

## Index

### **a**

absorbed dose 528, 530, 548, 549  
 absorption process 573, 710  
     CO<sub>2</sub> removal 711–713  
 acid/alkali leaching 737  
 acidogenesis 24, 279, 284, 290, 313,  
     314, 317, 318, 321, 322,  
     324–326, 330, 331, 333  
 acidogenic bacteria 279  
 activated carbons (ACs) 217, 222,  
     224–226  
 activated rice husk (ARH), gold  
     sorption of 477, 480  
 activated sludge (AS) 6, 8, 123, 127,  
     217–219, 223, 275–276, 293,  
     305–306, 317–318, 321,  
     326–329, 331–333, 374, 388,  
     490–491, 507, 550, 566  
 adenosine triphosphate (ATP)  
     339  
 adsorbents reusability and  
     phosphorus recovery 364–365  
 adsorption process 407, 416, 479,  
     573, 574, 710  
     CO<sub>2</sub> removal 712  
     description 409  
     Freundlich isotherm 409  
     isotherm models 409, 410–411  
     kinetic models 407–409  
     mass transfer 409  
     NO<sub>3</sub><sup>−</sup> and PO<sub>4</sub><sup>3−</sup> removal 401  
 adsorption yield (AY) 423, 427  
 advanced oxidation process (AOP)  
     525, 544

aerobic FO-based systems 14, 377,  
     383, 388, 389  
 aerobic granular sludge 217, 219,  
     220–222, 229–230, 235  
     laboratory-scale application 220  
 aerobic osmotic membrane bioreactor  
     (OMBR) 377, 380, 381–383  
 algae based birefinery system 212,  
     213  
 algal energy and bio-product  
     formation 200–202  
 algal process system  
     LCA 210–211  
     technological issues 208–210  
 alkaline pretreatment 283, 289, 293  
 amine scrubbing 711  
 ammonia stripping 143, 144, 149,  
     150, 489, 499, 570–573, 577,  
     585–587  
 ammonium removal methods, in  
     wastewater treatment 489  
 anaerobic digestion (AD) process  
     123, 147, 149, 565  
     bioenergy recovery 279–280  
     of microalgae biomass 582  
     theory of 279  
 anaerobic FO-based systems 377,  
     383, 388, 389  
 anaerobic membrane bioreactors  
     (AnMBRs) 565, 566  
 anaerobic OMBR (AnOMBR) 377,  
     383  
 animal husbandry 142  
 animal wastes 154, 560, 585

- anion exchange membrane (AEM) 494, 495, 506
- AnOMBR-based systems, for nutrient recovery 383
- aquaculture wastewater 561–563  
characteristics 561
- aqueous phases, of HTL 91, 92
- Aspergillus oryzae* palletization 173
- Aurantiochytrium* sp. 177, 183
- auto-flocculation 173, 208
- automatic rotating filter, for wastewater 647
- automatic strainer, for wastewater 647, 648
- auxochromes 535
- b**
- Bacillus licheniformis* 173
- bacterial decomposition 339
- BES-FO hybrid system 504, 510
- Best Available Techniques (BAT) 152
- biobased jet fuel 168
- biochar 437, 438, 564  
ash/mineral content 441  
characteristics 439–442  
feedstocks 442, 443, 444  
fractions 35  
macroporosity 441  
pH of 451  
phosphorous recovery 442–443  
cationic impregnation 449–450  
magnetic biochar composites 454–455  
metal (hydr)oxide and layered double hydroxide composites 450–454  
post-pyrolysis modification 449  
pre-pyrolysis modification 443, 455  
properties 440  
pyrolysis temperature 440  
surface area 441
- biochemical oxygen demand (BOD) 114, 117, 123, 219, 533  
removal 114
- bio-crude 21, 27–30, 32, 34–36, 40, 258  
fractions 35  
yield 29, 30, 36
- biodiesel 25, 26  
jet fuel 168, 169  
microalgae, selection of 169–170
- bioelectrochemical system (BES) 15, 208  
advantages 490  
ammonium recovery 498, 499  
application for resource recovery 507–508  
challenges 508–510  
chemical recovery 505–507  
energy recovery 496–498  
evolution of 493–496  
metals recovery 501–503  
nutrient recovery 498–501  
phosphate recovery 498–500  
types 493  
water recovery 503–505
- bioelectrochemical treatment system (BET) 208
- bioelectrogenesis 208
- bioenergy 11–12, 15, 26, 83–98, 125, 147, 149, 156, 199, 200, 206, 275–294, 560, 564, 581, 584–587
- bio-energy production, limitations 98  
aqueous by-products utilization 97–98  
poor quality, of crude bio-oil 97
- bio-fertilizer 23, 208
- biofilter digester 114
- bio-flocculant 172, 173, 236–237
- biofuel  
microalgae cultivation 170–172  
microalgae harvesting 172–174  
bio-flocculation 172–173  
magnetic separation 173–174  
oil, extraction of 174–175
- biogas potential, human faeces 110
- biohydrogen 7, 24, 209, 564
- bio-hydrology 481

- biohydrometallurgical process 738–740, 741  
     benefits and issues 739, 741  
 biohydrometallurgy 467, 468, 735  
 bioleaching 16, 142, 263, 264, 467, 472, 481, 601, 624–631, 738, 739, 744  
 bioleaching residues  
     SEM analysis 630–631  
     XRD analysis 629–630  
 bioleaching treatment 467  
 bioleaching, of Si  
     flask experiments 624, 625  
     heavy metals recovery 628–629  
     optimization of parameters 626–628  
     silicate bacteria culture medium 624  
     silicon bacteria growth, time courses of 625  
 biological approach, for resource recovery  
     anaerobic digestion 565–569  
     dark fermentation (DF) 569–570  
 biological methods 139, 340, 400, 401, 530, 544, 605, 632  
     NO<sub>3</sub><sup>−</sup> and PO<sub>4</sub><sup>3−</sup> removal 401  
 biological mineralization 208  
 biological nitrogen removal (BNR) 218, 308, 316  
 biomass 83  
     cultivation 202, 206  
     harvesting 172, 173, 175, 178, 179, 183  
 biomass conversion process 27, 581, 582  
     of aquatic biomass 581, 582  
 bio-oils 32, 35, 36, 84, 88, 90, 91, 97, 255, 259–260, 266, 267, 583  
     from food waste 37–39  
 bioplastics 7, 26, 207  
 biorefinery and integrated approaches 207–208  
 biosensors 465, 466  
 biosolids 8  
 bio-sorbents 142, 218, 229–236, 237–238, 402, 472–478, 480, 481, 739  
 biosorbent, removal of pollutant  
     heavy metal sorption 226, 237  
     organic pollutant sorption 237–238  
 biosorption process 739, 740  
 biosorbent source and selection 473  
 commercial sorbents 477–478  
 description 472  
 gold biosorption by industrial biomass 473  
     algae 474–476  
     bacteria 474  
     fungal microbes 476  
     plant material 476–477  
     of gold particle from biomass 478–479  
 blowers 279, 706, 707  
 blue baby syndrome 141, 400  
 breeding wastes management 560–563  
 breeding wastewater 585  
     anaerobic digestion process 565–569  
     characteristics 560–563  
     dark fermentation (DF) 569–570  
     microalgae and duckweed culture 583  
 microalgae/duckweed biomass production and nutrient removal 578, 579  
 nutrient recovery from  
     biological approach 565–570  
     physicochemical approach 570–578  
 organic wastewater in 565–569  
 plant-based treatment approach 578–583  
 resources in  
     bioenergy 564  
     nutrients 563–564  
     water 563

