

- acetate fibres 86
- acid dyes 85, 194
 - biosorption removal 216–17
- acrylic fibres 86
- activated carbon 152–3
- activated sludge 151–2, 214–15
- acute toxicity 46–9
- adsorption treatments 151–4
 - activated carbon 152–3
 - activated sludge 151–2, 214–15
 - clays 152
 - fly-ash 152
 - ion-exchange resins 153–4
 - microbial biomass 154
- Advanced Oxidation Processes (AOPs) 158–9, 160, 203
- aerobic treatments 214–17
- air emissions 143
 - EU legislation 1, 23–5
 - US legislation 34–6
- alkylating agents 66
- allergic reactions 49
- Ames test 50
- anaerobic treatments 217–18
- anthraquinone dyes 194
 - toxicity 60–2
- application of dyes 74–88
 - to acetate 86
 - to acrylic 86
 - to blended fibres 86–7
 - to cellulosic fibres 83–5
 - correct shade 76–7
 - to cotton 82–3
 - efficiency and environmental responsibility 79
 - fabric preparation 82–3
 - fastness 78–9
 - heat exchangers 80
 - level dyeing 78
 - machinery 79–80
 - to nylon 85–6
 - to polyester 86, 124, 139–40
 - to silk 83
 - water use 80
 - to wool 83, 85
- aromatic amino compounds 63–4
- asbestos fibres 13
- auxiliary chemicals 121–4
- azo dyes 192
 - ozone treatments 169–70
 - toxicity 52–60
- azoic colouring agents 13
- backtanning processes 85
- benzene 12
- benzidine-based dyes 192
- Best Available Techniques (BAT) 5–7
- Best Management Practices (BMP) 132–4
- biocidal products 11, 14–15
- biological oxygen demand (BOD) 196–7
- biosorption removal of acid dyes 216–17
- biotechnological treatments 151, 212–25
 - activated sludge 151–2, 214–15
 - aerobic 214–17
 - anaerobic 217–18
 - enzymatic 218–24
 - fungi 215–17
 - microbial processes 212–18
- Biotic Ligand Model (BLM) 38
- bladder cancer 46, 49–50, 60
- blended fibres 86–7

- BOD (biological oxygen demand) 196–7
BREF document 7
- Californian state legislation 36–7
- carbon dioxide
 and global warming 94
 industrial applications 95–6
 physicochemical properties 94–5
 see also supercritical carbon dioxide
- carbon electrophiles 65–7
- carcinogens
 and bladder cancer 46, 49–50, 60
 classes 51–2
 and EU legislation 13
 from carbon electrophiles 65–7
 from nitrogen electrophiles 52–65
 isomers of carcinogens 60
 list of carcinogenic dyes 62
 ultimate carcinogen 51
- carriers 139–40
- catalase enzymes 83
- catalytic ozonation 171–2
- catalyzed oxidation 203–5
- cationic dyes 51, 194
 toxicity 62
- cellulosic fibres 83–5
 PET poly(ethylene terephthalate)
 96–108
- chemical oxygen demand (COD) 196–7
- chemical substances legislation 8–16
 ecolabelling 15–16, 141–4
 lists of priority substances 10
 marketing restrictions 11–15
 persistent organic pollutants (POPs)
 15
 risk evaluation and control 8–11
 safety data sheets (SDS) 10–11
- chemical treatments for colour removal
 197–208
 dye classes 192–5
 dye compound characteristics 192
 electro-coagulation 200–1
 electrochemical 201–2
 ion exchange 207
 measurement of colour removal 195–6
 oxidation methods 202–7
 physico-chemical coagulation
 197–200
- chitin 154
- chitosan 153
- chlorine 121, 155, 203
- chromium 68
- chronic toxicity 49–68
 of anthraquinone dyes 60–2
 of aromatic amino compounds 63–4
 of azo dyes 52–60
 of cationic dyes 62
 direct-acting alkylating agents 66
 DNA reactions with genotoxic
 chemicals 50–1
 of hydrazines 65
 and metal complex dyes 67–8
 Michael acceptors 66–7
 of nitrosamines 64–5
 of pigments 51, 62–3
 of polycyclic aromatic hydrocarbons
 67
 and water solubility 51
 see also carcinogens
- classes of carcinogens 51–2
- classes of dyes 192–5
- clays 152
- Clean Air Act (CAA) 34–6
- Clean Water Act (CWA) 33–4
- coagulation
 electro-coagulation 200–1
 physico-chemical 197–200
- cobalt 68
- COD (chemical oxygen demand) 196–7
- colour as a pollutant 39, 124–5, 191
 see also decolorisation of effluent
- Colour Index (CI) system 192–3
- Community Right-To-Know 31–2
- continuous processing 79–80
- copper 68
- corona discharge 172–3
- cotton 82–3
- counter current washing 126–7
- Daphnia magna* 125
- decisions (in EU legislation) 3
- decolorisation of effluent 149–83
 adsorption 151–4
 biological 151
 biotechnological 212–25
 colour as a pollutant 39, 124–5, 191
 dyebath reuse 176–81
 measurement of colour removal 195–6
 oxidation 155–60
 separation 154–5

