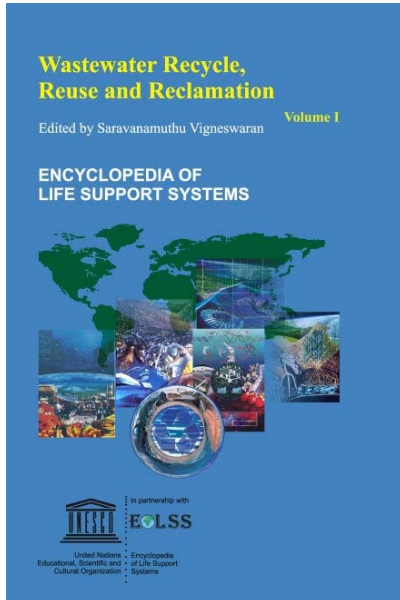


CONTENTS

WASTEWATER RECYCLE, REUSE, AND RECLAMATION



Wastewater Recycle, Reuse, and Reclamation - Volume 1

No. of Pages: 468

ISBN: 978-1-905839-24-7 (eBook)

ISBN: 978-1-84826-924-8 (Print Volume)

Wastewater Recycle, Reuse, and Reclamation - Volume 2

No. of Pages: 296

ISBN: 978-1-905839-25-4 (eBook)

ISBN: 978-1-84826-925-5 (Print Volume)

For more information of e-book and Print Volume(s) order, please [click here](#)

Or [contact : eolssunesco@gmail.com](mailto:eolssunesco@gmail.com)

CONTENTS

Preface

xv

VOLUME I

Wastewater Recycle, Reuse, and Reclamation	1
Saravanamuthu (Vigi) Vigneswaran, <i>University of Technology, Australia</i>	
Marimuthu Sundaravadivel, <i>Macquarie University, Australia</i>	

1. Introduction
2. Wastewater Recycling and Reuse: The Concept
3. Sources of Water Pollution
 - 3.1. Types of Water Pollutants
 - 3.1.1. Pathogens
 - 3.1.2. Oxygen-Demanding Substances
 - 3.1.3. Nutrients
 - 3.1.4. Thermal Pollutants
 - 3.1.5. Non-Toxic Chemicals
 - 3.1.6. Toxic Chemical Compounds
 - 3.1.7. Petroleum Compounds
 - 3.2. Effects of Water Pollution
 - 3.2.1. Bioaccumulation or Biomagnification
 - 3.2.2. Effect on Biodiversity
4. Management of Water Quality
 - 4.1. Preliminary Treatment
 - 4.2. Primary Treatment
 - 4.3. Secondary Treatment
 - 4.3.1. Advanced Secondary Treatment
 - 4.4. Natural Wastewater Treatment Systems
 - 4.4.1. Aquatic or Pond/Lagoon Systems
 - 4.4.2. Terrestrial or Land Application Systems
 - 4.4.3. Constructed Wetland Systems
 - 4.5. Tertiary Treatment
 - 4.6. Advanced Wastewater Treatment Systems
 - 4.7. On-site Treatment Systems
 - 4.8. Treatment of Sludge (or Biosolids)
 - 4.8.1. Disposal Without Treatment
 - 4.8.2. Disposal With Treatment
5. Types of Wastewater Reuse
 - 5.1. Reuse for Irrigation of Crops, Pastures, and Commercial Forests
 - 5.2. Reuse for Development of Habitat Wetlands
 - 5.3. Industrial and Commercial Reuse
 - 5.4. Reuse in Groundwater Systems
 - 5.5. Non-Potable Residential Reuse
 - 5.5.1. Localized Reuse Systems
 - 5.5.2. Dual Reticulation Systems
 - 5.6. Direct and Indirect Potable Reuse
 - 5.7. Sludge Reuse
6. Cleaner Industrial Production Through Recycling and Reuse
 - 6.1. Elements of Cleaner Production
 - 6.2. Recycle and Reuse as Strategies for Cleaner Production
 - 6.3. Role of Waste Audits in Cleaner Production
 - 6.4. Barriers in Adoption of Cleaner Production Policies
7. Water Treatment for Drinking Water Supplies: A Reuse Strategy
 - 7.1. Drinking Water Quality Standards

- 7.2. Conventional Water Treatment Technologies
- 7.3. Treatment Technologies for Rural Water Supply in Developing Countries
 - 7.3.1. Non-Conventional Alternatives
 - 7.3.2. Treatment for Specific Impurities