- breeding wastewater (*contd.*)  
 thermochemical approach 583–584  
 value-added bioproducts 564–565
- brominated flame retardants (BFRs) 734, 740, 742
- bubbling fluidized bed (BFB) 254, 256, 257
- bubbling fluidized bed reactor (BFBR) 254
- c**
- CAA (clean air act) 153, 699
- Ca-based phosphate (hydroxyapatites) 262
- calcium peroxide ( $\text{CaO}_2$ ) 289, 290
- Ca-modified biochar 455
- capital expenditure (CAPEX) 30, 204, 209–211
- catalyst concentration 36–37
- catalytic pyrolysis 255, 743
- cation exchange capacity (CEC) 114, 260, 261, 565
- cation-exchange membrane (CEM) 386, 494, 495, 500, 506
- cationic impregnation, of biochar 449–450
- CdTe thin-film modules recycling technique 747
- cell-independent sorption 474
- cellulose triacetate (CTA) membrane 386
- centrifugal blowers 707
- CFD-DEM 684
- channel heat exchanger-type 644, 645
- channel heat exchanger-type 1 644, 645
- characteristics of,  $\text{Fe}_3\text{O}_4$ ,  $\text{SiO}_2@\text{Fe}_3\text{O}_4$  &  $\text{ZrO}_2@\text{SiO}_2@\text{Fe}_3\text{O}_4$  345–348
- chars 441, 583
- chemical fertilizers 113, 128, 373, 398, 490
- chemical leaching 142, 467, 737
- chemical looping 255
- chemical oxygen demand (COD) 5, 8, 114, 141, 219, 276, 290, 309
- chemical precipitation 13, 14, 226, 232, 262, 305, 306, 307, 309, 320, 340, 374, 375, 377, 379, 380, 381, 382, 386, 387, 388, 389, 401, 489, 490, 499, 501, 502, 509, 540, 560, 574, 577, 744
- chemically enhanced primary sedimentation (CEPS) 13, 305
- chemisorption 232, 408, 411, 416, 425, 473
- chitin 235, 474, 478, 481
- Chlorella pyrenoidosa* 170
- Chlorella regularis* 173
- circular economy 10, 12, 47, 52, 64, 76, 77, 157, 158–159, 160, 161, 724, 731, 748
- business model 158–159
- circular economy concept 731
- circulating fluidized bed (CFB) 253–257
- circulating fluidized bed incineration technology (CFBIT) 253–257
- circulating fluidized bed reactor (CFBR) 255
- citric acid-soluble manganese 622
- cleaning system, with circulating rubber balls 654, 655
- climate change (CC) 1, 22, 50, 76, 126, 151, 157, 199, 250, 605, 708, 745
- Clostridiaceae* 25
- coagulants 305, 308, 309, 311, 312, 540, 542–544
- coagulation 151, 208, 232, 307, 309–311, 400, 401, 525, 530, 533, 540, 542, 543, 605
- coefficient of performance (COP) 7, 640, 655
- collection piping system, LPG recovery 706–707
- combined heat and power (CHP) systems 6, 219, 279, 715
- competent applications, of algae 205–207

- compounded annual growth rate (CAGR) 205
- comprehensive nutrient management plan (CNMP) 153
- comprehensive separation efficiency, of hydrocyclones 666, 667
- compressed natural gas (CNG) 715
- Computational Fluid Dynamics coupled with Discrete Element Method (CFD-DEM) 684
- concentrated animal feeding operations (CAFOs) 153, 559
- condensate knock-out system 707, 708
- condensate management system 704, 707
- condensation 88, 93, 96, 261, 264, 438, 657, 709, 710, 713
- cone pyrolyser 255
- Congo Red (CR) adsorption 238
- consumer electronics, average lifespans for 725
- continuous stirred-tank reactor (CSTR) 565, 566, 570
- Convention on Long-Range Trans-boundary Air Pollution (CLRTAP) 151
- conventional human excreta management systems 110, 111
- conventional microalgal biomass harvesting techniques 172
- conversion methods, analysis of 202
- algal biomass composition 202–203
- conversion routes 203–204
- product yield and market value 204–205
- co-precipitation of layered double hydroxides (LDH) 449, 452
- co-precipitation, of metal hydroxides 451
- COP value, of WWSHP system 635–637, 639–644, 646–648, 651, 652, 654–660
- copper metal recovery 470
- CO<sub>2</sub> removal 711
- absorption process 711–712
- adsorption process 712
- cryogenic process 713
- membrane separation 712–713
- Corynebacterium glutamicum* 474
- cross-draft gasifier 256
- cryogenic process 713
- crystal violet (CV) 230, 231, 232
- crystallization processes 340, 341
- NO<sub>3</sub><sup>−</sup> and PO<sub>4</sub><sup>3−</sup> removal 401
- CWA (clean water act) 153
- cyanide leaching 472, 474
- d**
- dark fermentation (DF) 208, 288, 560, 569–570, 582, 585
- Decentralised wastewater treatment systems 123
- Department of Environment Food and Rural Affairs (DEFRA) 58
- depolymerization 27, 32, 34, 89, 90, 93, 438
- desorption of PO<sub>4</sub><sup>3−</sup> 417, 419, 425
- desorption process 366, 473, 477, 478, 481
- desorption, of NO<sub>3</sub><sup>−</sup> 417, 420, 425
- digester 153, 155, 156, 276, 279, 284, 500, 566
- direct liquefaction 27
- direct wastewater source heat pump system 637, 638
- Docosahexaenoic acid (DHA) 12, 168–169
- domestic wastewater treatment 6, 123, 217, 491, 507
- dry-expansion shell-and-tube evaporator 641
- Dual Inconel pipe counter-current heat exchanger 29
- duckweed-based bioenergy 586
- dyeing process 534, 535, 538, 549
- dynamic light scattering (DLS) 345

**e**

- earthworm composting 138  
 e-beam process 526  
 ecological sanitation 11, 111, 112, 113, 115, 117, 119, 120, 126, 129, 130, 131  
 economical use, of LFG 714  
 economics of resource recovery 127–128, 157–158  
 effluent organic matter (EfOM) 227, 228, 229  
*Eicosapentaenoic acid (EPA)* 12, 168–169  
*Eisenia foetida* 138  
 electrical conductivity (EC) 143, 440  
 electrical hydrocyclones 677  
 electrochemical hydrocyclones 677, 678  
 electrodialysis (ED) 7, 375, 401, 576, 577, 578  
 electrokinetic remediation technology 264  
 electrolytic manganese metal (EMM) production process 601, 602–605 wastewater 602–604  
 electrolytic manganese residue (EMR) 602, 604 characterization of 615–616 chemical composition 615 components 604 leaching, of toxic elements 622–624 morphology evolution 622, 623 reutilization 605 silicon activation 617–618 distribution characteristics 615, 616 TG, DTG and DSC curves 617 transformations during bioleaching process 629–631 XRD pattern 615–616, 619–620  
 electrolytic manganese wastewater (EMW) 16, 602, 604, 614  
 electromagnetic hydrocyclones 677–678  
 electromagnetic spectrum, components of 526–527  
 electron beam (EB) process defined 526 irradiation 526 and membrane bioreactor process, on COD removal 547 for wastewater treatment 528–533 aeration biological treatment 545 economic feasibility 549–552 industrial applications 548–549 lab-scale tests 544–548 limitations 551–552 quantitative effects of 528 transformer oil treatment 530  
 electronic waste (e-waste) 9, 17, 723 categories 724–725 chronic hazards 726 collection 731–734 defined 724 generation 725 generation rates 723 global management 732 hazardous substances 727–729 health impacts of 726–729 health risks 726 lithium ion batteries, recovery of 743–745 management regulations 724 metal concentrations 730 metals recovery from 734–735 physical separation technologies 734 plastics recovery 740–743 recycling benefits 729–731 challenges 733, 748 in developing counties 733 pre-processing 734 reasons for 734 volume 723 worldwide generation 725  
 energy consumption system 635 energy recovery processes 39

