

How to Remove Pollutants and Toxic Materials from Air and Water

A Practical Guide

How to Remove Pollutants and Toxic Materials from Air and Water

A Practical Guide

Marshall Sittig

NOYES DATA CORPORATION

Park Ridge, New Jersey, U.S.A.

1977

Copyright © 1977 by Marshall Sittig

No part of this book may be reproduced in any form
without permission in writing from the Publisher.

Library of Congress Catalog Card Number: 77-71309

ISBN: 0-8155-0654-6

Printed in the United States

Published in the United States of America by

Noyes Data Corporation

Noyes Building, Park Ridge, New Jersey 07656

FOREWORD

This, the thirty-second volume in our Pollution Technology Review series is a practical book dealing with the removal of pollutants and toxic materials from air and water. Subject entries are arranged in alphabetic sequence. Because of the encyclopedic nature of the book it should prove to be very valuable to all those concerned with the problems of pollution abatement and engineering.

As explained in the introduction, this book is based almost exclusively on U.S. patents with coverage extending to a very late date. Because it supplies technical information in detail, it can also be used as a guide to the U.S. patent literature in this field. By indicating all the information that is significant, and eliminating legal jargon and juristic phraseology, this book presents an advanced, technically oriented review of modern pollutant removal practices as depicted in U.S. patents.

The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical, commercial, timely process information assembled here than is available from any other source. The technical information obtained from a patent is extremely reliable and comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure."

The patent literature covers a substantial amount of information not available in the journal literature. The patent literature is a prime source of basic commercially useful information. This information is overlooked by those who rely primarily on the periodical journal literature. It is realized that there is a lag between a patent application on a new process development and the granting of a patent, but it is felt that this may roughly parallel or even anticipate the lag in putting that development into commercial practice.

Many of these patents are being utilized commercially. Whether used or not, they offer opportunities for technological transfer. Also, a major purpose of this book is to describe the number of technical possibilities available, which may open up profitable areas of research and development. The information contained in this book will allow you to establish a sound background before launching into research in this field.

Advanced composition and production methods developed by Noyes Data are employed to bring our new durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

15 Reasons Why the U.S. Patent Office Literature Is Important to You —

1. The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical commercial process information assembled here than is available from any other source.
2. The technical information obtained from the patent literature is extremely comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure."
3. The patent literature is a prime source of basic commercially utilizable information. This information is overlooked by those who rely primarily on the periodical journal literature.
4. An important feature of the patent literature is that it can serve to avoid duplication of research and development.
5. Patents, unlike periodical literature, are bound by definition to contain new information, data and ideas.
6. It can serve as a source of new ideas in a different but related field, and may be outside the patent protection offered the original invention.
7. Since claims are narrowly defined, much valuable information is included that may be outside the legal protection afforded by the claims.
8. Patents discuss the difficulties associated with previous research, development or production techniques, and offer a specific method of overcoming problems. This gives clues to current process information that has not been published in periodicals or books.
9. Can aid in process design by providing a selection of alternate techniques. A powerful research and engineering tool.
10. Obtain licenses — many U.S. chemical patents have not been developed commercially.
11. Patents provide an excellent starting point for the next investigator.
12. Frequently, innovations derived from research are first disclosed in the patent literature, prior to coverage in the periodical literature.
13. Patents offer a most valuable method of keeping abreast of latest technologies, serving an individual's own "current awareness" program.
14. Copies of U.S. patents are easily obtained from the U.S. Patent Office at 50¢ a copy.
15. It is a creative source of ideas for those with imagination.

