STANFORD UNIVERSITY

Luthy CEE 270 **Autumn 2020—During the Covid Pandemic**

SYLLABUS

Organic Contaminants in Water

Lectures: MWF 8:30-9:20 Virtual classroom: On-line via Zoom with recording
Course Reader: **Required: Purchase at Bookstore**

Reference Texts: Tchobanoglous and Schroeder, *Water Quality*, Addison-Wesley, 1985 [WQ]
(optional) Schwarzenbach, Gschwend, and Imboden, *Environmental Organic Chemistry*, Wiley Interscience, 3rd Ed., 2017 [EOC]
Levenspiel, *The Chemical Reactor Omnibook,* OSU Bookstore, 2002
Water Treatment: Principles and Design, MWH, 3rd Ed, 2012
http://onlinelibrary.wiley.com/book/10.1002/9781118131473;jsessionid=29C0BB919C261D9315C67569BC14F7FB.d01t04
(Texts are on course reserve in the Engineering Library)

Instructor: Prof. Richard G. Luthy, luthy@stanford.edu, meet via Zoom;
Teaching Asst.: Jessica MacDonald, jmacdon@stanford.edu, meet via Zoom;
Grader: Yuwei Fu
Office Hours: Instr: two times per week, Mon and Wed (via Zoom); TA (Tues & Fri)
Credit: 3 Units, Grading basis: S/NC
Luthy research group information: https://luthygroup.stanford.edu

CLASS SCHEDULE		READING ASSIGNMENTS	
DATE	**TOPIC**	**TEXT (WQ) or (EOC)**	**COURSE READER Section**
Sept. 14	Introduction-Fate Processes	WQ: 43-53 EOC: 3-12	**0, 1**
16	Basic Chemistry Review	WQ: 56-76, 170-176, 231-233	**2**
	Organic Compound Nomenclature	EOC: 13-19, 31-51	
18	What's in Our Water/Regulations	WQ: 56-100	**3 C, D, E**
21	Transport & Fate Background	EOC: 4-6	**4**, **4A**
23, 25, 28, 30	Phase Equilibrium & Partitioning	EOC: 73-110, 133-142, 182-203, 275-288	**4**, **4B**
Oct. 2, 5, 7	Interphase Mass Transfer	WQ: 314-328 EOC: Chap. 8	**5**
9, 12	Reactions, Degradation, Persistence	WQ: 101-121, 231-247 EOC: 459-481, 689-693, 739-750	**6, 6A**
Wed. Oct. 14 In-class Exam			
16	Oxygen Demand & Reactors	WQ: 248-260, 267-282	**7, 8**
19, 21, 23	Reactor Theory	WQ: 248-260, 267-282	**8**
26	Oxygen Depletion in Streams	WQ: 338-351, 734-735, 742-743	**9**
28, 30, **Nov.** 2	Chemical Fate in Treatment	WQ: 443-457, 595-608	**10, 10A-C**
4	Partial Mixing & Dispersion	WQ: 283-287	**11**
6, 9, 11	Partial Mixing & Dispersion/Groundwater Flow Processes		**11**
13	Groundwater & Retarded Transport	WQ: 283-287	**12**
16	Groundwater and Transport	WQ: 405-434	**12**
Wed. Nov. 18 In-class Exam			
20	Sediment Cleanup & Closure		**12B**

No Final Exam Per Covid Pandemic Course Format

Guidance for Reading Assignments:

Course Reader: Instructor notes and a few articles from other sources. The lectures follow the Reader for the most part. Read ahead before class and follow the assignments conscientiously.

Water Quality Text: An orientation to traditional water pollution problems and engineering approaches to problem analysis. If you have a background in environmental engineering, you can skip these reading assignments. Other texts are suitable, e.g., Henry & Heinke.

Environmental Organic Chemistry Text: An advanced text on organic chemical behavior in the environment, especially for anthropogenic compounds. The specific pages assigned are intended mainly as reference for additional study in environmental chemistry. This text is used in CEE 270B.

Water Quality and Treatment Text: This is for reference and available for download from Stanford Libraries. The information on reactors and reactions is relevant to CEE 270.