Recycle and Reuse of Domestic Wastewater

48

Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
 Marimuthu Sundaravadivel, *Macquarie University, Australia*

- 1. Introduction
- 2. History of Wastewater Reuse
- 3. Motivational Factors for Recycling/Reuse
- 4. Quality Issues of Wastewater Reuse/Recycling
 - 4.1. Pathogen Survival
 - 4.2. Other Water Quality Parameters
 - 4.3. Effluent Quality Standards
- 5. Types of Wastewater Reuse
 - 5.1. Reuse for Irrigation
 - 5.1.1. Irrigation of Agricultural Crops
 - 5.1.2. Irrigation of Landscape and Recreational Area
 - 5.2. Domestic and Industrial Reuse
 - 5.2.1. Industrial Reuse
 - 5.2.2. Non-potable Domestic Reuse
 - 5.2.3. Indirect Potable Reuse
 - 5.2.4. Direct Potable Reuse
 - 5.3. Wastewater Sludge Reuse
 - 5.3.1. A Case Study of Sludge Reuse in Japan
- 6. Future of Water Reuse

Advanced Treatment Technologies for Recycle/Reuse of Domestic Wastewater

76

Hao Huu Ngo and Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Sydney*
 Marimuthu Sundaravadivel, *Macquarie University, Australia*

- 1. Introduction
- 2. Advanced Wastewater Treatment Technologies
- 3. Biological Nutrient Removal Processes
 - 3.1. Intermittently Decanted Aeration Lagoon (IDAL) System
 - 3.2. Biologically Enhanced Phosphorus Removal (BEPR) System
- 4. Physicochemical Processes
 - 4.1. Deep Bed Filtration for Wastewater Treatment and Reuse
 - 4.1.1. Direct Filtration (DF)
 - 4.1.2. Contact-flocculation Filtration (CFF)
 - 4.1.3. Mobile Bed Filter (MBF)
 - 4.1.4. Floating Medium Filters
 - 4.2. Deep Bed Filtration for Wastewater Reuse—A Case Study of Rouse Hill STP, Sydney, Australia
 - 4.3. Membrane Filtration Processes
 - 4.4. Membrane Filtration for Wastewater Reuse—Case Studies
 - 4.4.1. Water Reclamation at Eraring Power Station, New South Wales, Australia
 - 4.4.2. ‘Water mining’ plant at Canberra, Sydney
 - 4.4.3. Wastewater Reuse Plant at Taronga Zoo, Sydney, Australia
 - 4.5. Hybrid Processes

Membrane Separation Technologies**98**Takeshi Matsuura, *University of Ottawa, Canada*

1. History
2. Definition and classification
3. Performance parameters
4. Membrane separation processes where the driving force is pressure
 - 4.1. Reverse osmosis
 - 4.1.1. Principle of reverse osmosis
 - 4.1.2. Membrane materials and membrane structure
 - 4.1.3. Transport
 - 4.1.4. Concentration polarization
 - 4.1.5. Membrane modules
 - 4.1.6. Applications
 - 4.2. Nanofiltration, ultrafiltration and microfiltration
 - 4.2.1. Description of the processes
 - 4.2.2. Membrane materials and membrane structure
 - 4.2.3. Gel model for ultrafiltration
 - 4.2.4. Brownian diffusion, lateral migration and shear induced diffusion in microfiltration
 - 4.2.5. Applications
5. Membrane separation processes where the driving force is partial pressure
 - 5.1. Membrane gas separation
 - 5.1.1. Description of the process
 - 5.1.2. Transport model
 - 5.1.3. Applications
 - 5.2. Pervaporation
 - 5.2.1. Description of the process
 - 5.2.2. Transport
 - 5.2.3. Applications
 - 5.3. Recovery of vapor from air
6. Membrane separation processes where the driving force is difference in electrical potential
 - 6.1. Electrodialysis
 - 6.2. Bipolar membrane
7. Other membrane processes
 - 7.1. Membrane distillation
 - 7.2. Membrane extraction
 - 7.3. Membrane reactor
 - 7.4. Hybrid processes