- see also* chemical treatments for colour removal; ozone treatments
- decomposition of dyes 177–8
- detergents 14, 15
- dichromate oxidation 123
- direct dyes 84
- direct-acting alkylating agents 66
- directives (in EU legislation) 3
- disperse dyes 49, 86, 194
- DNA reactions with genotoxic chemicals 50–1
- drop-fill batch washing 126
- dye classes 192–5
- dye compound characteristics 192
- dyebaths
 - components 117, 134, 165–6
 - decolorisation 180–1
 - decomposition of dyes 177–8
 - exhaustion maximisation 133–6
 - low liquor ratio baths 138
 - ozone treatments 165–6, 173–6, 180–1
 - reuse 81, 127–32, 176–81
- Dynapol 51
- ecolabelling 15–16, 141–4
- electro-coagulation 200–1
- electrochemical colour removal 201–2
- electrochemical oxidation 157–8
- electrophiles
 - carbon 65–7
 - nitrogen 52–65
- energy consumption 103–5
- Environmental Management Systems (EMS) 40
- environmental permits 1, 5–7
- enzymatic processes 82–3, 218–24
 - oxidative enzyme remediation 219–24
 - reductive enzymes 224
- European legislation 1–28
 - on air pollution 1, 23–5
 - on chemical substances 8–16
 - forms of EU environmental legislation 3
 - GHS (Globally Harmonised System) 26
 - information and advice 27–8
 - IPP (Integrated Product Policy) 26–7
 - IPPC Directive 1, 3–8
 - principles of EU environmental policy 2
- REACH framework 25–6
 - registration of dyes 46
 - on water quality 1, 16–23
- European Pollutant Emission Register (EPER) 7–8, 27
- extremophiles 222–3
- eye irritation 46–7
- fabric preparation 82–3
- fastness 78–9
- Federal Clean Water Act (CWA) 33–4
- Fenton's reagent 155–6, 205–7
 - Photo-Fenton process 159
- Ferral 172
- fibres, pollutants in raw fibres 119–20
- fixation of dyes 136–7
- fly-ash adsorbents 152
- food dyes 51
- formaldehyde 123
- fungal treatments 215–17
- fusion of finishing processes 108–9
- gas feed system 174
- genotoxic chemicals 50–1
 - see also* carcinogens
- GHS (Globally Harmonised System) 26
- global warming 94
- Greenpeace 40, 121
- heat exchangers 80
- heavy metals *see* metals
- high-performance fibres 109–10
- history
 - of dyes 45
 - of supercritical dyeing 96–8
- horseradish peroxidase (HRP) 157
- hydrazines 65
- hydrogen peroxide 155, 157, 203
- hydroxyl radical generation 169–71
- hydroxylamines 64–5
- hyperfiltration 131
- ink-jet printing 88
- instrumental colour measurement 77
- interest groups 40
- ion-exchange 153–4, 207
- IPP (Integrated Product Policy) 26–7
- IPPC (Integrated Pollution Prevention and Control) Directive 1, 3–8
 - BREF document 7
 - environmental permits 1, 5–7