Chemistry refresher: Refer to chapters 2-5 in *Chemistry for Environmental Engineering and Science,* C. N. Sawyer, P. L. McCarty, G. F. Parkin, 5th Ed., McGraw-Hill, 2003.

Grading: S/NC Per Covid Pandemic Course Format

Goal of Instruction: To introduce issues of *water quality* in the context of water quality engineering; describe the *principles governing transport* of *organic chemical constituents* in engineered reactors, surface waters and groundwater, including advection, dispersion, sorption, inter-phase mass transfer, and transformation reactions. Further, to show how organic loads impact water quality in streams and how to estimate the fate of organic compounds in a wastewater treatment system or in groundwater or sediments by considering various fate pathways simultaneously. The emphasis is on *physical processes and relative reaction rates* that govern the behavior of hazardous chemicals, especially synthetic organic chemicals.

Learning Goals: (for course outcomes and evaluation)

- Concepts of phase partitioning and mass transfer
- Reactor theory applied to environmental compartments
- Movement and transport of organic compounds in water
- Examples of how environmental fate processes depend on organic chemical properties

Timeless words from some great physicists:

Nature is tricky, but not malicious. *and*
Everything should be made as simple as possible, but not simpler. Albert Einstein

The principles are simple, but not elementary. It's hard to get it right. Richard Feynman

...and from some great environmental writers:

When we try to pick out anything by itself, we find it hitched to everything else in the universe. John Muir

The "control of nature" is a phrase conceived in arrogance, born of the primitive age of biology and philosophy when it was supposed that nature exists for the convenience of humankind. We have to put an end to these unnatural manipulations. Rachel Carson

Something will have gone out of us as a people if we ever let the remaining wilderness be destroyed; … if we pollute the last clear air and dirty the last clean streams... We simply need that wild country available to us, even if we never do more than drive to its edge and look in. For it can be a means of reassuring ourselves of our sanity as creatures, a part of the geography of hope. Wallace Stegner [late Stanford professor], from the *Wilderness Letter*, 1960.

CEE 270
COURSE PROSPECTUS -- AUTUMN QUARTER

Students taking CEE 270 will be required to invest their time, attention, and imagination. In return they will receive 3 units of credit and gain new insights into the behavior of organic chemicals in the aquatic environment.

Distribution of topics according to percent of class time (30 classes):	Percent
Introduction	
Physical Properties of Water; Environmental Chemical Transport Perspective	3
Basic Chemistry Review	
Concentration Ranges; Stoichiometry; Organic Compound Nomenclature	3
Regulatory Background	
Water Quality Criteria and Standards; Legislation; Health Risks	3
Organic Chemical Introduction	
Origin and Pathways of Synthetic Chemicals	3
Phase Equilibrium and Partitioning	
Thermodynamic Concepts; Phase Equilibrium -- Air/Water, Solid/Water	19
Mass Transfer Principles	
Interphase Transfer; Mass Transfer Coefficients	7
Transformations	
Reactions, Degradation, and Persistence; Rate Equations	10
Reactor Theory	
Reactor Types; Residence Time Distribution; Extent of Reaction	10
Oxygen Depletion in Streams	
Oxygen Consumption and Reaeration, Stream Modeling & Parallel Processes	7
Chemical Fate in Wastewater Treatment	
Activated Sludge Process; Disappearance Mechanisms, Computation of Fate	7
Partial Mixing and Dispersion	
Causes of Dispersion; Advection/Dispersion Equation; Stimulus-Response	10
Groundwater	
Hydrogeology & Groundwater Flow; Advection, Dispersion, and Retardation	10
Sediment Contamination, Bioavailability Control	5
Course Review and Closure	3
Total	100

Course Grade:

Homework*	34%
Exam 1#	33%
Exam 2#	33%

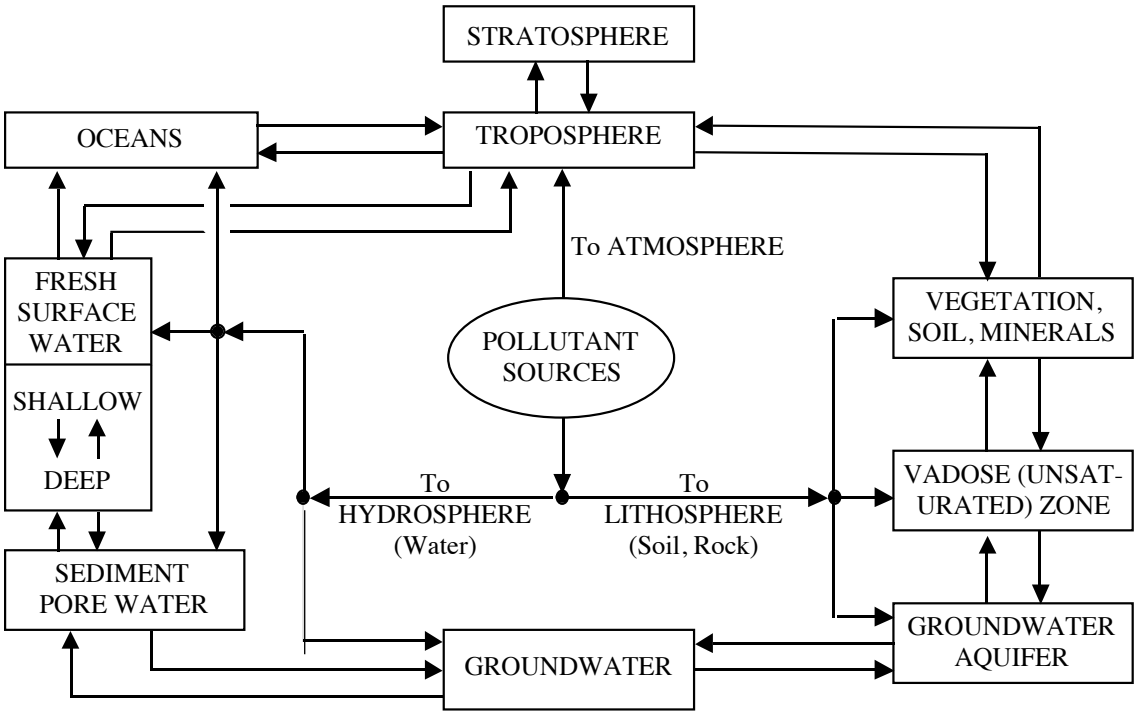
* Eight homework sets, about one per week to be written up as *three-person group* assignments. Students may discuss the assignments but must conduct computations and write up their work without referring to others' solutions or from prior classes. Observe the spirit of the Honor Code; if in doubt, ask the instructor or TA.

\# Students will be given a 24 hour period to complete the 65 minute exams. Open course reader and notes. See the Homework and Exam Policy for instructions on use of Gradescope.

Course Framework

We will develop an understanding of the factors governing the behavior of organic chemicals in the environment in consideration of advection and dispersion; distribution among air, water, and soil; rates of transformation; and relative rates of transport and transformation processes. This entails comprehension of equilibrium—the direction to which a process or system is trending—and rate process—how long it may take to approach equilibrium or a steady state condition.

We will follow an approach termed environmental fate and transport, *or chemical transport dynamics*, which is the applied science underlying the movement and fate of chemical substances within the three major compartments of the environment: air, water, and earthen solids. We will concentrate on what happens in water, and how that compartment interacts with air and solids.



Another important compartment:
The BIOTA is the sum total of living beings. The BIOSPHERE is the domain occupied by the biota, mainly comprised of near-surface portions of the hydrosphere, atmosphere, and lithosphere. From the viewpoint of chemodynamics, the biota is considered a separate compartment, whereas the biosphere overlaps compartment boundaries (hydro-, litho-, atmo-).

Course Motto "Eventually all things merge into one, and a river runs through it.... I am haunted by waters." Norman MacLean *A River Runs Through It*

Students with Documented Disabilities: Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty. Unless the student has a temporary disability, Accommodation letters are issued for the entire academic year. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: https://oae.stanford.edu/).