

Index

a

acaroid resin 114
 acoustic sensors 145–146
 afterburning 33, 34
 aftermath–residues 2
 air entrainment 33, 34
 2-amino-4,6-dinitrotoluene
 (2-A-DNT) 51
 4-amino-2,6-dinitrotoluene
 (4-A-DNT) 51
 ammonium dinitramide (ADN) 5, 80
 ammonium perchlorate (AP)
 oxidizer 51, 70, 199
 ammunition demilitarization 13–45, 176
 anti-tank ‘Barmines’ 36
 antitank ranges 60, 68
 aqueous solubility (S_w) 58
 artillery guns 66, 79
 autonomous underwater vehicles
 (AUVs) 146

b

bathymetry 146
 $B_4C/KNO_3/KCl/Ca$ stearate/PVAc 125
 beeswax 114
 Best Available Techniques Not Entailing
 Excessive Costs (BATNEEC)
 principle 43–44
 binders 26, 51, 96, 103, 104, 114, 117,
 120, 124
 bioaccumulation factor (BCF) 218
 bioturbation 143, 154
 5,5'-bis(1-hydroxytetrazole) 122
 blow-in-place (BIP) detonations 59, 78
 bulk propellants 32, 33

c

C4 92–97
 calibre projectiles 64
 cannon ammunition 22, 23
 carbon reduction 171
 characterization factors (CF) 184, 186,
 219, 220, 224
 Chemical Munitions Search and
 Assessment (CHEMSEA) 150,
 157
 Chemical Safety Assessment (CSA) 215
 Chemical Safety Report (CSR) 216
 chemical warfare agents (CWA) 139,
 156, 160
 Chemring Nobel Company 96
 chlorobenzenes 108
 chlorophenols 108
 circular economy 171
 civil authorities 1
 civilian pyrotechnic systems 107
 clean-up strategy 105
 CO_2 estimates 38
 Cold Regions Research and Engineering
 Laboratory (CRREL) 47
 commercial demilitarization contract 15
 commercially viable materials 19
 Composition B (Comp B) 51, 69, 77, 82
 contaminated water 58, 227
 contamination management 7
 corrosion 63, 64, 140–145, 151, 155–
 158, 233, 246
 cost-efficiency analysis (CEA) 83
 costs and associated logistics 15
 Council Directive 67/548/EEC 214
 CX-85 83–85, 89

d

- data quality objective (DQO) process 53
- Decision aid for marine munitions (DAIMON) 141
- decision units (DUs) 53
- deep sea dumping 13, 17
- Defence Research and Development Canada (DRDC) 47
- demilitarization 235
 - basic stages of 17–20
 - examples of cost and CO₂ 36
 - facilities 20
 - factors influencing 15–17
 - maturity and use of 21–26
 - munition manager's perspective 44–45
 - NATO AOP 4518 40–44
 - open burning (OB) 29–33
 - open detonation (OD) 29–31, 33–36
 - scale of issue 14–15
 - technical and environmental issues 27–29
 - techniques and processes 20–21
- Department of National Defence Director General Environment (DGE) 47
- design for demilitarization (DFD) 235
 - munition manager's perspective 44–45
 - NATO AOP 4518 40–44
- design for disposal 173
- detonation 2, 33–34
 - residues 90–91, 233
- detonators 32, 33, 94, 132, 243
- 3,3'-diamino-4,4'-dinitramino-5,5'-bi-1,2,4-triazolate 121
- 1,1-diamino-2,2-dinitroethylene (FOX-7) 80
- diazodinitrophenol (DDNP) 181
- dibutyl phthalate 105, 213, 220–223
- diisononylphthalate 220
- 2,4-dinitrotoluene 231
- 2,6-dinitroanisole 231
- dinitroanisole (DNAN) 69, 80
- 4,5-dinitro-1,3-imidazole 121
- 2,4-dinitrotoluene (2,4-DNT) 51
- 2,6-dinitrotoluene (2,6-DNT) 51
- dinitrotriazalone (NTO) 80
- diethylsebacate 220
- diethyl terephthalate 220–224
- dioxin/dibenzofuran cocktail of pollutants 108
- dioxins 108
- Directive 76/769/EEC 214
- Directive 79/831/EEC 214
- Director Land Environment (DLE) 47
- disposal and waste burning 126–127
- disposed military munitions (DMM) 139
- DM12 detonation and deposition rate measurement 94
- 2,4-DNT 51, 52, 58, 59, 64–66, 78, 80, 81, 88, 89, 152
- Doppler velocity log (DVL) 148
- DRDC Valcartier 48, 61, 90