- energy-dispersive X-ray spectroscopy (EDX) 237, 316, 345, 380
- enhanced biological P removal (EBPR) 305, 307, 489
- enhanced-separation hydrocyclone technologies 668
- challenges 683–685
  - perspectives 684–685
  - systematic and comprehensive studies 685
- Enterococcus faecalis* 152
- environment sanitation and financing 159–160
- ethanol 1, 24, 25, 30, 88, 91, 209, 210, 343, 344, 505, 564, 583
- EU Common Alerting Protocol (CAP) 151, 152
- Eudrilus esugeniae* 138
- excretion, frequency of 109
- expanded granular sludge bed (EGSB) reactor 219, 565
- Extended Producer Responsibility (EPR) 732, 748
- extracellular polymeric substances (EPS) 13, 173, 218, 276, 282, 283
- extraction wells, LFG 704, 708
- f**
- faeces 11, 110
- Fe-impregnated biochar materials 450
- Fe<sup>0</sup>/Fe<sub>3</sub>O<sub>4</sub> composites
- characteristics of 350–351
  - synthesis of 344–345
- Fe<sub>3</sub>O<sub>4</sub> and La(OH)<sub>3</sub>/Fe<sub>3</sub>O<sub>4</sub> nanocomposites, characteristics of 348–349
- Feed inlet system 28, 29
- fenvalerate, removal efficiency of 530
- fertilizers 578
- chemical 373
  - direct land application of 374
- filamentous fungi 173, 476
- fish-hook effect 675
- fixed bed gasifier (FXBG) 255, 256
- flocculant-assisted hydrocyclones 677, 679
- flocculation mechanism 237
- flue gas desulfurization method 465
- fluid flow, in hydrocyclones 16, 665–666
- fluidized bed furnace (FBF) 250–253
- fluidized bed reactor (FBR) 40, 254, 255
- fluorescence spectroscopy 237
- FO-based system
- CTA vs. TFC membrane 386
  - for nutrient recovery
  - challenges 387–388
  - recommendations 385–387
- focused pulsed (FP) pretreatment 282
- Fomitopsis carneae* 476
- food waste (FW) 1, 7–8, 10, 21–40, 52, 83, 148, 260, 318, 321–324, 326–328, 331–333
- composition and reaction 36–39
- Formaldehyde (FA) 90, 477, 543
- forward osmosis (FO) process 14, 375, 499, 576
- configurations 377
  - near coastal area, advantages of 379
  - for nutrients recovery 377–385
  - economic feasibility 379
  - pH values and chemical dose 386
  - vs. pressure-driven membrane technologies 385
- fossil fuels 24, 31, 38, 83, 84, 124, 125, 149, 168, 178, 179, 201, 258, 279, 294, 584, 586, 605, 744, 635
- fossil resource depletion (FD) 157
- foulant growth law, in WWHEs 657
- Fourier transmission infrared spectra (FT-IR) 226, 345, 620
- free ammonia (FA) 13, 283–284, 289
- pretreatment 283–284

- free nitrous acid (FNA) 13, 283, 289  
 pretreatment 283
- Freundlich equation 232
- Freundlich isotherm 233, 409
- Freundlich parameters 480
- fuel cells and biosensors 466
- Full Recovery End of Life
- Photovoltaics (FREL) 747
- furnace chamber 253
- g**
- gamma irradiation pretreatment 284, 288
- Gantt chart 607
- gas chromatography (GC) 38, 90, 258
- gasification technology 257, 584
- gel permeation chromatography 90
- genetically modified microalgae/  
*thraustochytrids* 184–185
- glassy polymers 712, 713
- global E-waste Monitor 2017 723, 725
- global e-waste production 467
- global food waste production
- advanced food waste management methods
  - acidogenesis 24
  - biodiesel 25–26
  - bioplastics 26
  - solventogenesis 24–25
- conventional food waste
- management practices
  - composting 24
  - fertilizer/animal feed 23
  - incineration 23
  - land filling 23
- global water demand 397
- glycol absorption process 710
- gold
- biocompatibility property 466
  - biosorption by industrial biomass 473
  - bacteria 474
  - as catalyst 464
  - chemical processing 464–465
- demand for 463
- electronic industry 466
- medical and biomedical application 466
- nanostructure-based electrodes 466
- recovery from e-waste 470–472
- gold biosorption by industrial biomass
- algae 474–476
  - fungal microbes 476
  - plant material 476–477
- gold colloids 466
- gold nanoparticles 466, 476
- granular activated carbon (GAC) 404, 438, 441, 530, 564
- granular sludge 13, 120, 217–225
- granular sludge biosorbent 229–236
- heavy metal contained wastewater
  - AnGS, for Pb(II) and Cu(II) removal 234–235
  - Cu(II) sorption 232–233
  - Ni(II) sorption, onto AGS/AnGS 233–234
  - Zn(II) sorption 232
- treatment
- biosorption, of dye wastewater 230–232
  - role of EPS 229–230
- granulation process 219–221
- gravity-film heat exchanger 642, 643
- green chemistry 464
- greenhouse gases (GHGs) emission 22, 31, 32, 137, 699
- h**
- Haber-Bosch process 373, 389
- halide leaching method 738
- hazardous substances, in e-waste 158, 727, 729, 742
- heat exchanger
- with cleaning function by strong flushing 653
  - with fouling fluidized-removing 654
  - with nylon brushes 652

