# Contents

Preface xi

## 1 Waste Minimization and Clean Technology: Waste Management Strategies for the Future 1

JOHN H. SKINNER, PhD

- Introduction 1
- Changing Waste Management Challenges 2
- Waste Must Be Reduced at the Source 4
- All Elements of Society Must Participate 5
- Waste Minimization through Industrial Process Modifications 6
- Innovations in Products and Technologies 7
- Conclusion 8
- References 9

## 2 Concepts for Developing and Implementing Low-Waste Technologies: Government Approaches 11

HANS SUTTER, PhD

- Introduction 11
- End-of-Pipe Technologies 11
- Low-Waste Technologies 13
- Economic Aspects 15
- Reduction Potential 17
- Implementing Low-Waste Technology 18
- Reference 19
3  Furthering Clean Technology: The Role of Decentralized Authorities 21
I. LARSEN and KIM O. OLSEN

A Cleaner Technology Strategy 21
Legislation Concerning National Authorities 23
Role of the Decentralized Authorities 24
General Measures Under the Copenhagen Strategy 25
Administrative Decisions 28
Industrial Waste Production 29
Production Processes and Operational Patterns 32
Conclusion 35
References 35

4  Waste Minimization in The People’s Republic of China 37
BO-XING CHENG

Introduction 37
Management and Control Strategy for Solid Waste 38
Hazardous Waste Utilization 41
Municipal Waste Reuse and Recycling 42
Ecological Agriculture and Circulation Technology 43
Research and Education 43
Model Engineering Projects 44
International Co-operation 44
References 45

5  Clean Technologies: The Cuban Experience 47
ROBERTO ACOSTA MORENO, PhD

Low- and Nonwaste Technologies 47
The Cuban Experience 51
Conclusions 54
References 55
6 Policies and Methods for Promoting Clean Technologies in French Industry 57
JEAN-CLAUDE NOEL

Introduction 57
Clean Technologies 58
Clean Technology Objectives 58
The Development of Clean Technologies 60
The Difficulties in Introducing Clean Technologies 62
Conclusion 64

7 Recycling and Clean Technologies: The Challenge for the 21st Century 65
FRANK VAN DEN AKKER, PhD

Introduction 65
The Right Way 66
Research and Development Programs 66
Policy on Environmental Technology 67
Cooperation with Industries within the European Community 69
Commercialization of Know-How and Export Promotion 71
Transfer of Knowledge and Exchange of Information 72
The Challenge for the Next Century 73
References 73

8 The Pollution Prevention Program of the United States Environmental Protection Agency: A New Focus on Pollution Sources 75
JEFFREY D. DENIT

Introduction 75
Promotion within EPA 76
Regulatory Limitations 78
The Pollution Prevention Promise 78
Notable Successes Realized 80
Barriers Still Exist 81
Conclusion 83
9 Cleaner Production Programs at UNEP/IEO
JACQUELINE ALOISI DE LARDEREL

Introduction 85
Objectives and Activities 86
Plans for the Future 90

10 Product Design and Waste Minimization
WALTER R. STAHEL

Introduction 91
The Role of the Industrial Designer 93
The Titanic Syndrome: Safer Product Waste 94
Utilization System Solutions: The Hidden Actors of Progress 94
The Lack of In-Built Flexibility: Elite Technology 95
The Risk of Superintelligent Systems 95
Fault-Tolerant System Design 95
Selling the Product of Utilization Instead of the Product 96
Conclusions 97
References 97

11 The Computer as a Tool for Analyzing Process Modification Alternatives for Waste Minimization in the Electroplating Industry
D. BEARDSLEY

Introduction 99

12 A Systems Approach to Electroplating Waste Minimization at Texas Instruments
DONALD C. ABBOT, MICHAEL E. MITCHELL, and FRANK VEALE

Introduction 101
Product 102
Process 102
<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascade Rinsing</td>
<td>102</td>
</tr>
<tr>
<td>Ion Exchange</td>
<td>103</td>
</tr>
<tr>
<td>Characterization</td>
<td>106</td>
</tr>
<tr>
<td>Recycling</td>
<td>107</td>
</tr>
<tr>
<td>Brine Recycle</td>
<td>108</td>
</tr>
<tr>
<td>Resin Effluent Recycle</td>
<td>108</td>
</tr>
<tr>
<td>Alkaline/Acid Rinse Recycle</td>
<td>108</td>
</tr>
<tr>
<td>Plans for the Future</td>
<td>109</td>
</tr>
<tr>
<td>Summary</td>
<td>109</td>
</tr>
<tr>
<td><strong>13</strong> The Economics of Resource Recycling, Zero-Discharge Waste Management Technologies, and Strategies for Heavy Metal Generating Industries**</td>
<td></td>
</tr>
<tr>
<td>BERNARD FLEET, JAY KASSIRER, TERRENCE BURRELL, and TOBY SANGER</td>
<td></td>
</tr>
<tr>
<td>Introduction and Objectives</td>
<td>112</td>
</tr>
<tr>
<td>Incentives for Hazardous Waste Management</td>
<td>113</td>
</tr>
<tr>
<td>Economics of Waste Management</td>
<td>114</td>
</tr>
<tr>
<td>An Economic Model</td>
<td>116</td>
</tr>
<tr>
<td>Testing of the Model: Case Studies</td>
<td>117</td>
</tr>
<tr>
<td>Conclusions</td>
<td>118</td>
</tr>
<tr>
<td>References</td>
<td>119</td>
</tr>
<tr>
<td><strong>14</strong> Clean and Add-On Technologies in the Italian Leather Industry**</td>
<td></td>
</tr>
<tr>
<td>A. M. CASTAGNOLA, G. R. GUIDOTTI, F. CIARDELLI, and E. TABURONI</td>
<td></td>
</tr>
<tr>
<td>Italian Leather Industry Outlook</td>
<td>123</td>
</tr>
<tr>
<td>Implementation of Low-Waste and Add-on Technologies</td>
<td>125</td>
</tr>
<tr>
<td>Mineral Tanning Options</td>
<td>126</td>
</tr>
<tr>
<td>Tannery Waste Treatment Options</td>
<td>127</td>
</tr>
</tbody>
</table>
## 15 Application of Clean Technology in the Pulp and Paper Industry