e

- ecodesign 171, 173, 174, 194
- Ecodesign Directive 173
- ecoinvent database 179, 187
- ecoinvent website 179
- ecolabel 171
- ecotoxicity 186, 187, 190, 192, 204, 220, 224, 237
- ecotoxicology 8
- effect factor 186
- embedded electronics 41
- EM sensors 146
- end-of-life (EOL) disposal 41
- end-of-mission (EOM) disposal 41
- end-of-operational-life (EOOL) 41
- Engineer Research and Development Center (ERDC) 47
- environmental and safety legislation 213
- environmental assessment 2, 16, 28, 38, 39, 64, 180, 200
- environmental hazard assessment 1
- environmental impact of munitions 2, 247
- environmental life-cycle impacts 188, 191
- Environmentally Sustainable Manufacturing for Energetic Formulations 243
- environmentally sustainable RTAs 58
- environmental management 1, 20, 68, 176, 194, 225, 243
- Environmental Management System (EMS) ISO 14001 27
- Environmental Occupational Health and Safety Assessment in Canada 63

- Environmental Protection for Heavy Weapons Ranges (EPHW) 47
- environmental releases 200, 204, 227, 231, 237, 249
- environmental safety and occupational health (ESOH)
- acquisition 233–234
 - conception 228–232
 - cost and time 208–210
 - current and evolving regulatory interests 207
 - data requirements 201–207
 - decision-making 238
 - demilitarization 235
 - disposal 237
 - ecotoxicity 237
 - engineering and
 - manufacturing 234–235
 - evolving science and new tools 203
 - fate and transport 235–237
 - field monitoring 237
 - industrial hygiene 237–238
 - integration of flow charts 204
 - life cycle environmental
 - assessment 200
 - material synthesis 231
 - M116, 117, 118 simulators 207–208
 - munition compounds and aetiology of 199–200
 - M-18 violet smoke 208
 - phased approach 201–203
 - Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) 238
 - reproduction/developmental effects 204–206
 - research and acquisition 200–201
 - research vs. testing 203–204
 - testing/demonstration 232–233
 - toxicology data requirement 228
 - Toxic Substances Control Act 238
- Environmental Security Technology Certification Program (ESTCP) 104, 159
- EPA 8330b method 56, 68
- European Chemical Agency (ECHA) 215, 238
- European Conference on Defence and the Environment (ECDE) 48
- explosive footprints 61–64
- explosive hazard 18, 20, 27
- explosive ordnance disposal (EOD) 15, 53, 92, 235
- explosive waste incinerator (EWI) 22, 23, 28
- exposure factor 186, 203
- f**
- fate factor 186
- Finnish Defence Administration 48
- firing positions (FP) 51, 54, 59, 64–66, 68, 75, 78, 79, 91
- fluffy layer of suspended matter (FLSM) 144
- four-power programme 5
- Free From Explosive Hazard 27
- freshwater ecotoxicity 185
- fuze 18, 82, 83, 92, 139
- fuzeheads 117
- g**
- GIM 83–85, 89–91
 - explosive residues 91
- Global Navigation Satellite System (GNSS) 148
- GLOBALNAYA NAVIGATSIONNAYA SPUTNIKOVAYA SISTEMA (GLONASS) 148
- global warming 170, 183, 186, 189
- greener munitions
 - definition 79, 242–243
 - development approach 79–82
 - green plastic explosive 92
 - hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) 77
- IM 60-mm mortar based on PAX-21 77
- M115A2 ground burst projectile simulator 77
- M116A1 hand grenade simulator 77
- M274 2.75" rocket simulator 77
- munitions constituents of
 - concern 77–78
- RIGHTTRAC 82–92
- source of munitions
 - constituents 78–79
- unexploded ordnances (UXO) 75

