultrathin graphene oxide (GO)-CNFs hybrid membranes 165
 US Environmental Protection Agency (EPA) 91, 110

v

vacuum filtration 50, 164, 167
 volatile organic compounds (VOC) 117

w

wastewater treatment
 cellulosic materials 212
 natural fibers 212
 water
 contaminants, types of 114
 problem related to 109–112
 quality measure for 113–118
 resources 111, 277, 371, 477
 solutions to water problem 112–113
 treatment techniques 113
 water contaminations 109
 anthropogenic actions 277
 biopolymer composites for removal of 124
 dyes 277
 functions 276
 heavy metals 277
 materials for removal of 120–122
 pollutants 277
 problems 276
 in sub-Saharan Africa 276
 water footprint (WF) 112
 water pollution 157, 222
 causes 91
 data 92
 definition 91
 diseases 92
 sources 110, 111
 treatment
 cellulose–metallothionein biosorbent 104
 cellulose–polyaniline–silver nanocomposite fused fiber 103
 chitosan chloride–graphene oxide composite modified quartz 97–98
 chitosan–clay composite 96, 97
 fungal chitosan in 98
 gelatin–beta cyclodextrin fiber adsorbent 100
 gelatin infused with chitosan/polyethyleneimine 100–101
 gum arabic 98–100

- water pollution (*contd.*)
 kappa carrageenan–graphene oxide composite 101–102
 lignin polymer in removal of virus 102
 magnetically phosphorylated chitosan composite in cobalt removal from water 95
 magnetic–carboxylated cellulose/starch composite 104–105
 magnetic chitosan bead in arsenic removal from water 95–96
 polycaprolactone–nanocellulose fiber in removal of heavy metals 103–104
 polyelectrolyte layered cellulose in removal of bacteria 102–103
 selenide–chitosan microsphere 94–95
 water quality biopolymers role in 119, 123–125 maintenance 119 for pesticides 116
- water quality index (WQI) 113
 water resources ecological footprint (WEF) 112
- X**
 xanthate-modified alginates 391
- X-ray diffraction (XRD) methods 68–69
- X-ray photoelectron spectroscopy (XPS) 65, 66, 214
- Z**
 Zeolite Socony Mobil (ZSM-5) zeolite loaded with PVA-carboxymethyl cellulose-SA membrane 395
 zeta potential analysis 187, 199, 283
 zinc-modified chitosan-based adsorbent material 383
 Zn-mediated chitosan nonwoven fabric 385
 Zr⁴⁺ crosslinked carboxymethyl cellulose/carboxymethyl chitosan hydrogel 387