- heat pumps 7, 16, 635, 636, 637–640, 659  
 heat recovery  
   from raw wastewater 637–639  
 helical heat exchangers 643  
 hemicellulose 23, 34, 85, 87, 88, 90, 92, 93, 138, 438, 582  
 heterotrophic microalgae/  
   *thraustochytrids* 182  
 heterotrophic or phototrophic  
   microbes 6  
 hierarchy of resource use (HRU) 2, 3  
 high karat gold 463  
 high-income country (HIC) 4, 5  
 higher heating value (HHV) 91, 122, 258, 260, 583  
 homoacetogens 279  
 horizontal gas collection wells  
   advantages and disadvantages 704, 706  
   configuration 704, 705  
 household waste composting 68, 69  
 household waste recycling 68, 69  
 Howdon domestic wastewater  
   treatment plant 507  
 human dietary changes 559  
 human toxicity (HT) 157  
 hydraulic oscillation system 29  
 hydraulic retention time (HRT) 155, 312, 316, 318, 508, 547, 549, 565, 566, 569, 570  
 hydro-denitrogenation 37  
 hydro-deoxygenation reactions 37  
 hydro-desulfurization 37  
 hydro-metallurgical treatment 467  
 hydro-thermal liquefaction (HTL) 21–33  
   FW treatment 32–37  
     reaction time 35  
     solid to solvent ratio 35–36  
     temperature 34–35  
   reactor 28  
 hydrochar 90, 91, 454  
 hydrocyclones 16, 663  
   applications 680–683  
 comprehensive separation  
   efficiency 667  
   cut size 667  
   enhanced by adjusting back pressure 679–680  
   enhanced by control particles 679  
   enhanced by flotation 679  
   enhanced by monitoring and automatic control 680  
   fluid flow characteristics 665–666  
   geometric parameters of 668  
     cone angle 671  
     conical-section shape 671–672  
     cylindrical-section diameter 668  
     cylindrical-section length 668  
     inclination angle 672  
     inlet shape 669  
     inlet size 668–669  
     inlet-section angle 669  
     overflow diameter 670  
     ratio of underflow diameter to overflow diameter 671  
     underflow diameter 670  
     underflow-pipe shape 671  
     vortex-finder length 669  
     vortex-finder shape 669–670  
     vortex-finder thickness 669  
     inclination angle 672  
     operating conditions 677  
     operating parameters of 674  
       feed concentration 675  
       feed density difference 675  
       feed flow rate 674  
       feed fluid viscosity/ rheology 676  
       feed particle arrangement 676  
       feed particle shape 675–676  
       feed particle size 675  
       feed pressure 674–675  
     publications and citations 663–664  
     reduced separation efficiency 667  
     separation efficiency 666–667  
     split ratio 667  
     total static pressure drop 667

- hydrocyclones (*contd.*)  
 water-injection 673  
 with inner cone 672–673  
 with reflux device 673  
 with solid rod 672  
 working principle of 663, 665
- hydrogen peroxide 465, 466, 467,  
 525, 544, 747
- hydrogen production from sludge  
 284
- biological pretreatment 290
- chemical pretreatment 289  
 acid pretreatment 289  
 alkaline pretreatment 289  
 $\text{CaO}_2$  pretreatment 290  
 free ammonia pretreatment 289  
 free nitrous acid pretreatment  
 289  
 ozone pretreatment 289  
 TCC 290  
 wet oxidation pretreatment  
 289–290
- physical pretreatment 284  
 freezing/thawing pretreatment  
 288
- gamma irradiation pretreatment  
 288
- microwave pretreatment 288
- sterilization pretreatment 288
- thermal pretreatment 284–288  
 ultrasonic pretreatment 288
- hydrogen sulfide removal 711
- hydrogen-oxidizing bacteria 9
- hydrogenotropic methanogens 279
- hydrogentrophic methanogenesis  
 279
- hydrometallurgical process 8, 467,  
 736–740, 741, 744, 747  
 benefits and issues 739, 741  
 hydrometallurgy 467, 468, 469, 481,  
 735, 747
- hydrothermal carbonization (HTC)  
 203, 26
- hydrothermal liquefaction (HTL)  
 26, 84, 257  
 of food waste 26–32
- fast HTL 30
- GHG 31–32
- iso-thermal HTL 30
- products 30–31
- reactor operation 27–29
- technology 10
- hydrothermal liquefaction, of  
 lignocellulosic biomass 91
- bio-oil 92–93
- catalysts 95–96
- cellulose, and degradation 87–88
- composition of 85
- development, of HTL technology  
 85
- heating rate 93–94
- hemicellulose, and degradation  
 88
- lignin, and degradation 88–90
- liquid-to-solid ratio 96–97
- pressure 94–95
- products description  
 bio-oil 90  
 other by-products 91  
 solid residue 90–91
- residence time 94
- temperature 93
- hydrothermal process 38, 583, 584
- hydrothermal pyrolysis 255
- hydrothermal technology 85
- hydrothermal treatment (HTT) 26,  
 27, 454
- hydrous iron oxides (HFO) 327, 332,  
 333
- hydrous pyrolysis 27
- hydroxyacetone 88
- hydroxyapatite formation 150
- 5-hydroxymethyl furfural (HMF)  
 34, 37
- p-hydroxyphenyl propanoid units  
 88
- i*
- incineration 23, 248, 250, 257, 261,  
 275, 417, 481, 736
- indirect wastewater source heat pump  
 system 637–638

- inductively coupled plasma atomic emission spectroscopy (ICP-AES) 345
- industrial wastewater 492  
characteristics 492–493  
COD concentration 492
- inner cones, of hydrocyclones 672–673
- inorganic coagulants 540, 543, 544
- integrated  
microalgae/thraustochytrids cultivation 183–184
- integrated  
microalgae/thraustochytrids system 186
- intergovernmental panel on climate changes (IPCC) 151
- internal circulation (IC) 219
- International Energy Agency (IEA) 205
- intra-particle diffusion process 408, 416–417, 480
- ion exchange method 573, 574  
 $\text{NO}_3^-$  and  $\text{PO}_4^{3-}$  removal 401
- ionizing process 526
- ionizing radiation 526, 528
- iron ore reduction 255
- iron-based adsorbents, for phosphate removal 364
- isotherm models 407–410
- j**
- Johkasou system 123–124
- l**
- Lagerstroemia speciosa* 477, 480
- $\text{La(OH)}_3/\text{Fe}_3\text{O}_4$  nanocomposites, synthesis of 344
- land-farming 247–248, 266
- Landfill Allowance Trading Scheme (LATS) 66, 68, 71
- landfill gas (LFG) 16, 699  
applications 715  
collection 699  
collection efficiency 699–700, 703
- LandGEM model 701–702  
vs. LFG recovery 704, 705
- regression model 703
- theoretical model 702–703
- conversion 716–717
- generation and recovery projection 704
- recovery system 700, 704  
collection piping system 706–707
- condensate management system 707
- extraction wells 704, 705
- wellheads 704, 706
- site assessment 700–701  
cover and liner system, type of 701
- depth of landfill 701
- moisture 701
- waste characteristics 701
- utilization  
combined heat and power systems 715
- direct use of 714
- electricity generation 714–715
- high Btu applications 715
- Landfill Methane Outreach Program (LMOP) 716
- landfills 699, 719  
and state-level projects 716  
tax escalator 71
- landfilling process 23, 699
- LandGEM model 701–702
- Langmuir isotherm model 228, 230, 422
- Langmuir model 14, 224, 226, 232–233, 351, 353, 356, 409, 421, 480
- lannate, removal efficiency of 530
- layered double hydroxides (LDH)  
structure of 453
- leachate 217, 250, 306, 385, 398, 400, 478, 481, 492, 503, 602–604, 614, 622, 632, 706
- leaching of ambient acid (AAL) 470