Water Reuse for Agriculture**136**Krish Illungkoo, *Department of Land and Water Conservation, New South Wales, Australia*
Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. Introduction
2. Treated Water Reuse by Irrigation
 - 2.1. Principles
3. Public Health Aspects
 - 3.1. Treatment
 - 3.1.1. Secondary Treatment
 - 3.1.2. Disinfection
 - 3.2. Effluent Quality
 - 3.3. Microbial Issues
4. Irrigation Schemes
 - 4.1. Planning and Designing a Sustainable Irrigation System
 - 4.1.1. Site Selection
 - 4.1.2. Maximum Loading Rates and Minimum Land Requirements
 - 4.2. Managing a Sustainable Irrigation System

- 4.2.1. Environmental Management Plan
- 4.3. Management Issues Specific to the Schemes
 - 4.3.1. Ownership and Operation of Land
 - 4.3.2. Calling for Expressions of Interest
 - 4.3.3. Involving Potential Users in the Development of the Scheme
 - 4.3.4. Identifying the Hidden Costs
 - 4.3.5. Agreements
 - 4.3.6. Scheme Manager
 - 4.3.7. Involving the Broader Community
 - 4.3.8. Potential Reuse Market
- 5. Conclusion

Constructed Wetlands for Wastewater Treatment

165

Marimuthu Sundaravadivel, *Macquarie University, Australia*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

- 1. Introduction
- 2. Natural Systems for Wastewater Treatment
- 3. Wetland Systems
- 4. Constructed Wetlands
 - 4.1. Constructed Habitat Wetlands
 - 4.2. Constructed Flood Control Wetlands
 - 4.3. Constructed Aquaculture Wetlands
- 5. Constructed Treatment Wetlands (CTW)
 - 5.1. Components of a CTW
 - 5.1.1. Wetland Vegetation
 - 5.1.2. Supporting Media or Substrate
 - 5.1.3. Water Column
 - 5.1.4. Living Organisms
 - 5.2. Types of Constructed Wetlands
 - 5.3. Pollutant Removal Mechanisms
 - 5.3.1. Physical Processes
 - 5.3.2. Chemical Processes
 - 5.3.3. Biological Processes
 - 5.3.4. Limiting Factors of Wetland Processes
 - 5.4. Design of Constructed Wetlands
 - 5.4.1. The UK Design Model
 - 5.4.2. The First-order Plug-flow Biokinetic Model
 - 5.4.3. Design Procedure
 - 5.5. Construction and Operation of Constructed Wetlands
 - 5.6. Advantages of CTWs
 - 5.7. Limitations of CTWs

Artificial Recharge as a Method of Wastewater Disposal

186

Douglas James McAlister and J. Arunakumaren, *Department of Natural Resources, Australia*

- 1. Introduction
- 2. Background
- 3. Methods
 - 3.1. Surface Distribution Techniques
 - 3.1.1. On-channel Systems
 - 3.1.2. Off-channel Systems
 - 3.2. Injection Techniques
- 4. Wastewater Types available for Artificial Recharge Operations
- 5. Problems Associated with Artificial Recharge Operations with Wastewater

- 5.1. Clogging of Pore Space
- 5.2. Environmental Effects
- 5.3. Health Effects Associated with the Reuse of Recharged Waste
6. Solutions to Problems Encountered with Recharge Operations
 - 6.1. Prevention of Clogging
 - 6.1.1. Physical Clogging
 - 6.1.2. Chemical Clogging
 - 6.1.3. Biological Clogging
 - 6.1.4. Air Entrapment
 - 6.2. Wastewater Treatment before and after Recharge
 - 6.3. Reduction in Organic Constituents in Wastewater during Artificial Recharge
7. Major Steps in a Successful AR Operation
 - 7.1. Initial Planning
 - 7.2. Field Investigations
 - 7.3. Data Interpretation
 - 7.4. Construction of a Pilot Test Facility
 - 7.5. Modeling and Prediction
 - 7.6. Construction of a Production Facility
 - 7.7. Redevelopment and Monitoring
8. Field Monitoring
9. Predicting the Impacts of Recharge by Modeling
10. Economic Considerations
11. Future Trends and Perspectives
12. Conclusion

Human Health Risks Associated with Water Reuse

213

Nicholas John Ashbolt, *University of New South Wales, Australia*

1. Introduction
2. Risk Assessment Paradigm
3. Pathogens and their Indicators
 - 3.1. Fecal Indicator Groups
 - 3.2. Viable Counts and Guideline Numbers
 - 3.3. Properties Necessary for Indicator/Index Microorganisms
 - 3.4. Human Specific Fecal Indicators
4. Chemicals
 - 4.1. Nutrients
 - 4.2. Disinfection By-products (DBP)
 - 4.3. Pharmaceuticals
 - 4.4. Bioassay of Toxic Chemicals
 - 4.4.1. Ames assay
 - 4.4.2. Micronucleus test
 - 4.4.3. General Mutagenic and Carcinogenic assays
 - 4.4.4. Fathead minnow (fish) biomonitoring
5. Conclusions

