



Environmental Engineering Processes

Laboratory Manual

Table of Contents

Preface (Susan E. Powers, Clarkson University)	pref.pdf
Safety (Deanna Hurum, Northwestern University)	safety.pdf
Statistical Analysis (Catherine Peters, Princeton University)	stats.pdf

1 Transport and Partitioning Processes

1.1 Fluid Flow

1.1.1 Darcy's Law and Hydraulic Conductivity

(J. Mark Stapleton and James R. Mihelcic, Michigan Technological University)

Student lab

1-1-1lab.pdf

Instructor notes

1-1-1inst.pdf

1.2 Reactor Analysis – Hydraulic Characteristics

1.2.1 Laboratory Study of Completely Mixed Flow Reactor Using UV/Visible Spectrophotometry

(Alan T. Stone, William P. Ball, A. Lynn Roberts, Johns Hopkins University)

Student lab

1-2-1lab.pdf

Instructor notes

1-2-1inst.pdf

1.2.2 Laboratory Study of Plug Flow Reactors

(Alex Mayer, Michigan Technological University)

Student lab

1-2-2lab.pdf

Instructor notes

1-2-2inst.pdf

1.2.3 Non-Ideal Reactor Behavior

(Ernest R. Blatchley III, Purdue University)

Student lab

1-2-3lab.pdf

Instructor notes

1-2-3inst.pdf

1.2.4 Residence time distribution in a Chlorine Contact Chamber

(Susan E. Powers, Clarkson University)

Student lab

1-2-4lab.pdf

Instructor notes

1-2-4inst.pdf

1.3 Interphase and Mass Transfer Rates and Equilibria

1.3.1 An Introduction to Phase Partitioning and Contaminant Transport

(Stefan J. Grimberg and Susan E. Powers, Clarkson University)

Student lab

1-3-1lab.pdf

	Instructor notes	1-3-1inst.pdf
1.3.2	Single Component Activated Carbon Adsorption Isotherm (Gerald E. Speitel Jr., University of Texas at Austin)	
	Student lab	1-3-2lab.pdf
	Instructor notes	1-3-2inst.pdf
1.3.3	Multi-component Carbon Adsorption Isotherms (Gerald E. Speitel Jr., University of Texas at Austin)	
	Student lab	1-3-3lab.pdf
	Instructor notes	1-3-3inst.pdf
	Excel file (Iastaees.xls)	Iastaees.xls
1.3.4	Measurement of Henry's Law Constant for Volatile Organics (James M. Gossett, Cornell University)	
	Student lab	1-3-4lab.pdf
	Instructor notes	1-3-4inst.pdf
1.3.5	Gas Transfer: Measurement of Overall Oxygen Mass Transfer Coefficient in Simulated Engineered and Natural Systems (Tanju Karanfil, Clemson University and Bruce Logan, Pennsylvania State University)	
	Student lab	1-3-5lab.pdf
	Instructor notes	1-3-5inst.pdf
1.4	Unit Operations for Solute Separation Processes	
1.4.1	Rapid Small Scale Column Tests (Gerald E. Speitel Jr. University of Texas at Austin; Bruce I. Dvorak, and Matthew C. Morley, University of Nebraska – Lincoln)	
	Student lab	1-4-1lab.pdf
	Instructor notes	1-4-1inst.pdf
	Excel file (Rssct.xls)	Rssct.xls
1.4.2	Continuous Flow Ion Exchange Contactor (James J. Bisogni, Jr. Cornell University)	
	Student lab	1-4-2lab.pdf
	Instructor notes	1-4-2inst.pdf
1.4.3	Ultrafiltration/Microfiltration (UF/MF) Membrane Treatment of Industrial Wastewaters (Brian E. Reed and Ronald Vaughan, University of Missouri-Columbia)	
	Student lab	1-4-3lab.pdf
	Instructor notes	1-4-3inst.pdf
1.4.4	Air Stripping (Thomas D. DiStefano, Bucknell University)	
	Student lab	1-4-4lab.pdf
	Instructor notes	1-4-4inst.pdf

2 Chemical Processes

2.1 Oxidation and Reduction

2.1.1 Iron Metal as a Reducing Agent: Kinetics of Nitrate Reduction

(Lenly J. Weathers and K. Larry Roberts, Tennessee Technological University)

Student lab 2-1-1lab.pdf

Instructor notes 2-1-1inst.pdf

2.1.2 Advanced Chemical Oxidation: Fenton's Reagent Degradation of Organic Compounds

(Christopher M. Miller and Kevin C. Bower, University of Akron)

Student lab 2-1-2lab.pdf

Instructor notes 2-1-2inst.pdf

2.1.3 Process Behavior in Ultraviolet Disinfection Systems

(Ernest R. Blatchley III, Purdue University)