- leaching of high pressure (HPAL) 470  
 leaching process 263, 472, 476, 604, 606, 736  
 leaching, of toxic elements 622  
 LFG extraction site plan sample 707  
 life cycle analysis (LCA), of hydro-thermal algal biomass 584  
 Life Cycle Assessment (LCA), of sanitation systems 125–126  
 ligand exchange mechanism 416, 451  
 light brown suspension 276  
 lignocellulosic biomass 11, 83–98, 203, 254, 260, 582, 584  
 linear combination fitting (LCF) 327–328  
*Lipomyces* sp. 26  
 liquefied natural gas (LNG) 713, 715  
 lithium-ion batteries (LIBs) 743  
     advantages 743  
     recycling process, flowchart of 745  
     spent 743, 744  
 livestock wastewater 560–561  
     anaerobic digestion, performance of 567  
     characteristics 561  
 local authorities (LAs) 10–11, 47, 50, 52–54, 56–58, 64–65, 71–75  
 low energy mainline (LEM) 6  
 low-cost adsorbents  
     for nutrient removal 403  
         adsorbent dose effect 403–404  
         contact time 404–405  
         initial adsorbate concentration 403  
         interfering anions effect 406–407  
         pH effect 405–406  
         temperature effect 404  
     for pollutants removal 402  
     regeneration and reuse of 426–427  
 low-cost WW decontamination technologies 647  
     anti-fouling technology 648–654  
     filtration technology 647–648  
 low-karat gold 463  
 lower heating value (LHV) 259  
 lower middle-income country (LMIC) 4, 397  
 low-cost de-foulant methods 657  
*Lumbricus rubellus* 138  
*Lyngbya majuscula* 475, 476  
 lysis-thickening centrifuge  
     pretreatment 281–282
- m**
- magnesium-hydroxide flue gas desulfurization (MFGD) process 575  
 magnetic biochar composites 454–455  
 magnetic fluids hydrocyclones 678  
 magnetic iron based-oxide materials, characterization methods 345  
 magnetic nanomaterials 343  
 magnetic separation 173–174, 343, 347, 349–350, 365–366, 603, 734, 744  
 Maillard reaction 35–36  
 Malachite green (MG) 224  
 manganese carbonate, thermal stability of 602, 604, 606, 611, 613–614, 632  
 manganese citrate 622  
 manganese slag 605  
 manganese-bearing wastewater  
     manganese recovery  
         CO<sub>2</sub> dosage effect 607–609  
         ion recovery efficiency 611  
         manganese carbonate, thermal stability of 613, 614  
     onsite CO<sub>2</sub> emission 606–607  
     operational modes 611  
     pilot treatment system and performance 609–611  
     precipitates, characteristics of 611–613  
     treatment strategy 605–606

- operational modes 609
- treatment strategy 605–606
- manure management
  - anaerobic digestion/co-digestion 147
  - centralized and de-centralized models 148–149
  - composting/co-composting 147–148
  - energy production 149
  - mineral reutilization 150–151
    - ammonia stripping 150
    - struvite crystallisation 150
  - nutrient recovery, from manure 142–147
  - sanitization and hygiene
    - aerobic composting 139–141
    - heavy metal recovery, from livestock manure 142
    - nitrogen and phosphorus recovery 141
- material recycling 10, 746
- material synthesis, development and  $\text{Fe}_3\text{O}_4$  nanoparticles, synthesis of
  - coprecipitation method 343
  - solvothermal method 343
- MEC-FO system 385, 389
  - for ammonium and water recovery 385
  - for nutrients recovery 384
- MEC/MRC-AnOMBR system 384
- mechanical plastic recycling 742
- mechanical-baking coupling method 622
- mechanical-grate incineration technology (MGIT) 253
- membrane bioreactors (MBRs) 6, 13, 127, 306, 308–309, 317–326, 377, 546, 565
- membrane distillation (MD) 39, 375, 576–577
- membrane separation process 375, 712
- membrane technique
  - $\text{NO}_3^-$  and  $\text{PO}_4^{3-}$  removal 401
- metal biosorption process 472
- metal coagulants 542
- metal extraction
  - biohydrometallurgical process 738–740
  - hydrometallurgical process 736–738
  - metallurgical process for 735
  - pyrometallurgical process 736
- metal impregnation, of biochar 449
- metal recovery 142, 463, 469, 472, 476, 490, 501–503, 608, 733–734, 738, 739, 749
- metal regeneration 472
- metallic manganese 601
- methane ( $\text{CH}_4$ ) 122, 280–284, 505, 566, 699–719
  - methane emissions
    - LandGEM model 701–702
    - regression model 703
    - theoretical model 702–703
  - methane production, from sludge 277, 280
    - biological pretreatment 284
    - chemical pretreatment
      - alkaline pretreatment 283
      - FA pretreatment 283–284
      - FNA pretreatment 283
      - ozonation 283
    - physical pretreatment 280
      - FP pretreatment 282
      - mechanical pretreatment 281–282
      - microwave pretreatment 282
      - THP 280, 281
      - ultrasonic pretreatment 282
  - methane recovery 708–709
    - absorption process 710
    - adsorption process 710
    - condensation 710
    - particulates filtration 711
    - stages of 710
    - systems 704–708
    - and utilization 717
      - economic challenges 718
      - impurities 718
      - low methane production 718

- methane recovery (*contd.*)  
 regulatory challenges 719  
 social challenges 719  
 technical challenges 718
- methane utilization 713–717
- methanol 25, 30, 34–35, 91, 174, 204, 259, 716
- methyl orange (MO) 230
- MFC-FO systems 389
- Mg-accumulated tomato tissue biochar 443
- Mg-Al-Cl-LDH-hydrochar composite material 454
- Mg-Al-NO<sub>3</sub>-LDH-functionalised biochars 454
- Mg-modified biochar 455
- microalgae 167  
 biorefinery 209  
 as feed ingredients 565  
 and thraustochytrids  
   DHA and EPA productions 179–183  
 microalgae/thraustochytrids-based biofuel production 12
- microalgal biofilm system 183–184
- microalgal oil  
 biodiesel production 176  
 jet fuel production 176, 177
- microbial desalination cell (MDC) 208, 493–495, 504–505, 507
- microbial electrolysis cell (MEC) 208, 383, 385, 389, 493–495, 498–500, 503, 505, 507
- microbial electrolysis desalination cell (MEDC) 506–507
- microbial electrosynthesis (MES) 493–496, 505–506, 510
- microbial fuel cells (MFCs) 119, 208, 383, 389, 493–495, 497, 500, 507
- microbial solar cell (MSC) 493, 496
- microfiltration (MF) 382, 576  
 membrane 382
- microwave pretreatment 282, 288, 293
- microwave-assisted pyrolysis 255
- Millennium Development Goals (MDGs) 128–129
- mineral concentrates 150–151
- mixed integer nonlinear programming (MINLP) 204
- mixed-liquor suspended solids (MLSS) 220–221, 317, 545–547
- modular systems 644, 646
- molecular polymerization 93
- monounsaturated fatty acids (MUFAAs) 169, 177, 181, 186
- multi-component contaminants, treatment of 235–236
- multi-hydrocyclone arrangements 668, 673
- multi-scale governance (MSG) 50
- multilateral environmental agreements (MEA) 151
- multiple hearth furnace (MHF) 250, 252
- municipal solid waste (MSW) 8  
 landfills 700–708  
 management 699–700
- municipal wastewater 5–6, 16, 130, 217, 219, 221–222, 305, 307, 319, 389, 397, 491, 530, 544  
 global quantity of 492
- n**
- Nannochloropsis oculata* 170
- nanofiltration (NF) 7, 306, 576
- National Synchrotron Radiation Research Center (NSRRC) 327
- net energy ratio (NER) 211, 496
- nickel metal recovery 469–470
- nitrate pollution 400
- nitrogen-containing wastewaters 217
- NO<sub>3</sub><sup>−</sup> removal 400, 402  
 adsorbents for 414–415  
 and recovery using *Prosopis juliflora* weed 421
- low-cost adsorbents  
 adsorbent dose effect 403–404