Wastewater Reuse: Case Studies in Microbial Risks

241

Nicholas John Ashbolt, *University of New South Wales, Australia*

1. Introduction
2. Case 1—Salad Crop Irrigation Risks
 - 2.1. Important Issues in undertaking a Microbial Risk Assessment of Salad Crops
3. Case 2—Dual Reticulated Water Microbial Risks
 - 3.1. Regrowth and Pipe Biofilm Issues in Reclaimed Water Systems

Industrial Waste Minimization 250

Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
 Veeriah Jegatheesan, *Australian Water Technologies, Australia*

1. Introduction
2. Background
3. Waste Minimization Techniques
 - 3.1. Improved Housekeeping
 - 3.2. Changes in Process Technology
 - 3.3. Changes in Products
 - 3.4. Changes in Input Materials
 - 3.5. Recycling Process Chemicals and Raw Materials
 - 3.6. Recovery of By-products and Wastes
4. Policy Aspects and Governmental Responsibilities

Raw Materials and Process Chemical Recovery in Industrial Wastewater Pollution Control 268

Veeriah Jegatheesan, *Australian Water Technologies, Australia*
 R. Ben Aim, *Institut Nationale Sciences Appliquees (INSA), France*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. Introduction
2. Case Studies
 - 2.1. Car Industry
 - 2.2. Metal Workshop
 - 2.3. Electroplating Industry
 - 2.3.1. Copper Recovery
 - 2.3.2. Nickel Plating Rinse Water
 - 2.4. Textile Industry
 - 2.5. Abattoir Industry
 - 2.6. Pesticide Formulation Process

By-product Recovery in Industrial Wastewater Pollution Control 279

Veeriah Jegatheesan, *Australian Water Technologies, Australia*
 R. Ben Aim, *Institut Nationale Sciences Appliquees (INSA), France*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. Introduction
2. Case Studies
 - 2.1. Pulp and Paper Industry
 - 2.2. Dairy Industry
 - 2.2.1. Treatment of Cheese Waste by Cross Flow Ultrafiltration (CFUF)
 - 2.2.2. Use of CFUF in Fermentation of Lactose
 - 2.2.3. Use of Cross Flow Microfiltration (CFMF) in the Treatment of Whey Waste
 - 2.3. Pig Farm
 - 2.4. Food Industry
 - 2.4.1. Waste Recovery in Pineapple Processing
 - 2.4.2. Waste and Waste Recovery in Canned Soup Manufacturing

Process/Technology Modifications in Water Pollution Control 288

Veeriah Jegatheesan, *Australian Water Technologies, Australia*
 R. Ben Aim, *Institut Nationale Sciences Appliquees (INSA), France*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. Introduction

2. Case Studies
 - 2.1. Alteration in Washing/Cleaning Procedure (adapted from Riikonen, 1992)
 - 2.2. Employing New Methods in Production Line Cleaning
 - 2.3. Changing the Method of Water Transport
 - 2.4. Biological Degreasing of Metals
 - 2.5. Change Product
 - 2.6. Change Input Material
 - 2.6.1. Electrical Light Fixture Manufacturing Industry

The Potential for Industrial Wastewater Reuse

299

Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*
 Takashi Asano, *University of California, USA*

1. Introduction
2. Water Availability and Consumption
3. Industrial Wastewater Reuse: Present Status, Trends and Issues
 - 3.1. Internal Wastewater Recycling
 - 3.2. Reuse of Treated Industrial Wastewater
4. Available Treatment Technologies
 - 4.1. Pulp and Paper Industries
 - 4.2. Power Plants
 - 4.3. Textile Industries
 - 4.4. Food Processing Industries
 - 4.5. Other Industries
5. Policy and Institutional Aspects
6. Conclusions

Waste Minimization in Metal Finishing Industries

317

Marimuthu Sundaravadivel, *Macquarie University, Australia*
 Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
 Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*