TABLE OF CONTENTS

Introduction	1
Acetone Cyanohydrin	3
Acid Mine Waters	3
Acrolein Process Effluents	3
Acrylic Resin Process Emissions	4
Acrylonitrile Process Effluents	6
Adipic Acid Process Effluents	11
Aldehydes	13
Alkalis	14
Alkali Cyanides	15
Alkyl Iodides	15
Alkylation Process Effluents	18
Aluminum	18
Aluminum Cell Effluents	21
Aluminum Chloride	31
Aluminum Chloride Production Effluents	31
Aluminum Etching Liquors	31
Aluminum Refining Effluents	32
Amines	35
Ammonia	35
Ammonia-Soda Plant Effluents	38
Ammonia Synthesis Process Effluents	39
Ammonium Phosphate Plant Effluents	41
Ammonium Sulfate	42
Ammonium Sulfide	42
Ammonium Sulfite	43
Antifouling Ship Paint Residues	43
Asbestos	45
Asphalt Vapors	45
Automotive Exhaust Gases	46
Battery Charging Effluents	48
Bayer Alumina Process Effluents	49

Blast Furnace Effluents.....	50
Blast Furnace Slag Quenching Effluents	52
Boron	52
Boron Trifluoride	53
Brewery Effluents.....	54
Cadmium.....	56
Calcium Oxide.....	56
Carbon Black Process Effluents.....	56
Carbon Electrode Manufacturing Effluents.....	59
Carwash Effluents.....	63
Catalytic Cracking Process Effluents.....	68
Caustic-Chlorine Process Effluents	70
Cellulose Fibers.....	70
Cement Kiln Dusts	70
Chlorinated Hydrocarbons	72
Chlorinated Phenols	73
Chlorination Process Effluents	74
Chlorine	74
Chloroisocyanuric Acid Process Effluents.....	76
Chloromethyl Ethers.....	77
Chloroprene Manufacturing Effluents.....	78
Chromium.....	79
Coal Gasification Process Effluents.....	82
Coal Handling Effluents	91
Coal Mining Effluents.....	95
Coffee Roasting Effluents.....	97
Coke Oven Emissions	97
Colored Materials	107
Concrete Batching Effluents	107
Container Industry Effluents.....	108
Cooling Tower Blowdown Effluents.....	112
Copper	115
Corn Milling Effluents.....	120
Cupola Furnace Emissions.....	124
Cyanides	126
Cyanohydrins	131
Cyanuric Acid.....	131
Cyclohexane Oxidation Wastes	133
Dairy Effluents	134
Degreasing Process Wastes	135
Detergents.....	138
Diisopropyl Amine	139
Dimethyl Sulfate.....	139
Dithiocarbamates	139
Dry Cleaning Plant Wastes.....	140
Drying Oven Effluents.....	142
Duplicating Machine Effluents	143
Dyestuff Wastes.....	144
Electric Arc Melting Furnace Effluents.....	151
Electroplating Wastes	151
Emulsifiers	152

Table of Contents

ix

Epoxide Resin Manufacturing Effluents	152
Ethyl Chloride Manufacturing Effluents	152
Ethylenediaminetetraacetic Acid (EDTA)	152
Fats and Fatty Oils	154
Feedlot Industry Wastes	157
Fertilizer Manufacturing Effluents	158
Fiberglass Production Effluents	161
Fireflood Operation Effluents	168
Flexographic Printing Process Effluents	171
Fluoborates	172
Fluorine Compounds	174
Fly Ash	178
Forest Industry Wastes	181
Formaldehyde	182
Foundry Casting Operation Effluents	182
Fruit Processing Wastes	185
Furfural	187
Galvanizing Process Effluents	188
Gas Turbine Engine Effluent	189
Gasoline Service Station Effluents	190
Glass Production Effluents	195
Glass Treatment Effluents	208
Glycolic Acid	214
Grain Dryer Effluents	214
Grease	218
Heat Treating Furnace Effluents	220
Hydrazine	220
Hydrocarbons	221
Hydrogen Chloride	228
Hydrogen Cyanide	230
Hydrogen Fluoride	235
Hydrogen Sulfide	236
Iodine	244
Iron and Steel Pickle Liquors	245
Iron Cyanides	257
Iron Oxides	263
Irrigation Pumping Engine Effluents	265
Ketones	268
Kraft Paper Mill Effluents	268
Lacquer Spray Effluents	279
Latex	279
Laundry Wastes	279
Lead	280
Lead Alkyls	280
Leather Processing Effluents	280
Lignin Sulfonic Acids	284
Lime Kiln Effluents	285
Limonene	288
Linoleum Manufacturing Effluents	288
Lithographic Printing Process Effluents	291