- contact time 404–405  
initial adsorbate concentration  
403  
interfering anions effect  
406–407  
pH effect 405–406  
temperature effect 404  
non-conventional human excreta  
management systems 111  
non-conventional sanitation systems  
110, 112, 126  
non-ionizing radiation 526  
non-point source, of nitrate pollution  
400  
NPDES (National Pollutant Discharge  
Elimination System) 153  
N-removal processes 119  
nucleophilic addition reaction 535,  
538, 542  
nucleophilic substitution reaction  
535, 538, 539  
nutrients 398, 563, 564  
pollution  
nitrate pollution 400  
 $\text{NO}_3^-$  and  $\text{PO}_4^{3-}$  removal  
methods 400–401  
phosphate pollution 398–399  
potential sources of 398, 399  
recovery 1  
chemical precipitation 374  
MEC-FO system for 384  
OMBR-based system for 381  
organic contaminants 375  
systems 156  
removal  
disadvantages of 374  
utilization 118
- o**  
Oleaginous yeasts 26  
OMBR-based system, for nutrients  
recovery 380–383  
OMBR-MF hybrid system, for  
nutrient recovery 382  
OMBR-MF system 382–383  
open raceway pond (ORP) system  
179, 183, 208, 210, 322, 329  
operating expenditure (OPEX) 30,  
204, 209, 210  
operational LFG energy projects  
714, 716, 717  
ore mining process 603–604  
organic coagulants 540, 543–544  
organic matter (OM) 7, 15, 83, 110,  
113, 115, 119, 122, 123, 130,  
137, 218–219, 227, 247, 250,  
253, 284, 288, 494, 496, 530,  
559–564, 569, 578, 718  
osmo-heterotrophic unicellular  
marine protists 167  
ozonation 283, 290, 293, 525, 528,  
533, 544  
ozonation pretreatment 283
- p**  
palladium/gold composite material  
466  
particulate matter formation (PMF)  
157  
particulates filtration 711  
partition-release-recover (PRR) 6  
*Peronyx excavatus* 138  
permanent magnetic hydrocyclones  
677, 678  
*Persimmon tannin* 477  
personal care products (PPCPs)  
290  
*Phaeodactylum tricornutum* 180,  
181, 185  
pH and zeta potential analysis  
352–353  
phosphate accumulating organisms  
(PAO) 219, 305, 380, 388  
phosphate adsorption  
processes and mechanisms 341  
of  $\text{ZrO}_2@\text{Fe}_3\text{O}_4$  357  
of  $\text{ZrO}_2@\text{SiO}_2@\text{Fe}_3\text{O}_4$  357–358  
phosphate adsorption equilibrium  
351  
phosphate adsorption isotherms  
of  $\text{ZrO}_2@\text{Fe}_3\text{O}_4$  nanoparticles 351  
of  $\text{ZrO}_2@\text{SiO}_2@\text{Fe}_3\text{O}_4$  351  
of  $\text{La}(\text{OH})_3/\text{Fe}_3\text{O}_4$  nanocomposites  
353

- phosphate adsorption kinetics  
of  $\text{ZrO}_2@\text{Fe}_3\text{O}_4$  351  
of  $\text{ZrO}_2@\text{SiO}_2@\text{Fe}_3\text{O}_4$  351  
of  $\text{La(OH)}_3/\text{Fe}_3\text{O}_4$  nanocomposites 353
- phosphate recovery and reusability  
of  $\text{Fe}^0/\text{Fe}_3\text{O}_4$  composite 361  
of  $\text{La(OH)}_3/\text{Fe}_3\text{O}_4$  nanocomposites 360
- phosphate removal  
current adsorbents 341–342  
and recovery of 342–343
- phosphonates 339
- phosphorus (P) 13, 305, 339  
capture and reuse 437–439  
biochar use for 439–442  
pollution and eutrophication 340
- phosphorus, from wastewater and sludge  
acidogenic fermentation  
Al dosage 315–316  
experimental methods 312  
Fe dosage 312–315  
organic carbon 316
- membrane bioreactor  
experiment 317–319  
P removal 319–321
- P recovery technologies  
on CEPS 307–308  
chemically-enhanced membrane bioreactors 308–309  
chemical precipitation 307  
thermal treatment 307  
WWTP 306–307
- P removal and recovery,  
mechanisms of  
acidogenic fermentation 330–331  
experiment 326–327  
Fe speciation 329–330  
Fe-P complex, solubility 331–332  
microbial iron reduction 331  
P speciation 327–329
- P removal, from wastewater  
experimental methods 309  
results 310–311
- sludge fermentation and P recovery 321–326  
acidification vs. acidogenesis 325–326  
batch fermentation 321–324  
long-term performance 324–325
- phosphorus removal  
capacity 362–363  
by  $\text{Fe}^0/\text{Fe}_3\text{O}_4/\text{Fe}^{2+}$  system 355–356  
kinetics 363–364  
and recovery technologies 340–341
- photobioreactor (PBR) system 179, 181, 183, 211
- physical methods  
 $\text{NO}_3^-$  and  $\text{PO}_4^{3-}$  removal 401  
physicochemical approach, for nutrient recovery  
advantages and disadvantages 577  
ammonia stripping 570–573  
chemical precipitation 574–576  
ion exchange and adsorption 573–574  
membrane filtration technologies 576–578
- physisorption 408, 411, 416, 473
- Pit-latrines 121
- plant-based approach for wastewater treatment 578–583
- plate heat exchanger 640, 644, 646
- $\text{PO}_4^{3-}$  removal 402  
adsorbents for 412  
and recovery using *Prosopis juliflora* weed 421–426
- low-cost adsorbents  
adsorbent dose effect 403–404  
contact time 404–405  
initial adsorbate concentration 403  
interfering anions effect 406–407  
pH effect 405–406  
temperature effect 404
- methods 400

- point sources, of nitrate pollution 400
- pollution control and monitoring 464, 465
- polyaluminum chloride (PACl)-based enhanced primary treatment 308
- polycondensation 93
- Polyethyleneimine modified *Lagerstroemia speciosa* leaf powder 480
- Polyethyleneimine modified chitosan fiber (PCSF) 480
- Polyethylenimine modified bacterial biosorbent (PBBF) 480
- Polyhydroxyalkanoates (PHAs) 26, 308
- Polyhydroxybutyrate (PHB) 324
- Polymerization/condensation reactions 261
- polyphosphate 305, 327, 339, 380
- polyphosphate-accumulating organisms (PAOs) 219, 305, 380, 388
- polysaccharide polymers 88
- Polyvinyl chloride (PVC) 464, 740, 743
- positive displacement blowers 707
- Potential Environmental Applications 217–238, 365–366
- poultry feed 562
- poultry wastewater 561–562
- anaerobic digestion, performance of 567
  - characteristics 561
- pre-water treatment 637
- precious and critical elements 470, 471
- precious metal recovery 463, 472
- cyanide leaching 472
  - from biodegraded materials 470, 472
- precious metal recovery (PMR) 463, 469, 472, 476, 749
- precious metal recycling, importance of 467–469, 481
- pressure pipe heat exchangers 643–644
- pressure swing adsorption (PSA) process 713
- pretreatment technologies 291
- evaluation 290–294
- primary plastic recycling 742
- primary pollutant concentrations 311
- primary sludge 275–276, 308, 312, 332
- primary wastewater 636–637
- printed circuit boards (PCB), leaching and metal recovery process 469
- product yield and market value 204–205
- Prosopis juliflora* weed (PJAC) 421
- $\text{NO}_3^-$  and  $\text{PO}_4^{3-}$  removal and recovery
  - adsorbate and adsorbent preparation 421
  - desorption study 425–426
  - equilibrium adsorption study 421–425
- pyro-metallurgy 467–469, 735–736
- pyrolysis 253–255, 260, 438, 454, 583
- pyrometallurgical process 8, 736
- benefits and issues 741
- pyrometallurgy 467–469, 735
- metal extraction 736
- q**
- quaternary plastic recycling 742
- r**
- radiolysis process 528
- rare earth element (REE) 342
- raw domestic sewage 309
- raw wastewater 306, 545, 547, 549, 636
- Reactive Brilliant Red K-2G (RBR) 238
- reactive dyeing mechanism 535, 538–539, 541, 602
- reactive dyes 533–535, 538–539, 547