1. Introduction
2. Metal Finishing Operations
 - 2.1. Chemical and Electrochemical Conversions
 - 2.2. Case-hardening
 - 2.3. Diffusion Coating
3. Waste Streams of Metal Finishing Industries
4. Environmental Impacts of Metal Finishing Wastes
 - 4.1. Impacts on Water Bodies
 - 4.2. Impact on Soil
5. Opportunities for Waste Minimization
 - 5.1. Substituting and Reducing Raw Materials/Process Chemicals
 - 5.1.1. Non-cyanide Processes
 - 5.1.2. Pretreatment and Process Monitoring
 - 5.1.3. A Case Study of Substitution of Less Toxic Chemicals
 - 5.2. Improving Housekeeping and Operating Procedures
 - 5.2.1. Reducing drag-out
 - 5.2.2. Modifying Rinsing Method
 - 5.2.3. Modifying Process Operations and Controls
 - 5.3. On-site/In-plant Recovery for Recycle and Reuse
 - 5.3.1. A Case Study of Raw Material Recovery
 - 5.4. Innovative technological improvements
 - 5.4.1. A Case Study of Process Technology Improvement
 - 5.5. Product Change
6. Profitability of Process Modifications—a Feasibility Study in Bangkok, Thailand

- 6.1. Implementation of In-plant Control Measures
- 6.2. Results of Implementation of In-plant Control Measures
- 6.3. Cost Evaluation
7. Water Reclamation from Small-scale Metal Pickling Units—a Feasibility Study in Delhi, India

Wastewater Characteristics, Management and Reuse in Mining and Mineral Processing Industries

337

Hagare B. Dharmappa and Muttucumaru Sivakumar, *University of Wollongong, Australia*

Raghu N. Singh, *University of Wollongong, Australia*

1. Introduction
2. Wastewater Sources and Characteristics
 - 2.1. Mine Water
 - 2.2. Process Wastewater
 - 2.3. Domestic Wastewater
 - 2.4. Surface Run-off
 - 2.4.1. Estimation of Storm Water Peak Flow from Catchments in Mining Areas
 - 2.4.2. Contamination of Run-off
3. Wastewater Minimization
 - 3.1. Mine Water Minimization
 - 3.2. Process Wastewater Minimization
 - 3.3. Domestic Wastewater Minimization
 - 3.4. Stormwater Minimization
4. Wastewater Reuse/Recycle
 - 4.1. Mine Water Reuse
 - 4.2. Process Wastewater Reuse
 - 4.3. Domestic Wastewater Reuse
 - 4.4. Surface Run-off Reuse
5. Wastewater Treatment
 - 5.1. Sedimentation Basins
 - 5.1.1. Layout of a Sedimentation Pond
 - 5.1.2. Arrangement of Ponds
 - 5.2. Evaporation Ponds
 - 5.3. Filtration
 - 5.3.1. Process Description
 - 5.3.2. Design of Filtration Process
 - 5.4. Oil and Grease Trap
 - 5.4.1. Removal of Free Oil and Scum
 - 5.4.2. Removal of High Viscosity Oil and Grease
 - 5.4.3. Removal of Emulsified Oil
 - 5.4.4. Removal of Residual Amounts of Oil
 - 5.5. Biological Treatment
 - 5.5.1. Activated sludge process (ASP)
 - 5.5.2. Septic Tanks
 - 5.5.3. Facultative Ponds
6. Wastewater Disposal
 - 6.1. Discharge into Natural Water Body
 - 6.2. Discharge into Public Sewers
 - 6.3. Discharge into Underground Strata
 - 6.4. Discharge into Absorption Trenches
7. Conclusions

Fresh Water Minimization by Membrane Filtration in the Pulp and Paper Industry

372

Jutta Nuortila-Jokinen, *Lappeenranta University of Technology, Finland*

1. Introduction

2. Surroundings for Closed Water Circuits
 - 2.1. Fresh Water use and Water Segregation in a Paper Mill
 - 2.2. The Process Waters
 - 2.3. Potential Problems of Closed Water Circuits
3. Internal Purification
 - 3.1. Techniques used in Internal Purification
 - 3.2. Concepts of Internal Purification
4. Overview of Membrane Filtration in the Pulp and Paper Industry
5. Membrane Filtration
 - 5.1. Membranes and Membrane Modules
 - 5.2. The Influence of Operating Parameters
 - 5.3. The Effect of Papermaking Process on Membranes
 - 5.4. Membrane Fouling
 - 5.4.1. Cleaning of Membranes
 - 5.4.2. Feed Pre-treatment