Table of Contents

Machine Tool Operation Effluents	295
Maleic Anhydride Process Effluents	302
Malic Acid	303
Meat Processing Wastes	304
Mechanical Inspection Penetrant Process Effluents	307
Melamine Process Effluents	309
Mercaptans	309
Mercury	312
Metal Arc- and Flame-Cutting Effluents	319
Metal Carbonyls	320
Metal Finishing Effluents	321
Methanol	321
Methionine Process Effluents	321
Mineral Wool Industry Effluents	324
Mining Effluents	325
Molybdenum	327
Naphthoquinone	328
Natural Gas Processing Effluents	329
Neoprene Production Process Effluents	329
Nickel	330
Nickel Smelter Effluents	330
Nitration Process Effluents	333
Nitric Acid	334
Nitric Acid Plant Tail Gases	334
Nitrating Process Effluents	337
Nitriles	339
Nitrites	340
Nitro Compounds	340
Nitroanilines	340
Nitrocellulose Process Wastes	341
Nitrogen Oxides	342
Noise	346
Nonhalogenated Solvent Wastes	346
Nuclear Industry Effluents	348
Odorous Compounds	353
Oil	356
Oil Spills	359
Olive Processing Effluents	365
Organic Chemical Wastes	368
Organic Vapors	372
Organotin Compounds	372
Oxo Process Effluents	372
Oxydehydrogenation Process Effluents	375
Packinghouse Effluents	379
Paint Manufacturing Effluents	380
Paint Spray Booth Effluents	385
Paint Wastes	386
Paper Box Plant Effluents	389
Papermill White Water	390
Partial Oxidation Process Effluents	392
Particulates	392

Table of Contents

xi

Pentachlorophenol	398
Perchlorates	400
Pesticide Manufacturing Effluents	400
Pesticide Residues	406
Petroleum Production Effluents	406
Petroleum Refinery Effluents	407
Petroleum Storage Effluents	414
Pharmaceutical Industry Effluents	418
Phenol Manufacturing Effluents	426
Phenolic Resin Process Emissions	426
Phenols	430
Phenylene Diamine	433
Phosgene	433
Phosphates	434
Phosphoric Acid Process Effluents	436
Phosphorus	441
Photographic Processing Effluents	445
Photoresist Process Effluents	447
Phthalic Anhydride Process Effluents	451
Phthalic Ester Manufacturing Effluents	451
Pickle Liquors	454
Pigment Manufacturing Effluents	454
Plastic Film Manufacture Emissions	454
Plutonium	456
Polychlorinated Biphenyls (PCBs)	456
Polyester Manufacturing Effluents	457
Printed Circuit Board Manufacture Effluents	459
Propylene Oxide Process Effluents	462
Proteins	463
Pulp Mill Effluents	464
Radioactive Materials	475
Radon	478
Railroad Equipment Servicing Effluents	479
Rare Earth Ions	480
Rendering Plant Effluents	480
Restaurant Effluents	484
Rhenium	485
Rock Drilling Dust	485
Rolling Mill Effluents	486
Roofing Factory Wastes	488
Rubber Chemical Manufacturing Effluents	492
Rug Industry Effluents	492
Salicylaldehyde Production Wastes	493
Scrap Melting Furnace Effluents	493
Seafood Processing Effluents	494
Selenium	497
Selenium Compounds	498
Sewage Treatment Effluents	498
Silicon Tetrafluoride	507
Silicone Polymer Process Effluents	509
Silver	513

