Industrial Waste Treatment

Contemporary Practice and Vision for the Future

By

Nelson Leonard Nemerow
Industrial Waste Treatment

Editor

Nelson Leonard Nemerow
BRIAN (GRANDSON, UNIVERSITY OF CALIFORNIA, ENVIRONMENTAL STUDENT)

GLEN (SON, SCRIPPS RESEARCH INSTITUTE SCIENTIST)

NELSON (FATHER, PHD, ELSEVIER ENVIRONMENTAL BOOK AUTHOR)
## Contents

11. Hazardous Wastes 245

12. Removal of Industrial Air Contaminants 355

### Part B—Twenty-First Century 361

- Foreword to the Twenty-First Century i
- Preface to the Twenty-First Century iii

13. Prologue to the Twenty-First Century 363

14. Rationale of Environmentally Balanced Industrial Complexes 369

15. Procedure for Industry in Attaining Zero Pollution 373

16. Economic Justification for Industrial Complexes 379

17. Realistic Industrial Complexes 405

18. Potential Industrial Complexes 443

19. Potential Municipal–Industrial Complexes 515

20. Naturally Evolving Industrial Complexes 527


22. Summary 545

Index 549
In 1963, one year after Rachel Carson published her last book, *Silent Spring*, which warned of the interdependence of industrial waste pollution and human development, I published my first textbook on the subject of industrial waste treatment, *Theories and Practices of Industrial Waste Treatment*. Most of my current readers were not actively participating in this field at that time. Therefore, I feel impelled to republish—in modified and somewhat updated form—the considerable amount of historical theories and practices of twentieth-century industrial waste treatment. It is remarkable how much of this technical information has remained the same since the publishing of that original book, but it is difficult to locate a book from that long ago. I followed that book with updated books on the subject—*Liquid Wastes of Industry* in 1971, *Industrial Water Pollution* in 1978, *Industrial and Hazardous Waste Treatment* with Dr. Dasgupta in 1991, *Zero Pollution* in 1995, and *Strategies of Industrial and Hazardous Waste Management* with Dr. Agardy in 1998. But they too (except for the last two) would be hard to locate in most libraries. In fact, many of the publishers themselves have changed or gone completely out of the business. For an updated and excellent version of current conventional industrial waste treatment equipment and practices (including costs), I urge you to consult another Elsevier text, *Industrial Waste Treatment Handbook*. It was prepared by the collective effort of the firm Woodard and Curran of Portland, Maine. Many of the figures in this book are replicated from the above titles with permission from John Wiley and Sons.

I have made a special effort in this book to reference publications that are still in print and available for purchase. In that way readers may opt to select works that serve their specific interests.

I intend for this book to be an overview of the subject of industrial waste treatment and disposal as used in the twentieth century and how it is evolving into a new conceptual field as we enter the twenty-first century. Further, I have attempted to provide some historical data of people and concepts of industrial waste treatment for generations to come to look back on for a more complete understanding of its significance in industrial production and how we naturally evolved the solutions to which we must resort in the twenty-first century.

It is critical to note that this book not only recounts the past theories and practices, but even more importantly, confronts the present dilemma with innovative solutions to industrial wastes for the future.

Nelson Leonard Nemerow
List of Tables

1  Primary Personnel and Fields of Study in U.S. Universities  7
1.1  Typical Analyses of Sewage Effluents After Conventional Primary and Secondary Treatment  19
1.2  Composition of Secondary Treated Municipal Wastewater Effluents and Irrigation Water  20
2.1  Wastes from a Textile Mill  28
3.1  Cost Comparison of Various Alkaline Agents$^a$  38
5.1  Rectangular Primary Settling-Tank Data  60
5.2  Circular Primary Tanks: Long-Term Performance Data$^a$  62
5.3  Typical Efficiencies of Dissolved-Gas Flotation Treatment of Wastes  69
6.1  Types and Characteristics of Colloidal Solids  80
6.2  Valence and Coagulant Dosage  84
6.3  Properties of Coal-Derived Granular Carbon for Waste Treatment  86
7.1  Typical Overall Coefficients in Evaporators  91
7.2  Elemental Composition of Green Algae  95
7.3  Occurrence of Cyanophyceae and Chlorophyceae in Massachusetts Lakes and Reservoirs  96
7.4  Refractory Containment Removal Techniques  100
8.1  Biological Degradation of Organic Constituents in Sewage  107
8.2  Materials Potentially Useful for Liners of Ponds Containing Hazardous Wastes  110
8.3  Summary of Disposal Systems  118
8.4  Summary of Disposal Systems  129
10.1  Industrial Contaminants and General Limiting Values for Discharge into Municipal Sewerage Systems$^a$  187
10.2  Sewer Use Ordinance City of Palo Alto Regional Water Quality Control Plant (September 1995)  191
10.3  Maximum Allowable Discharge Limits for Wastewater  192
10.4  Allocation of Fixed Costs  194
10.5 Allocation of Operation and Maintenance Costs 195
10.6 Summary of Allocation of Fixed and Operating Cost 196
10.7 Calculation of Users’ Charges Based on Three Factors 198
10.8 Cayadutta Creek Analyses in October 1964 201
10.9 Time of Flows from Station 5 Downstream Obtained 1 Week Before Stream-Sampling Program in October 1964 203
10.10 Summary of 7-Day Sampling of Cayadutta Creek in Dry Period, from 10/8/64 to 10/18/64 203
10.11 Minimum Flow Data of Measured Creek Compared with Cayadutta Creek 205
10.12 Normal Probability Distribution Analysis of Data (1927–1960) 206
10.13 Summary of Data Required from Cayadutta Creek Analyses in October 1964 for Churchill Method of Analysis 207
10.14 Churchill Analysis Applied to Cayadutta Creek Data 208
10.15 Summary of 24-Hour Sampling Results 209
10.16 Summary of 24-Hour Sampling Results 215
10.17 Composite Analysis (24 Hours) of Gloversville and Johnstown Wastewater 216
10.18 Summary of Total Loads for Treatment 218
10.19 Industrial Production During Sampling Days 220
10.20 Water Consumption Related to Production Percentage\(^a\) 222
10.21 Industrial Waste Flow 224
10.22 Sludge Digestion (Laboratory Study)\(^a\) 225
10.23 Activated-Sludge Pilot Laboratory Studies 226
10.24 Prototype Operating Data 230
10.25 Prototype Operating Results and Design Parameters 231
10.26 Inconsistencies Between Theory of Design and Actual Practice in Design 242
11.1 Cost of Hazardous Waste Disposal Practices 250
11.2 Hazardous Waste Industries 251
11.3 List of Hazardous Characteristics 252
11.4 RCRA-Regulated Hazardous Wastes 254
11.5 Typical Automotive Oil Waste Composition 255
11.6 Sources of Asbestos Wastes 269
11.7 Hazardous Waste Disposal in United States, circa 1980 275
11.8 Organic Chemical Treatment 276
11.9 Commercial Hazardous Waste Disposal Methods 276
11.10 Emerging Alternative Technologies, circa 1985 278
11.11 Incineration 285
11.12 Typical Industrial Laundry Wastewater Constituent Concentration 304
11.13 Some New Treatments for Hazardous Waste, Many Still on the Drawing Board 318
11.14 Water Quality Limits for Toxic Pollutants for Three Uses 328
11.15 Allowable Concentrations for Air Contaminants Resulting from Hazardous Waste Treatment, Storage, and Disposal Emissions (EPA) 334