- green plastic explosive
 - HMX option 95–96
 - PETN option 93–95
 - green procurement 171, 173
 - green pyrotechnic systems 104
 - groundwater plume contamination 49
 - gun propellant 51, 64, 79, 82, 83, 86, 88, 213, 220, 243
 - gun testing 89–90
- h**
- Hawaii Undersea Military Munitions Assessment (HUMMA) 142, 143, 157
 - hazardous wastes 14, 18, 20, 28, 33, 56, 127, 199, 234
 - industrial demilitarisation 19
 - Health and Safety Executive (HSE)
 - Explosives Industry Group 35
 - heavy metals 18, 49, 77, 104, 105, 108, 109, 115, 118–122, 155, 169, 170, 184
 - hexachloroethane (HCE) smoke systems 116
 - 1,3,5-hexahydro-1,3,5-trinitrate (RDX) 199
 - hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) 77, 152
 - 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazaisowurtzitane (CL-20) 80
 - hexavalent chromium compounds 115
 - HK416 76
 - human health and ecosystems 169, 184, 185, 187, 213–215, 218–220, 225
 - human health (CTUh) and ecosystems (CTUe) 186
 - human-occupied vehicles (HOVs) 142
 - human toxicity 186, 187, 189, 192, 193, 220, 224
 - hydrolysis 58, 141, 144, 153, 229, 232
- i**
- IM 60-mm mortar based on PAX-21 77
 - individual disposal/demilitarisation action 13
 - industrial demilitarization 13, 17, 19, 21, 22, 27, 30, 31, 36, 39, 44
 - Industrial Emissions Directive 28
 - industrial hygiene 208, 227, 234, 237–238
 - inertial navigation systems (INS) 148
 - input–output analysis 171
 - insensitive high explosive (IHE) 41, 69, 70
 - insensitive munitions (IM) 6, 70, 77, 82, 169
 - Intergovernmental Panel on Climate Change (IPCC) 185
 - in vitro*–*in vivo* extrapolation (IVIVE) 207
 - ISO 9001 27
 - isocyanates 6, 117
- j**
- just-in time manufacturing 111
- l**
- L320 86–90
 - land management 246–247
 - large munitions 44
 - large-scale explosive waste incinerator 23
 - laser line scanners (LLS) 146
 - lead azide 105, 106
 - lead-free bullets/primers 76
 - lead styphnate (TNR-Pb) 106, 181
 - legislative impact 2–4
 - life cycle analysis 7, 91–92, 199
 - life cycle assessment (LCA)
 - methodology 171–172
 - environmental and toxicological impacts 170
 - four interrelated phases 172
 - functional unit 175–176
 - goal and scope phase 174–178
 - ISO standards 14040 and 14044 172
 - life-cycle impact assessment (LCIA) 182–194
 - life-cycle inventory 178–182
 - life-cycle thinking 170–171
 - limitations of 194
 - purpose of 173–174
 - simplified representation 171
 - life-cycle costing 171
 - life cycle environmental assessment 200
 - life-cycle impact assessment (LCIA)
 - case study 188–194
 - characterization 183

- classification 183
- methods 185–187
- normalization and weighting 183
- software 187–188
- life-cycle inventory (LCI) 172, 178–182
- local exhaust ventilation (LEV) systems 117
- long baseline (LBL) 148
- m**
- magnesium teflon viton (MTV) 116–117
- M115A2 ground burst projectile simulator 77
- M116A1 hand grenade simulator 77
- marine Mk144 illumination signal 122
- material flow analysis 171
- maximum acceptable concentrations (MACH) 58
- metal-based colourant 113
- methyl centralite (MC) 88, 89
- military live-fire training ranges
 - analytical tool and adsorption method for MC in aqueous samples 67–68
 - DRDC Valcartier 48
 - emerging constituents 69–70
 - explosive footprints 61–64
 - firing positions 64–66
 - groundwater plume contamination 49
 - mitigation measures 67–69
 - munition related contaminants 51
 - octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) 48
 - surface soil characterization 52
 - thermal treatment of shoulder rocket propellant contaminated surface and sub-surface soils 68–69
 - unexploded ordnance (UXO) 50
- 105-mm army artillery munition 82
- 105-mm Howitzer gun 89, 90
- 155-mm artillery munition (M777) 87
- mobile demilitarisation plants 40
- modified single-base (MSB) 86–89
- Monitoring of dumped munitions (MODUM) 151, 154
- M274 2.75" rocket simulator 77
- M116, 117, 118 simulators 207–208
- multicriteria analysis 171
- Multiple Launch Rocket Systems (MLRS) 38
- munition constituents (MC) 52, 225
- munition manager's perspective 44–45
- munition-related contaminants 51–52
- munitions, handling of 151–152
- munitions and explosives of concern (MEC) 139
 - acoustic sensors 145–146
 - chemical degradation 152–153
 - corrosion 142–143
 - detection 150–151
 - ecotoxicological aspects 154–156
 - EM sensors 146
 - environmental aspects 141–142
 - fate and transport of constituents 144–145
 - geopolitical aspects 156–158
 - global collaboration 159–160
 - global EU and NATO efforts 160–161
 - handling 151–152
 - human capacities 161–162
 - in situ* methods 141
 - location 150
 - long-term and long-distance transport 153–154
 - monitoring 151
 - navigation and positioning systems 148
 - optical sensors 146
 - platforms 146–147
 - remediation 141–150
 - research infrastructures 161
 - scientific advances 161
 - sea disposal process 145
 - technology innovation 161
- munitions constituents (MCs) 47
 - of concern 77–78
 - RTA 58–61
 - source of 78–79
- munitions, disassembly of 13, 27
- Munitions Safety Information and Analysis Centre (MSIAC) 45
- M-18 violet smoke 208