Index **401**

About EOLSS **407**

VOLUME II

Small and Rural Community Water Supply	1
Saravanamuthu (Vigi) Vigneswaran, <i>University of Technology, Australia</i>	
Marimuthu Sundaravadivel, <i>Macquarie University, Australia</i>	

1. Introduction
2. Various Aspects of Water Supply to Small and Rural Communities
 - 2.1. Health Aspects
 - 2.2. Socioeconomic Aspects
 - 2.3. Technological Aspects
3. Planning for Small Community Water Supply Systems
4. Assessment of Quantity and Quality of Water
 - 4.1. Water Quantity
 - 4.2. Water Quality
5. Conventional Water Treatment Technologies
 - 5.1. Overview of Water Treatment Processes
 - 5.1.1. Conventional Processes
 - 5.1.2. Advanced Processes
6. Treatment Technologies for Small Communities
7. Sourcing Water for Rural Community Supply
 - 7.1. Groundwater Sources
 - 7.2. Rainwater Harvesting
 - 7.3. Surface Water Sources
8. Understanding the Traditional Wisdom of Rural Communities
9. Removal of Specific Impurities
10. Perspectives for the Future
 - 10.1. Water Quality
 - 10.2. Water Quantity
 - 10.3. Water Treatment

Quantity and Quality of Drinking Water Supplies	23
Saravanamuthu (Vigi) Vigneswaran and Hao Huu Ngo, <i>University of Technology, Sydney, Australia</i>	

Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*
Marimuthu Sundaravadivel, *Macquarie University, Australia*

1. Introduction
2. Assessment of Water Quantity
 - 2.1. Water Demand
3. Assessment of Water Quality
 - 3.1. Physical Parameters
 - 3.2. Chemical Parameters
 - 3.3. Microbiological Parameters

Conventional Water Treatment Technologies

36

Saravanamuthu (Vigi) Vigneswaran and Hao Huu Ngo, *University of Technology, Sydney, Australia*
Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*
Marimuthu Sundaravadivel, *Macquarie University, Australia*

1. Introduction
2. Treatment Processes
3. Rapid Mixing
 - 3.1. Hydraulic Mixers
 - 3.2. Mechanical Mixers
4. Flocculation
 - 4.1. Types of Flocculators
5. Sedimentation
 - 5.1. Tube Settlers
 - 5.2. Sludge Blanket Clarifiers
6. Filtration
 - 6.1. Slow Sand Filtration
 - 6.2. Rapid Sand Filtration
 - 6.2.1. Improvements on Rapid Filters
7. Disinfection

Rural Water Supply Systems

56

Marimuthu Sundaravadivel, *Macquarie University, Australia*
Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. Introduction
2. Need for Alternative Water Supply Systems
3. Water Sources
4. Rainwater-based Rural Water Supply Systems
 - 4.1. Roof Catchment and Storage
 - 4.2. Ground Catchment and Storage
5. Groundwater-based Water Supply Systems
 - 5.1. Extraction Devices
 - 5.1.1. Sanitary Rope and Bucket System
 - 5.1.2. Bucket Pumps
 - 5.1.3. Chain Pumps
 - 5.1.4. Hand Pumps
6. Surface Water Supply Systems
 - 6.1. Water Intake Systems
 - 6.1.1. Fixed Level Intake
 - 6.1.2. Floating Level intake
 - 6.1.3. Infiltration Galleries
 - 6.2. Water Treatment Systems
 - 6.2.1. Slow sand Filtration
 - 6.2.2. Alternative Filtration Technologies

- 6.2.3. Selection of Treatment Systems
- 7. Water Distribution Systems
 - 7.1. Methods of Water Transportation
 - 7.2. Types of Distribution Networks
 - 7.3. Types of Consumer Outlets
 - 7.3.1. Public Standposts
 - 7.3.2. Yard Tap Connections

Traditional and Household Water Purification Methods of Rural Communities in Developing Countries 84

Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
 Marimuthu Sundaravadivel, *Macquarie University, Australia*