- European Pollutant Emission Register (EPER) 7–8, 27
 - implementation 4–5
- isomers of carcinogens 60
- labelling 15–16, 141–4
- laccases 219–24
- legislation *see* European legislation; United States legislation
- level dyeing 78
- life-cycle analysis 75
- liposomes 139–40
- low liquor ratio baths 138
- machinery for application of dyes 79–80
- manganese-catalysed ozonation 172
- maritime waters protection 19–22
- marketing restrictions 11–15
- measurement of colour removal 195–6
- mercury 12, 38–9
- metal complex dyes 85
 - toxicity 67–8
- metals
 - accumulation in sludge 119
 - heavy metals in dyes 120–1
 - heavy metals in wastewater 38–9
- metamerism 76–7
- Michael acceptors 66–7
- microbial biomass 154
- microbial processes 212–18
- microfiltration 154–5, 199
- mutagens 50
- nanofiltration 154–5
- natural dyes 45, 69–70
- NEC (National Emission Ceilings) 23–4
- nickel 12, 68
- nitroaromatic compounds 63–4
- nitrogen electrophiles 52–65
- nitrosamines 64–5
- nonylphenol ethoxylate 14
- nylon 85–6
- octaBDE 13
- Oeko-tex 100 scheme 75
- off-gas destruction 176
- OSPAR Convention 22
- overflow batch washing 126
- oxidation treatments 155–60, 202–7
 - Advanced Oxidation Processes (AOPs) 158–9, 160, 203
 - catalyzed oxidation 203–5
 - chlorine and chlorine dioxide 155, 203
 - electrochemical oxidation 157–8
 - Fenton's reagent 155–6, 205–7
 - hydrogen peroxide 155, 157, 203
 - peroxidase enzymes 157
 - Photo-Fenton process 159
 - photocatalytic oxidation 159–60
 - ultra-violet radiation 158
- oxidative enzyme remediation 219–24
- oxygenases 219–24
- ozone contractors 175–6
- ozone generators 174–5
- ozone treatments 160–76
 - of azo dyes 169–70
 - catalytic ozonation 171–2
 - composition of ozone 161
 - decomposition of ozone 166–7
 - and dyebath additives 165–6
 - and dyebath reuse 180–1
 - dyestuff reaction mechanism 168–9
 - effectiveness of ozonation 162
 - gas feed system 174
 - generation of ozone 172–3
 - hydroxyl radical generation 169–71
 - off-gas destruction 176
 - and pH 163–5
 - of spent dyebaths 173–6
 - and temperature 162–3
- PACS (polyaluminium silicate chlorides) 198–9
- paraffins 13
- PARCOM Recommendation 22
- PBB 12
- pentaBDE 13
- pentachlorophenol 13
- permits 1, 5–7
- peroxidases 157, 219–24
- peroxide oxidation 123
- persistent organic pollutants (POPs) 15
- pesticides 119
- PET poly(ethylene terephthalate) fabrics 96–108
- pH and ozone treatments 163–5
- Photo-Fenton process 159
- photocatalytic degradation 204
- photocatalytic oxidation 159–60
- phthalocyanine dyes 51
- physico-chemical coagulation 197–200