S. VIGNESWARAN

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>131</td>
</tr>
<tr>
<td>Methods to Achieve Low-Waste Technology</td>
<td>133</td>
</tr>
<tr>
<td>Process Chemicals and Raw Materials Recycling</td>
<td>133</td>
</tr>
<tr>
<td>Application in Pulp and Paper Industry</td>
<td>134</td>
</tr>
<tr>
<td>Water Reuse and Recycling</td>
<td>136</td>
</tr>
<tr>
<td>By-Product Recovery</td>
<td>139</td>
</tr>
<tr>
<td>Pollution Reduction by Process Chemicals Change</td>
<td>140</td>
</tr>
<tr>
<td>References</td>
<td>142</td>
</tr>
</tbody>
</table>

## 16 Establishing and Implementing Waste Minimization Programs in the Chemical and Oil Industries

G. J. HOLLOD, PhD

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>145</td>
</tr>
<tr>
<td>Getting Started</td>
<td>146</td>
</tr>
<tr>
<td>Barriers</td>
<td>148</td>
</tr>
<tr>
<td>Essential Components</td>
<td>149</td>
</tr>
<tr>
<td>Defining the Target</td>
<td>150</td>
</tr>
<tr>
<td>Tracking</td>
<td>151</td>
</tr>
<tr>
<td>Action Plan</td>
<td>152</td>
</tr>
</tbody>
</table>

## 17 Minimization of Industrial Oil Wastes

ROBERT A. COLONNA, PE, MARY SAVAGE, and FRANCO E. GODOY

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>155</td>
</tr>
<tr>
<td>Types and Characteristics of Waste Oils</td>
<td>156</td>
</tr>
<tr>
<td>Waste Minimization Techniques</td>
<td>156</td>
</tr>
<tr>
<td>Fuel Blending</td>
<td>162</td>
</tr>
<tr>
<td>Waste Minimization Examples</td>
<td>163</td>
</tr>
</tbody>
</table>
## CONTENTS

### 18 The Clean Technology Problem in Waste Oil Treatment

JEAN-BERNARD LEROY

- Introduction: 165
- Waste Oil Categories: 166
- Quantities Differ Worldwide: 166
- Available Treatment Techniques: 167
- Pyralene Contamination: 168
- Regeneration Required: 169
- Preliminary Treatment: 169
- Evaporation-Incineration: 171

### 19 Releases of Solvents from Chemical Processes in the Pharmaceutical Industry

J. P. M. ROS, PhD and P. VAN DER POEL, IngD

- Introduction: 173
- Sources of Environmental Releases and Prevention: 174
- Biological Wastewater Treatment: 177
- Extended Pollution Control: 178
- References: 179

### 20 Waste Minimization Possibilities in the Tanning Industry

C. COLLIVIGNARELLI

- Introduction: 181
- Chromium Recovery from the Tanning Bath: 182
- Energy and Fertilizer Recoveries: 183
- Other Recoveries from Tanning Wastes: 184
- Sodium Sulfide Recovery from Lime-Pit Bath: 185
- Pilot Plant Experimentation: 185
- Technical Feasibility: 187
- References: 190
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Author</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>The Role of Environmental Engineers in Waste Minimization</td>
<td>THOMAS T. SHEN, PhD, PE</td>
<td>191-201</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td></td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>Definition</td>
<td></td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td></td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Professional Development</td>
<td></td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>Computer Application</td>
<td></td>
<td>199</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td></td>
<td>201</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td></td>
<td>201</td>
</tr>
<tr>
<td>22</td>
<td>Employee Incentives for Waste Minimization</td>
<td>SUSAN J. BURNS</td>
<td>203-211</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td></td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>Barriers to Waste Minimization</td>
<td></td>
<td>204</td>
</tr>
<tr>
<td></td>
<td>Elements of Successful Waste Minimization Programs</td>
<td></td>
<td>204</td>
</tr>
<tr>
<td></td>
<td>Examples</td>
<td></td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td></td>
<td>211</td>
</tr>
<tr>
<td></td>
<td>Reference</td>
<td></td>
<td>211</td>
</tr>
<tr>
<td>23</td>
<td>Waste Minimization in the Field of Household Hazardous Wastes</td>
<td>GERHARD VOGEL, PhD</td>
<td>213-222</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td></td>
<td>213</td>
</tr>
<tr>
<td></td>
<td>Measures of Waste Minimization and Avoidance</td>
<td></td>
<td>214</td>
</tr>
<tr>
<td></td>
<td>Strategies For Minimization</td>
<td></td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>Pollution Control in Treatment Facilities</td>
<td></td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Collection Systems</td>
<td></td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Composition of Separately Collected Household Hazardous Wastes</td>
<td></td>
<td>221</td>
</tr>
<tr>
<td></td>
<td>Outlook</td>
<td></td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td></td>
<td>222</td>
</tr>
<tr>
<td>24</td>
<td>A Good Beginning</td>
<td>ALBERT J. FRITSCH, PhD</td>
<td>225</td>
</tr>
</tbody>
</table>