- 1. Introduction
- 2. Traditional Water Treatment Methods
 - 2.1. Filtration through Winnowing Sieve
 - 2.2. Filtration through Cloth
 - 2.3. Filtration through Clay Vessels
 - 2.4. Clarification and Filtration using Plant Parts
 - 2.5. Jempeng Stone Filter Method
- 3. Appropriate Water Treatment Methods
 - 3.1. Horizontal Flow Coarse Media Filter
 - 3.2. Upflow Gravel Filter
 - 3.3. Two-stage Filter
 - 3.4. Upflow-downflow Filter
- 4. Household Water Treatment Methods
 - 4.1. Filtration and Siphoning Technique
 - 4.2. Coagulation and Sand Filtration Unit
 - 4.3. Water Filter Canister
 - 4.4. Household Slow Sand Filtration Unit
 - 4.4.1. Indian Design
 - 4.4.2. Thailand Design
 - 4.5. Household Defluoridator

Treatment Options for Removal of Specific Impurities from Water 97

Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
 Chettiyappan Visvanathan, *Asian Institute of Technology, Thailand*
 Marimuthu Sundaravadivel, *Macquarie University, Australia*

- 1. Introduction
- 2. Iron (Fe) and Manganese (Mn) Removal
 - 2.1. Problems of Fe and Mn in Water
 - 2.2. Treatment Processes for Fe and Mn Removal
 - 2.2.1. Aeration Filtration Method
 - 2.2.2. Chemical Oxidation Filtration Method
 - 2.2.3. Fe and Mn Removal Combined with Removal of Carbonates
 - 2.2.4. Potassium Permanganate–Manganese Greensand Filtration
 - 2.2.5. Ion Exchange
 - 2.2.6. Biological Treatment Methods
 - 2.3. Small-scale Fe and Mn Removal Plants for Rural Water Supply
- 3. Fluoride Removal (Defluoridation)
 - 3.1. Treatment Processes for Defluoridation
 - 3.1.1. Precipitation Methods
 - 3.1.2. Lime Softening
 - 3.1.3. Coagulation
 - 3.1.4. Ion Exchange and Adsorption Methods

3.2. Nalgonda Method—An Alternative Defluoridation Technique for Developing Countries

Small Community and Rural Sanitation Systems**112**Thiruvengkatachari Viraraghavan, *University of Regina, Canada*Marimuthu Sundaravadivel, *Macquarie University, Australia*Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

1. History of Sanitation
2. Issues in Adoption of Conventional Sanitation Technologies
3. On-site Sanitation Technologies
4. On-site Technologies for Developing Countries
 - 4.1. Ventilated Improved Pit (VIP) Latrines
 - 4.2. Reed's Odorless Earth Closet (ROEC)
 - 4.3. Batch Composting Toilets
 - 4.4. Continuous Composting Toilets
 - 4.5. Aquaprivy with Soakaway
 - 4.6. Pour-flush (PF) Latrine with Soakaway
5. On-site Sanitation Technologies for Developed Countries
 - 5.1. Total On-site Wastewater Management Systems
 - 5.1.1. Septic Tanks/Septic Closets with Collection Wells
 - 5.1.2. Aerated Wastewater Treatment Systems (AWTS)
 - 5.1.3. Waterless Composting Toilets
 - 5.1.4. Wet Composting Toilets
 - 5.1.5. Combustion Toilets
 - 5.1.6. Graywater Treatment Devices
 - 5.2. Ancillary Systems for On-site Wastewater Management
 - 5.2.1. Recirculating Aerobic Sand Filter Devices (RASFD)
 - 5.2.2. Disinfection Systems
 - 5.2.3. Constructed Wetlands
 - 5.2.4. Sand Mounds or Sand Filter Systems
 - 5.2.5. On-site Land Application Systems
 - 5.3. Partial On-site Wastewater Management Systems
 - 5.3.1. Common Effluent Systems
 - 5.3.2. Chemical Toilets
 - 5.3.3. Pump-out Systems
 - 5.3.4. Wastewater Ejection Units

On-Site Sanitation Technologies for Reuse**145**Prashanthi Hagare, *University of Technology, Australia*Hagare B. Dharmappa, *University of Wollongong, Australia*

1. Introduction
2. Options for Small Decentralized Systems
 - 2.1. Effluent Reuse Options
 - 2.1.1. Agricultural Irrigation
 - 2.1.2. Landscape Irrigation
 - 2.1.3. Industrial Reuse
 - 2.1.4. Recreational/Environmental Uses
 - 2.1.5. Groundwater Recharge
 - 2.1.6. Habitat Wetlands
 - 2.1.7. Miscellaneous Uses
 - 2.1.8. Augmentation of Potable Supplies
 - 2.2. Guidelines for Wastewater Reuse
 - 2.3. Appropriate Wastewater Management Technologies
3. On-site Sewage Management for Single Households
 - 3.1. Guidelines for Wastewater Reuse