n

NAMMO Buck 29, 30
 NAMMO NAD 29
 national legislation and public acceptance 15
 NATO AOP 4518 40–44
 NATO Applied Vehicle Technology (AVT) 48
 NATO AVT 115 4
 NATO AVT 177 4
 NATO AVT 179 4
 NATO AVT 197 4
 NATO AVT 269 4
 NATO AVT-249 task group 48
 NATO Collaboration Support Office tasked AVT-197 48
 NATO Cooperative Demonstration of Technology (CDT) 48
 NATO Industrial Advisory Group (NIAG) 21
 NATO RTO AVT-177 symposium 63
 NATO Support Agency 8
 NATO Support and Procurement Agency (NSPA) 16, 247
 navigation and positioning systems 148
 neurotoxin 6
N-guanylurea-dinitramide (FOX-12) 80
 nitramines 51, 80, 95, 231
 nitrate esters 7, 51, 231
 nitroaromatics 81, 153, 231
 nitroaromatic-trinitrotoluene (TNT) 2, 4, 6, 80, 152
 nitroglycerin (NG) 51, 59, 69, 97, 231
 nitroguanidine (NQ) 51, 59, 86
 nitrotriazalone (NTO) 69, 80
 North American RTAs 49, 51, 82
 Norwegian Armed Forces 76
 Norwegian servicemen 6

o

obscure smokes 124
 octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) 48, 59, 80, 95, 152
 octanol/water partition coefficients (K_{ow}) 58, 209
 octol (TNT/HMX) 51

OHSAS 18001 27
 old red lead/silicon primer 115
 One health approach 199–210
 on-site disruption and disposal 8
 open burning (OB) 4, 22, 25, 29–33, 66, 78, 128, 170, 235, 249
 vs. EWI incineration of SAA 39
 open detonation (OD) 4, 13, 22, 25, 29–31, 33–36, 52, 170, 176
 optical sensors 145, 146
 ordnance disposal site 247
 Organization for Security and Cooperation in Europe (OSCE) 23
 oxydiethane-2,1-diyl dibenzoate 220, 224
 ozone depletion 183, 184

p

pentaerythritol trinitrate (PETN) 80
 option 93
 perchlorates 7, 49, 51, 59, 77, 78, 97, 104, 108, 109, 112, 120, 199
 chlorate 116, 122–124
 periodates 120, 123
 persistent, bioaccumulative, or toxic (PBT) 216
 phosphorus (V) nitride (P3N5) 118
 physical destruction techniques 20
 plastic-bonded explosives (PBX) 41
 plume dispersion 33, 34
 plume formation 33, 34
 polychlorinated biphenyls 123
 post-detonation residues 62, 77, 91, 93
 Prevention of Marine Pollution by Dumping of Wastes 139
 Programmatic Environmental Safety and Health Evaluation (PESHE) 200
 propellant production 192, 220
 propellant residues 54, 59, 60, 65, 66, 68, 79, 236
 propellant's environmental hazard assessment 1
 propelling charge system 66
 pyrotechnics 5, 227
 civilian pyrotechnic systems 107
 'clean-up' strategy 105
 compositions 103, 104
 disposal and waste burning 126–127