- reduced separation efficiency, of hydrocyclones 666, 667
- regression model 38, 703
- Renewable Energy Directive (RED) 201
- Renewable Transport Fuel Certificates (RTFC) 201
- residence time 27–30, 94, 98, 254–255, 258, 260, 583, 671, 673–674, 708, 742
- resource recovery 1
- backgrounds
    - economical aspect 4–5
    - environmental impacts 4
    - HRU 2
    - population growth 2–4
    - resource scarcity 4
  - internationally coordinated framework 10
  - novel technologies, development of 9
  - social and economic feasibility 9–10
  - waste
    - E-waste 9
    - electronic waste and hazardous waste 7
    - global food waste 7
    - industrial waste 7
    - municipal solid waste 7
  - wastewater 5
    - heat recovery 7
    - nutrient recovery 6
    - organic carbon recovery 6–7
  - resource recovery oriented sanitation
    - ecological sanitation 112–113
    - biofilters 114–115
    - failures and success 115–116
    - Rottebehaelter and centrifugal separation sanitation 113–114
  - human excreta and sustainable future
    - economics, of resource recovery sanitation 127–128
    - sanitation access and resource recovery 128–129
- in rural areas 116–117
- anaerobic digestion 119–121
- community scale 121
- nutrient recovery, from urine 117–119
- in urban context
- energy matters 121–123
  - industrial scale units 124–125
  - Johkasou systems 123–124
- resource recovery sanitation
- in developing countries 151–153
  - anaerobic treatments 154–155
  - chemical treatments 154
  - commercial scale resource recovery 155–156
  - composting 155
  - pasteurization 154
  - storage 154
- Rhizoclonium hieroglyphicum* 475–476
- Rhizopus oryzae* 476, 739
- Rhodosporidium* sp. 26
- Rhodotorula* sp. 26
- rice husk (RH)
- gold sorption 477
  - rotary lobe blowers 707
- rotating cone pyrolysis reactor (RCPR) 254–255
- rotating hemispherical filter
- wastewater collection device 650
- rotating particle separator (RPS) 264
- rotating sleeve filter wastewater collection device 650
- Rottebehaelter and centrifugal separation sanitation 113–114
- Rottebehaelter system 112, 113
- rubbery polymers 712
- S**
- Saccharomyces cerevisiae* 24, 739
- Salmonella* 152, 154
- sanitation 11, 109–131, 149, 151–155, 157–160, 397, 719
- saturated fatty acids (SFAs) 169, 177, 181, 186

- saturation magnetization 345–346, 349–350  
 scanning electron microscopy (SEM) 220–221, 225, 230, 237, 316, 345, 350, 379–380, 475–477, 608, 610–613, 615, 630–631, 676  
 scanning electron microscopy/energy-dispersive X-ray spectroscopy (SEM/EDS) 316  
*Scenedesmus* sp. 170, 174  
*Schizochytrium* sp. 177  
 secondary plastic recycling 742  
 secondary wastewater 276, 463, 481, 637  
 seed sludge 220–221, 312, 318  
 selective phosphate adsorption, of  $\text{La(OH)}_3/\text{Fe}_3\text{O}_4$  nanocomposites 358–360  
 selective phosphate removal, of  $\text{Fe}^0/\text{Fe}_3\text{O}_4/\text{Fe}^{2+}$  system 360, 361  
 semi-continuous reactors 309, 316  
 separation efficiency, hydrocyclones 666–667  
 sewage filter structure 649  
 sewage sludge  
     characteristics of  
         primary sludge 276  
         WAS 276  
     composition 251  
 sewage treatment plants (STPs) 126, 217, 275, 279–284, 289, 293–294, 491, 530, 636, 639, 643–644  
 side-stream co-fermentation 306, 333  
 silicon 16, 91, 601, 605, 615–632, 746–747  
 silicon activation  
     ball milling effect 617–618  
     flow chart of 618  
     mass ratio effect 619  
     roasting temperature effect 619–620  
     roasting time effect 620–621  
 silicon bioleaching 624–632, 738–739, 744  
 simultaneous saccharification and fermentation (SSF) 24–25  
 $\text{SiO}_2@\text{Fe}_3\text{O}_4$  nanoparticles, synthesis of 343, 344  
 sludge microflora 288  
 sludge volume index (SVI) 220  
 sludge-based activated carbon  
     dye wastewater, treatment  
         MG sorption 225  
         mineral acid modification 225–226  
     heavy metal wastewater, treatment 226  
         Cu(II) sorption 227–229  
         heavy metal sorption 226–227  
 production method 222–223  
      $\text{H}_3\text{PO}_4$  223–224  
      $\text{ZnCl}_2$  223  
 sodium acetate 343  
 soft reinforcement 71  
 solar PV panels 745–747  
     average lifetime 746  
     generations 746  
     waste PV panels 746  
     processing and recycling 746–747  
 solid residue (SR) 27–28, 30, 87, 90–91, 93–97, 736  
 solids retention time (SRT) 308–309, 312, 316, 321, 325, 326, 332, 566  
 soluble chemical oxygen demand (SCOD) 289–290, 309, 311, 313, 315–316, 324  
 soluble microbial products (SMPs) 233, 321  
 solventogenesis 24–25  
 sorption isotherms 232, 234  
 sorption process 478–479  
     Freundlich model 480  
     Langmuir model 480  
 spent adsorbent handling and management 417  
 spent LIBs 743–744

- split ratio 16, 663, 666, 667, 670, 672, 674, 676, 679–680, 683–685
- spraying type wastewater evaporator 642
- Statutory Management Requirements (SMRs) 152
- steel slag, in LFG treatment 712
- stockpiling 603, 740
- struvite formation 1, 150, 307, 380, 499, 501, 574–575, 577, 587
- struvite precipitation 6, 119, 128, 374–375, 383, 385–387, 500, 575, 577, 585
- SulfaTreat 711
- supercritical liquefaction, waste biomass 95
- supercritical water gasification 97, 584
- sustainability 24
- manure management systems
  - LCA 156–157
  - transitions literature 48–51
- swirling decontamination method 651
- synthesis gas 258
- t**
- Tailor-made food waste 38
- tannin gel 476, 739
- target transformation (TT) 327
- tech devices, average lifespans for 725, 726
- techno-economic analysis (TEA) 10, 199–200, 203, 211–212
- Teflon-lined stainless-steel autoclave 343, 344
- temperature-phased anaerobic digestion (TPAD) 13, 284, 293, 294
- tertiary plastic recycling 742
- tetraethyl orthosilicate (TEOS) 344
- textile dyes
- chemical structure formula
  - 534
- classification 534–535, 536
- dyeing process 535, 538
- nomenclature of 535, 537
- reactive dyeing mechanism 535, 538–539
- textile wastewater 525, 539
- characteristics 539–540
  - composition 539
  - treatment 525
- treatment methods 540, 544
- advanced oxidation process (AOP) 544
  - biological methods 544
  - physico-chemical treatment 540, 542–544
- thermal hydrolysis pretreatment (THP) 280, 281
- thermal hydrolysis vendor system 281
- thermal-chemical treatment, of sewage sludge
- ashes to value-added materials 261
- bio-oils 259–260
- biochar 260–261
- characterization of 250
- combustible gas 258–259
- gasification
- performance-cost-benefit analysis 257
  - typical gasification processes 255–257
- heavy metals removal and recovery 263–264
- impact on, environmental sustainability 248–250
- incineration
- performance-cost-benefit analysis 253
  - typical incineration processes 250–253
- liquefaction
- performance-cost-benefit analysis 258
  - typical liquefaction processes 257–258
- nutrient recovery 261–263