Student lab 2-1-3lab.pdf

Instructor notes 2-1-3inst.pdf

2.2 Precipitation

2.2.1 Chemical Precipitation : Removal of Complexed Metals From an Industrial Wastewater

(Mark O. Barnett and Timothy E. Kramer, Auburn University; William P. Hamilton and Alan R. Bowers, Vanderbilt University)

Student lab 2-2-1lab.pdf

Instructor notes 2-2-1inst.pdf

2.2.2 Water Softening

(Phillip L. Thompson, Seattle University and Steven I. Safferman, University of Dayton)

Student lab 2-2-2lab.pdf

Instructor notes 2-2-2inst.pdf

3 Biological Processes

3.1 Aerobic Processes

3.1.1 Estimation of Biological Kinetic Parameters: Aerobic Heterotrophic Bacteria

(Lenly J. Weathers and Richard W. Lowhorn, Tennessee Technological University)

Student lab 3-1-1lab.pdf

Instructor notes 3-1-1inst.pdf

3.1.2 Determination of Biological Kinetic Parameters: Nitrification

(Lenly J. Weathers, Tennessee Technological University)

Student lab 3-1-2lab.pdf

Instructor notes 3-1-2inst.pdf

3.2 Anaerobic Processes

3.2.1 Measurement of Kinetic Parameters and COD Mass Balance

(David L. Freedman, Clemson University)

Student lab 3-2-1lab.pdf

Instructor notes 3-2-1inst.pdf

3.3 *Environmental Biodegradation*

3.3.1 **Biodegradation of Individual Organic Contaminants**

(Barth F. Smets, Kartik Chandran, U. Conn; R. Guy Riefler, Ohio University)

Student lab 3-3-1lab.pdf

Instructor notes 3-3-1inst.pdf

3.3.2 **Estimation of Biokinetic Parameters**

(Barth F. Smets, Kartik Chandran, U. Conn; R. Guy Riefler, Ohio University)

Student lab 3-3-2lab.pdf

Instructor notes 3-3-2inst.pdf

Excel File (template.xls) template.xls

3.3.3 **Petroleum Hydrocarbon Degradation in Soils: Monitoring Cell Growth as a Measure of Performance**

(Dan L. McNally, Bryant College, James R. Mihelcic, Michigan Technological Univ.)

Student lab 3-3-3lab.pdf

Instructor notes 3-3-3inst.pdf

3.3.4 **Phytoremediation**

(Phillip L. Thompson, Seattle University)

Student lab 3-3-4lab.pdf

Instructor notes 3-3-4inst.pdf

4 **Particle Dynamics and Separations in Environmental Systems**

4.1 *Gravity Separations*

4.1.1 **Sedimentation and Expansion of Type I Solids**

(Steven I. Safferman, Univ. Dayton)

Student lab 4-1-1lab.pdf

Instructor notes 4-1-1inst.pdf

4.1.2 **Type II Sedimentation - Flocculent Settling**

(Linda K. Weavers Ohio State Univ.)

Student lab 4-1-2lab.pdf

Instructor notes 4-1-2inst.pdf

4.1.3 **Development and Utilization of Gravity Settling Solids Flux Curve for the Design and Operation of a Secondary Clarifier – Batch Settling Flux Approach**

(David R. Yonge, Washington State Univ.)

Student lab 4-1-3lab.pdf

Instructor notes 4-1-3inst.pdf

4.2 *Filtration*

4.2.1 **Hydraulics of Rapid Sand Filtration**

(Joel Burken, U. Missouri Rolla)

Student lab 4-2-1lab.pdf

Instructor notes 4-2-1inst.pdf

5 Design Applications¹

- 5.1.1 **Drinking Water Disinfection Optimisation Using Watpro**
(Ron Hofmann, Robert C. Andrew, University of Toronto)
Student lab 5-1-1lab.pdf
Instructor notes 5-1-1inst.pdf
- 5.1.2 **Building the Better Oil/Water Separator - An Environmental Engineering Design Laboratory**
(John W. Duggan, Wentworth Institute of Technology)
Student lab 5-1-2lab.pdf
Instructor notes 5-1-2inst.pdf

6 Classic Labs from Previous AEEP Lab Manual²

6.1 Coagulation

- 6.1.1 **Coagulation and Flocculation: Hydrolyzing Metal Salts** coag.pdf
6.1.2 **Polymer coagulation** polymer.pdf
6.1.3 **Coagulation: Electrophoretic Mobility** epm.pdf

6.2 Solids Separation

- 6.2.1 **Sludge Conditioning and Resistance to Dewatering** sludge.pdf
6.2.2 **Floatation: Batch Laboratory Test** float.pdf

6.3 Chlorination

- 6.3.1 **Disinfection: Chlorination of Wastewater** chlorination.pdf

¹ see also parts A and B of Section 1-2-4

² Suidan, M.T., Environmental Engineering Unit Operations and Unit Processes Laboratory Manual. Published by AEEP, September 1988.