- environmental effect 103, 104
 environmental legislation 127, 129
 green pyrotechnic systems 104
 heavy metal 115, 118–122
 integration 129–133
 list of ingredients 104
 magnesium teflon viton (MTV)
 countermeasures 116–117, 127
 obscurant smokes 124
 packaging waste 118
 perchlorate and chlorate 116,
 122–124
 perchlorate levels 104
 production 109–110
 pyrotechnic devices 112
 qualification 107
 raw materials acquisition and quality
 control 112–114
 Registration, Evaluation, Authorisation
 and Restriction of Chemicals
 (REACH) 105–106
 resins, binders and solvents 117
 and simulators 32
 site location 110–112
 smokes 116
 specific materials
 production 114–115
 storage 117–118
 suitably qualified and experienced
 person (SQEP) issues 128–129
 usage and disposal 118
 volatilization smokes 116, 124–125
- q**
 quality assurance/quality control (QA/
 QC) 57, 231
 quantitative structural activity relationship
 (QSAR) models 230
 quantitative structural property
 relationship (QSPR) 230
- r**
 range and training areas (RTA)
 characterization 47
 R440 dim illuminant 122
 RDX 6, 49, 51, 52, 58–60, 63, 68, 77, 79,
 80, 82, 83, 85, 92–97, 149,
 152–156, 182, 199, 213, 231
 RDX/TNT 36, 37
 reactive injection moulding 249, 250
 Registration, Evaluation, Authorisation
 and Restriction of Chemicals
 (REACH) 2, 105, 238
 European defence capabilities 213
 overview of 214–215
 regulation 793/93 214
 regulatory thresholds 218
 remotely operated vehicles (ROVs) 142
 removal from storage 17–18
 residual material disposition 20
 resins 114, 117
 resonant acoustic mixing technology 249
 reuse, recovery and recycling (R3)
 methods 18, 26, 41
 Revolutionary Insensitive, Green and
 Healthier Training Technology
 with Reduced Adverse
 Contamination (RIGHTTRAC)
 cost-efficiency analysis (CEA) 83, 91
 fate, transport and toxicity 88–89
 field demonstration 89
 IM properties 83–84, 87–88
 main explosive charge 83
 105-mm army artillery munition 82
 performance 83
 propellant charge 86
 rising gas 143
 rocket motors 18, 26, 29, 32, 33, 45, 243
- s**
 Safe Drinking Water Act 97
 safety data sheet (SDS) 106
 sea disposal 139, 140, 145, 146
 sea disposal process 145
 sea-disposed munitions 140, 143, 161
 sea-dumped munitions 4, 160, 245
 sea dumping 13, 159, 176, 241
 SENTINEL project 107
 settling sediments 143
 short baseline (SBL) 148
 shoulder rocket propellant contaminated
 surface and sub-surface
 soils 68–69
 SimaPro 187, 188
 single-base propellant 51, 86, 87
 size reduction/removal 18
 small arms ammunition (SAA) 15, 28,
 29, 32, 33, 39, 40

- small arms ammunition destruction oven (SAADO) 33
- small arms propellant residues 65
- small-scale incinerator and products 22
- smokeless propellant 5
- snow sample filtration 62
- soil sorption constants (K_d) 58
- solvents 32, 56, 105, 116, 117, 125, 243
- space agencies 1
- SS Richard Montgomery 158, 245
- steel/lead projectile 188–193
- Strategic Environmental Research and Development Program (SERDP) 47, 77, 104, 159, 210, 239, 243
- stypnate 105, 106, 152
- substances of very high concern (SVHC) 105, 213, 214, 216
- substantial residues 170
- suitably qualified and experienced person (SQEP) issues 128–129
- surface soil characterization
 - cleaning 57–58
 - data quality and sampling objectives 53–55
 - risk to the receptors through the transport of munitions constituents 58–61
 - safety aspects 53
 - soil samples 56–57
- surface soil sampling pattern 55
- surface to near-surface UXOs 64
- surface vessels 146–148
- system boundaries 172, 175–178
- t**
- Technology Demonstration Program (TDP) 77
- terrestrial toxicity 80, 85, 88
- thermal treatment 32, 68–69, 170
- toxicological life-cycle impacts 189
- Toxic Substances Control Act 238
- trichloroethane (TCE) 105
- 1,3,5-trinitrobenzene (TNB) 58, 154–156, 231
- 2,4,6-trinitrotoluene (TNT) 6, 51, 59, 77, 80, 152, 156, 176, 200, 231
- twin screw extrusion 249
- u**
- ultrashort baseline (USBL) 148
- unexploded ordnance (UXO) 35, 50, 75, 92, 139, 170
- United Nations Environment Programme/Society of Environmental Toxicology and Chemistry (UNEP/SETAC) 185
- unplanned disposal 8, 247
- unmanned surface vehicles (USVs) 147
- unmanned vehicles 146
- unused/surplus munitions 247
- USA peer-reviewed funding program 47
- U.S. Army Corps of Engineers 6
- U.S. Army Environmental Quality Technology Program 208
- U.S. Army's Green Ammunition Program 76
- US Environmental Protection Agency 2, 49, 78, 104, 201, 238
- U.S. EPA Contaminant Candidate List 3 (USEPA web site) 97
- U.S. EPA Interim Lifetime Drinking Water Health Advisory 78
- USEtox method 185–189, 193, 194, 218–220, 224
- U.S. Massachusetts Military Reservation (MMR) 49, 76
- US Strategic Environmental Research and Development Program (SERDP) 47, 77, 104, 159, 243
- v**
- volatilization smokes 116, 124–125
- w**
- Wallop Defence Systems site 117
- waste disposal 19, 20, 110, 126
- waste management 110–112, 116, 126, 176
- watercraft 147
- water solubility of energetic materials 81
- 'whistle, bang, flash' simulators 207–208