- pyrolysis  
 performance-cost-benefit analysis 255  
 typical pyrolysis processes 253–255  
 technology limitations  
   deactivation, of catalyst 264  
   high moisture content 265–266  
   NO<sub>x</sub> and SO<sub>x</sub> emission 265  
   tar formation 264–265  
 thermochemical conversion 203, 207, 581, 583–584  
 thin-film composite (TFC) membrane 386  
 thiourea ((NH<sub>2</sub>)<sub>2</sub>CS) leaching 738  
*Thraustochytrids* 167  
   for biodiesel production 177–178  
   microalgae, challenges 178–179  
 total ammonia nitrogen (TAN)  
   concentration 150, 496, 575, 576  
 total bio-oil (TBO) 95–96  
 total chemical oxygen demand (TCOD) 309–311  
 total nitrogen (TN) 5, 6, 141, 220, 260, 262, 309, 545, 563, 565  
 total phosphorus (TP) 5, 6, 141, 545  
   removal 220  
 total primary energy supply (TPES) 200  
 total static pressure drop, of hydrocyclones 667  
 total suspended solids (TSS) removal 114, 508  
 toxic triphenylmethane 224  
*Trachydiscus minutus* 181  
 trade names, of dyes 535  
 traditional sewage sludge treatment 247, 250  
 transesterification, of triglyceride 175–177, 179, 204, 581  
 transformer oil treatment, using EB 530  
 transmembrane pressure (TMP) 318, 320  
 transmission electron microscopy (TEM) 345–346, 348  
 triacylglycerides (TAGs) 168, 170, 183, 224  
 triazine and vinyl sulphone dyes, reaction of 539  
 triclocarban (TCC) 289, 290  
 trisodium citrate 343  
 trisodium citrate dihydrate 343  
 Tungstated zirconia catalyst 176  
*Turbinaria conoides* 475, 476  
 two parameter isotherm models 409  
 2000 Waste Strategy, implementation 66–67  
   financial instruments 70–72  
   LA implementation, of waste policy 67–69  
   local authorities and the public 72–74  
   regional governance 72  
   strategy, legacy of 74–75  
   targets 70
- U**
- ultrafiltration (UF) 150, 383, 503, 576  
 United Nation economic commission for Europe (UNECE) 151  
 United Nations Children's Emergency Fund (UNICEF) 128  
 United States environmental protection agency (US EPA) 124, 465, 700, 701, 703–705, 707, 709, 712, 714, 716  
 unmodified biochars 442, 443, 455  
 upflow anaerobic sludge blanket (UASB) reactor 6, 117, 120, 219, 233, 565–566  
 Upper middle-income country (UMIC) 4, 397  
 Urine Diversion Dehydration Toilets (UDDTs) 116, 126  
 U.S. Environmental Protection Agency 155, 340
- V**
- valuable soil conditioner 110  
 Ventilated Improved Pit (VIP) 126

- vertical gas collection wells
  - advantages and disadvantages 706
  - configuration 705
- vibrating sample magnetometer (VSM) 345, 347, 350–351
- volatile fatty acids (VFA) 7, 24, 97, 279, 308, 496, 566, 577
- volatile organic compounds (VOCs) 151, 551, 577, 718
  
- W**
- waste activated sludge (WAS) 275–276, 293
- waste electrical and electronic equipment (WEEE) generation 723
  - metal extraction from 735
  - recovery options 732
- waste management, in England 51–52
- waste management, revolution
  - English waste, EU 58–64
  - in England 51–52
  - influences, in the UK 64–66
  - interviewees, selection of 54–58
  - research design 53, 54
  - research methods 53
  - secondary data 58
  - sustainability transitions literature 48–51
- waste printed circuit boards (WPCB) 9, 733
- waste-to-energy (WTF) 157–158
- wastewater (WW)
  - characteristics of 636–637
  - collection device, in open type 651
- wastewater heat exchangers (WWHE) 639–640
  - classification of 640–641
  - flow heat transfer law 657
  - foulant growth law in 657
  - soft-foulant separation 657
  - style of 641–646
- wastewater P-recovery processes 305
  
- wastewater source heat pump (WWSHP) 635, 637
  - application 639–640
  - case study 654–657
  - challenges 657
  - energy source 639–640
  - operating costs 658–659
  - principle 637–639
  - with de-foulant hydrocyclone 651, 652
- wastewater treatment 489
  - ammonium removal methods 489
  - bioelectrochemical systems 490
  - electricity consumption of 489
  - energy consumption of 489
- wastewater treatment plants (WWTPs) 1, 6–7, 9, 117, 123, 124, 210, 222, 228, 255, 263, 282, 305–306, 308, 374, 380, 437, 454–456, 490, 491, 507, 547, 552, 654–655
- wastewater treatment process
  - activated sludge 218–219
  - granular sludge
    - aerobic granular sludge 220–222
    - anaerobic granular sludge 219
    - pilot-scale application 220–222
- wastewaters decomposition, by EB technology 530, 531
- water contamination 5, 490
- water hyacinth-based biochar 454
- water scarcity 130, 397
- water scrubbing process 711
- water scrubbing unit 712
- water soluble (WS) 35, 37, 84, 96, 110, 209, 622
- water source heat pump (WSHP) 7, 16, 635, 637–640
- water-injection hydrocyclones 673
- wet air oxidation (WAO) 465
- woody biomass 85
- World Health Organization (WHO) 128, 233, 397, 400

**X**

- X-ray absorption near edge structure (XANES) spectroscopy 13, 327–330, 332–333
- X-ray absorption spectrometer (XAS) 327
- X-ray diffraction (XRD) 230, 261, 316, 324, 327, 345–346, 349–350, 608, 610–612, 616, 620, 629–630
- X-ray photoelectron spectroscopy (XPS) 345
- X-ray powder diffraction (XRD) 316, 608

**Z**

- zeolites 96, 119, 138, 142, 186, 438, 573–574, 576
- zeta potential analysis 352–354
- zirconium oxide ( $\text{ZrO}_2$ ) 37, 342, 344–346, 352, 357, 364–365
- $\text{ZrO}_2@\text{Fe}_3\text{O}_4$  nanoparticles  
phosphate recovery and reusability 357–358  
synthesis of 344
- $\text{ZrO}_2@\text{SiO}_2@\text{Fe}_3\text{O}_4$  nanoparticles, synthesis of 344

