- 3.2. Technologies to Treat all Wastewater from a Single Household
 - 3.2.1. Aerated Wastewater Treatment Systems
 - 3.2.2. Evapotranspiration
 - 3.2.3. Land Treatment

On-Site Sanitation Technologies for Cold and Temperate Climates **178**
Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*
Marimuthu Sundaravadivel, *Macquarie University, Australia*

- 1. Introduction
- 2. Problems of On-site Sanitation Systems in Cold and Temperate Climates
- 3. Appropriate On-site Sanitation Systems
- 4. Soil Absorption Systems
 - 4.1. Mound Absorption System
 - 4.2. "At-grade" System
 - 4.3. Low-pressure Pipe (LPP) System
 - 4.4. "In-drain" System
 - 4.5. Contour Trench Systems
- 5. Treatment Systems
 - 5.1. Recirculating Sand Filter with Rock Storage Filter
 - 5.2. Ruck System
 - 5.3. Peat Treatment System

Non-Conventional Sewerage **190**
Marimuthu Sundaravadivel, *Macquarie University, Australia*
Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

- 1. Introduction
- 2. Development of Non-conventional Sewage Collection Systems
 - 2.1. Pressure Sewers
 - 2.2. Vacuum Sewers
 - 2.3. Simplified Sewers
 - 2.4. Settled Sewers

Public Health Aspects of On-Site Sanitation **202**
Thiruvengkatachari Viraraghavan and Shivakumar Krishnamurthy, *University of Regina, Canada*
Saravanamuthu (Vigi) Vigneswaran, *University of Technology, Australia*

- 1. Introduction
- 2. Factors Affecting Transmission of Diseases
 - 2.1. Excreted Load
 - 2.2. Infective Dose
 - 2.3. Latency
 - 2.4. Persistence
 - 2.5. Multiplication
- 3. Pathogens in Excreta
 - 3.1. Bacteria
 - 3.2. Viruses
 - 3.3. Protozoa
 - 3.4. Helminths
- 4. Environmental Classifications of Diseases
 - 4.1. Environmental Classification of Water-related Diseases
 - 4.1.1. Fecal-oral Diseases
 - 4.1.2. Water-washed Diseases
 - 4.1.3. Water-related Insect Vectors

- 4.2. Environmental Classification of Excreta-related Diseases
 - 4.2.1. Nonbacterial Fecal-oral Diseases
 - 4.2.2. Bacterial Fecal-oral Diseases
 - 4.2.3. Geohelminthiases
 - 4.2.4. Taeniasis
 - 4.2.5. Water-based Helminthiases
 - 4.2.6. Excreta-related Insect-vector Diseases
 - 4.2.7. Excreta-related Rodent-vector Diseases
- 4.3. Unitary Environmental Classification of Water- and Excreta-related Diseases
- 5. Pathogens in the Environment
 - 5.1. Detection of Pathogens
 - 5.1.1. Total Coliforms
 - 5.1.2. Fecal Coliforms (Thermotolerant Coliforms)
 - 5.1.3. Fecal Streptococci and Enterococci
 - 5.1.4. Sulfate-reducing Clostridia
 - 5.1.5. Pseudomonas Spp
 - 5.1.6. Fecal Sterols
 - 5.1.7. Heterotrophic Plate Count (HPC)
 - 5.1.8. FC/FS Ratio
 - 5.1.9. Pathogen Indicators
 - 5.2. Survival of Pathogens
 - 5.2.1. Survival of Pathogens in Feces, Night Soil and Sludge
 - 5.2.2. Survival of Pathogens in Fresh Water and Wastewater
 - 5.2.3. Survival of Pathogens in Soil
 - 5.2.4. Survival of Pathogens on Crops
- 6. On-site Excreta Collection and Treatment Systems
 - 6.1. Dry Systems for Night Soil
 - 6.1.1. Pit latrines
 - 6.1.2. Composting Toilets
 - 6.1.3. Cartage Systems
 - 6.2. Wet Systems (for Excreta Diluted with Water)
 - 6.2.1. Aquaprivies
 - 6.2.2. Septic Tanks

Index 229

About EOLSS 235