- physiochemical flocculation 214
 pigments
 and textile printing 87–8
 toxicity 51, 62–3
 pollutants in raw fibres 119–20
 pollution abatement 116–33, 144
 air emissions 143
 auxiliary chemicals 121–4
 Best Management Practices (BMP)
 132–4
 dyebath reuse 81, 127–32
 heavy metals in dyes 120–1
 information and advice 140–4
 pre-screening chemicals 141–3
 wastewater contents 124–5, 133
 water conservation 125–7
 and wool processing 119
 polyaluminium silicate chlorides (PACS)
 198–9
 polycyclic aromatic hydrocarbons 67
 polyester 86, 124, 139–40
 POPs (persistent organic pollutants) 15
 pre-screening chemicals 141–3
 printing 87–8
 product quality 107
 Proposition 65 regulations (California)
 36–7

 quality 107
 quaternised sugar cane bagasse 153

 radio frequency (RF) drying machines
 138
 REACH framework 25–6
 reactive dyes 47–9, 83–4, 194
 removal from wastewater 198–9
 reconstitution of dyebaths 176–7, 179
 red ochre 45
 reductive enzymes 224
 registration of dyes 46
 regulations (in EU legislation) 3
 reverse osmosis (RO) 131, 154–5
 right-first-time (RFT) approach 132
 Right-To-Know 31–2
 rinsing processes 125–7
 risk evaluation and control 8–11

 safety data sheets (SDS) 10–11
 salt use 137–8
 separation techniques 154–5

 shades, and application of dyes 76–7
 silk 83
 skin irritation and sensitisation 46–7
 sodium hypochlorite 203
 spin finishing 119–20
 standing baths 81
 sulphur dyes 84–5
 supercritical carbon dioxide dyeing
 93–110, 138–9
 commercial competitiveness 108
 consumption of carbon dioxide 105–6
 definition of a supercritical fluid 94
 economization of chemical use 106–7
 energy consumption 103–5
 environmental compatibility 93–4,
 100
 fusion of finishing processes 108–9
 future prospects 110
 high-performance fibres 109–10
 history of supercritical dyeing 96–8
 information and advice 110
 process steps 100–1
 process times 102–3
 product quality 107
 scale-up parameters 101–7
 viscosity of supercritical fluids 94
 surfactants 14, 39, 81
 sustainability 39–40, 93
 synthetic dyes 45–6

 temperature, and ozone treatments 162–8
 teratogens 50
 textile printing 87–8
 titanium dioxide 204–5
 total organic carbon (TOC) 196
 Toxic Release Inventory 31–2
 Toxic Substances Control Act 36
 toxicology of dyes 44–70
 acute toxicity 46–9
 bladder carcinogens 46, 49–50
 chronic toxicity 49–68
 information and advice 70
Trametes hirsuta laccase 221–2
Trametes modesta laccase 222
 tributyl tin complexes 38

 ultimate carcinogen 51
 ultra-violet radiation 158
 ultrafiltration 154–5
 United States legislation 30–42

- Clean Air Act (CAA) 34–6
- Community Right-To-Know 31–2
 - current regulations 31
 - future trends 37–40
- hazardous and non-hazardous waste
 - 33
- information and advice 41–2
 - and interest groups 40
- Proposition 65 regulations (California)
 - 36–7
- sustainability and environmental management 39–40
- Toxic Release Inventory 31–2
- Toxic Substances Control Act 36
 - on water quality 33–4, 38–9
- urban waste water directive 22–3

- vat dyes 84, 194
- viscosity of supercritical fluids 94
- VOC (Volatile Organic Compounds)
 - Directive 23–5

- wash off processes 136–7
- washing processes 125–7
- waste minimisation 116, 133–8
 - dyebath exhaustion maximisation 133–6
 - fixation of dyes 136–7
 - information and advice 140–4
 - low liquor ratio baths 138
 - salt use 137–8
- wastewater
 - classification of treatments 149–50
 - contents 124–5, 133
 - physical treatments 149
- water consumption 80, 125–7
- Water Framework Directive (WFD)
 - 17–19
- water quality legislation
 - European 1, 16–23
 - maritime waters protection 19–22
 - metals in wastewater 38–9
 - United States 33–4, 38–9
 - urban waste water directive 22–3
 - Water Framework Directive (WFD)
 - 17–19
- Water-Effects-Ratio (WER) 38
- white-rot fungi 215–17
- wool processing
 - application of dyes 83, 85
 - pollution abatement 119