Sintering Plant Effluents	513
Smokehouse Effluents	515
SNG (Substitute Natural Gas) Process Effluents	521
Sodium Carbonate	524
Sodium Hydrosulfite Process Wastes	525
Sodium Monoxide	526
Sodium Sulfur Oxide Wastes	526
Solvents	529
Soot	532
Sour Water	532
Spent Sulfuric Acid	534
Spray Booth Effluents	535
Starch Wastes	536
Steam-Electric Industry Effluents	537
Steel Converter Effluents	544
Steel Mill Effluents	552
Strontium	554
Sugar Processing Effluents	555
Sulfides	557
Sulfur	558
Sulfuric Acid	558
Sulfuric Acid Process Effluents	560
Sulfur Oxides	564
Surface Active Agents	568
Surface Coating Effluents	569
Tall Oil Processing Effluents	571
Tar Sand Processing Effluents	574
Tellurium Hexafluoride	575
Terephthalic Acid Process Effluents	575
Tetraalkyllead Combustion Products	578
Tetraalkyllead Manufacturing Effluents	578
Tetrabromomethane	583
Textile Fibers	584
Textile Industry Wastes	586
Thermal Pollution	590
Thiosulfates	592
Tin Compounds	592
Tire Retreading Process Effluents	593
Titanium Compounds	594
TNT Explosive Wastes	595
TNT Process Wastes	596
Trichloroethylene	599
Turpentine	599
TV Tube Manufacturing Effluents	599
Uranium Production Effluents	602
Urea Manufacturing Effluents	603
Vanadium	606
Vegetable Oil Refinery Wastes	606
Vinyl Chloride	607
Viruses	610

Table of Contents

xiii

Waste Wood Processing Effluents	611
Welding Process Effluents	611
Wood Dryer Effluents	612
Wood Preserving Plant Effluents	615
Wool Scouring Effluents	616
Yttrium	619
Zinc	620
Zinc Smelter Effluents	620

INTRODUCTION

This book is designed to provide a one-volume ready reference for the handling of toxic materials and other pollutants emerging into the air and water from industrial processes.

The developments are coming so fast that getting this information between the covers of one book is virtually impossible. Hence the present volume supplements and updates the earlier (1973) *Pollutant Removal Handbook* from this same publisher.

This book is based almost entirely on material from U.S. patents dealing with practical environmental control systems. It surveys some 500 patents in the 1973 to 1976 period with exhaustive coverage up to November 1, 1976. Since environmental patents are given priority handling by the U.S. Patent Office, many of these were applied for in late 1975 and even early 1976.

So in this volume we offer broad coverage of timely, practical information. This book is addressed to:

- the industrialist who wants to and must keep abreast of the latest control techniques
- the environmental protection or public health official
- legislators who are contemplating control measures and their advisory staffs
- the conservationist who is interested in exactly what can be done about the effluents of local factories
- the manufacturer of pollution control equipment

Since, in the interest of combining comprehensiveness with compactness, all literature references cannot be cited here, the reader is referred to the following companion volumes, also published by Noyes Data Corp, for more detail on specific topics.

- Mercury Pollution Control* (1971)
Sulfuric Acid Manufacture and Effluent Control (1971)
Environmental Control in the Organic and Petrochemical Industries (1972)
Environmental Control in the Inorganic Chemical Industry (1972)
Detergents and Pollution (1972)
Fine Dust and Particulates Removal (1972)
Pollution Control in the Nonferrous Metals Industry (1972)
Waste Disposal Control in the Fruit and Vegetable Industry (1973)
Pollution Control in the Textile Industry (1973)
Pollution Control and Chemical Recovery in the Pulp and Paper Industry (1973)
Pollutant Removal Handbook (1973)
Pollution Control in the Petroleum Industry (1973)
Pollution Control in the Metal Finishing Industry (1973)
Pollution Control in Meat, Poultry and Seafood Processing (1974)
Pollution Control in the Dairy Industry (1974)
Pollution Detection and Monitoring Handbook (1974)
Pollution Control in the Organic Chemical Industry (1974)
Oil Spill Prevention and Removal Handbook (1974)
Environmental Sources and Emissions Handbook (1975)
Pollution Control in the Plastics and Rubber Industry (1975)
Pollution Control in the Asbestos, Cement, Glass and Mineral Industries (1975)
Resource Recovery and Recycling Handbook of Industrial Wastes (1975)
How to Dispose of Toxic Substances and Industrial Wastes (1976)

ACETONE CYANOHYDRIN

Removal from Water

A process developed by W. Fries; U.S. Patent 3,984,314; October 5, 1976; assigned to Rohm and Haas Company relates to the purification of industrial effluents containing cyanide ions, and cyanide precursors like acetone-cyano-hydrin. The purification of such effluents is carried out by utilizing a complexing compound followed by treatment with an anion exchange resin and optionally cation exchange resin to remove the cyanide complexes. The cyanide values are recovered from the resin by acid regeneration.

ACID MINE WATERS

See Mining Effluents (U.S. Patent 3,823,081)

See Mining Effluents (U.S. Patent 3,717,073)

See Mining Effluents (U.S. Patent 3,795,609)

See Iron Oxides (U.S. Patent 3,537,966)

ACROLEIN PROCESS EFFLUENTS

The toxicity of alpha,beta-ethylenically unsaturated aldehydes and ketones even in low concentrations to biological treatment systems has been recognized by those skilled in the art. A review article on this problem is presented by V.T. Stack, Jr. in *Industrial and Engineering Chemistry*, Volume 49, No. 5, page 913 (1957). In the manufacture of such compounds, the wastewaters containing these organic substances must be processed at very low concentrations if they are further treated by a biological system. If not, the biomass is in danger of being killed or inhibited to a very low level of activity. This problem is particularly acute in the treatment of wastewaters from the manufacture of acrolein, acrylic acid and acrylic acid esters.

Removal from Water

Although disposal of toxic wastes by injection into a deep well has been used, this is a method of questionable efficiency and is not a long-term solution to the problem. Incineration of toxic wastes is also not economical because such methods are more expensive than biological oxidation and can have adverse environmental consequences. Wastewaters containing alpha,beta-ethylenically unsaturated aldehydes or ketones have been processed in the past by slowly adding the contaminated waters to a waste stream effluent so that the level of toxic component is diluted below that which is detrimental to the biological system. This method suffers from the disadvantage of being slow and inconvenient and

is subject to the danger of at times exceeding the toxic limit of the contaminant, because of metering problems, thereby upsetting the operation of the treatment plant. The required dilution may also involve recycle of previously treated wastewater adding significantly to the hydraulic flow and thus to the cost of the biological treatment plant.

A process developed by *E. R. Lashley, Jr.; U.S. Patent 3,923,648; December 2, 1975; assigned to Union Carbide Corporation* for the disposal of wastewaters containing alpha,beta-ethylenically unsaturated aldehydes or ketones containing 3 to 10 carbons comprises contacting the wastewaters with sufficient base to render the pH of the wastewaters alkaline, maintaining the alkaline wastewaters at a temperature of about 25° to 100°C for at least about 15 minutes and then degrading the wastewater in a biological system containing active biomass.

The method outlined above is particularly preferred for use with wastewaters containing acrolein as the alpha,beta-ethylenically unsaturated aldehyde. It is equally useful for other aldehydes such as methacrylaldehyde, crotonaldehyde, 2,4-hexadienal, 2-ethylcrotonaldehyde, and the like as well as alpha,beta-ethylenically unsaturated ketones such as methyl vinyl ketone, and the like.

ACRYLIC RESIN PROCESS EMISSIONS

Water having organic residues such as acrylics, where the acrylic emulsion constitutes only about 2% or so of the total solution by weight, have been difficult to treat because such a solution does not lend itself to conventional chemical treatment or to conventional drying procedures. There is thus a long felt and extremely urgent need for an efficient and high capacity process for purification of such polluted liquids.

Removal from Water

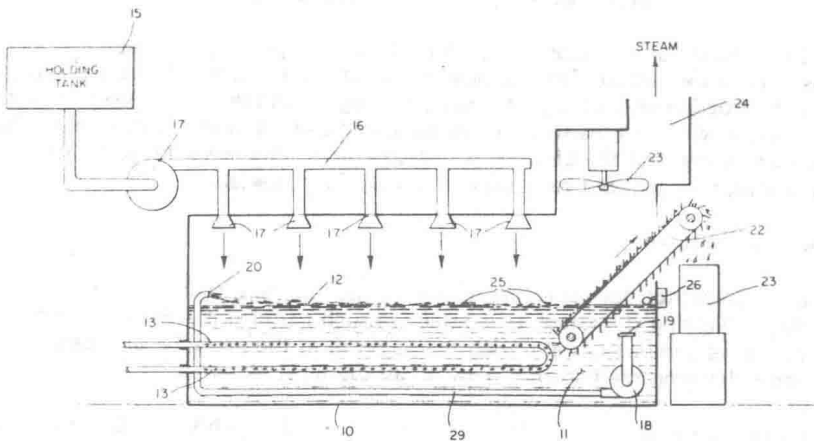
A process developed by *J. Greenberg; U.S. Patent 3,766,087; October 16, 1973; assigned to Anti-Pollution Systems, Inc.* is one in which the polluted water is fed onto the surface of a brine solution maintained at the boiling point, the emulsion being broken instantly at the surface of the brine and accumulated as an organic residue, while the water is boiled off. The organic residue is skimmed off for separate handling.

Such a process is shown in Figure 1. Referring to the drawing, there is shown a container **10** in which is maintained a brine solution **11** having a level **12**. The solution is preferably a concentrated brine solution of water and salt. The process is nonspecific as to the salt, and may be worked with good results with ordinary NaCl, chlorates, nitrates and carbonates. In a preferred example, the brine is a saturated solution of NaCl (39.8% by weight), with some small amount of salt settling at the bottom of container **10**.

A gas fired immersion tube **13** is positioned within container **10** below the brine surface **12**, and provides a source of heating energy to maintain the brine at or just above the boiling level. In the preferred example, the brine solution is maintained at the boiling point, i.e., above 100°C. It is, of course, understood that any suitable means of heating may be employed. The polluted water solution is

fed from a holding tank 15 through a spigot feed 16, having a plurality of spigots 17 from which the polluted solution is entrained or dropped onto the surface 12 of the brine. A pump 17 is used for transporting the solution into the spigot feed. A second pump 18 takes brine collected from an inlet 19 near the surface 12, and pumps it through pipe 29 to an ejecting orifice 20 positioned so that the emitted brine pushes the accumulated organic residue (noted at 25) on the surface 12 from left to right as seen in the drawing.

FIGURE 1: APPARATUS FOR TREATING ACRYLIC RESIN PROCESS WASTEWATERS WITH LOW TEMPERATURE BRINE SOLUTION



Source: U.S. Patent 3,766,087

There is thus, in the figure, a clockwise circulation of the brine, transporting the surface accumulation of organic residue, or scum, toward a conventional skimmer 22 which removes the scum and deposits it into a collection drum 23. This skimming system is exemplary only, and any type of conventional skimming apparatus and/or system may be utilized which has the function of transporting the scum on the surface to a point where it may be skimmed or otherwise removed into a suitable collection instrument.

In operation, the polluted solution is spread from spigot 17 and distributed substantially uniformly onto the surface 12 of the brine. The brine, which is maintained at the boiling point, causes the emulsion to be broken instantly at the surface, such that it accumulates as organic residue. This effect in breaking the emulsion is also known as salting-out. At the same time that the emulsion is being broken, the water is being boiled off, and is drawn by exhaust fan 23 through port 24 where it is passed into the atmosphere in a safe and substantially pure form. The remaining organic residue, or scum, is pushed and/or drawn toward the skimmer and removed into the collection drum. Since there is about a 5% carryout of the salt with the curdled scum, or organic matter, the salt must be periodically replenished. In practice, the pump 18 and skimmer 22 operate continuously, drawing off the unburned residue. The system has been operated successfully at a rate of pressing 400 gal/hr of polluted water having a 2% emul-