Course Syllabus

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EnvH 552 - Environmental Chemistry of Pollution - Spring 2018 (4 credits)
M, W 3:30 – 4:50PM HSE E216
F 3:30 – 4:20PM HSBB BB1404

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Course Description and Instructional Objectives
This course provides an overview of the concepts and applications used to predict and explain chemical concentrations found in different parts of indoor and outdoor environments, as they result from releases, transport, phase transfer and chemical reaction processes. Simply put, the course aims to answer the question: "what is the connection between chemical uses and mishaps, and damage to human health or to ecologies ?"

The teaching methods for this course include didactic presentations, on-line recorded materials, class discussion of basic concepts, and group and individual problem solving.

This course introduces concepts that form a basis for rationalizing or predicting environmental behavior of pollutant chemicals. We will consider the roles of pollutant properties and behavior, environmental conditions, and pollutant release scenario details to address the following questions:

What parts of the environment (air, water, soils, etc) are likely to be most affected?
What will determine the resulting environmental concentrations (over time, and location)?
How may these concentrations be calculated or estimated?

How do modifying factors like temperature, salinity, and mixtures affect these answers?

Lastly, the implications for understanding the resulting possible environmental exposures leading to human health risks will be illustrated.

Student Learning Objectives:
At the completion of the course, students should be able to:

- Describe what is meant by "environmental fate":

discuss possible application to common chemicals of environmental concern
identify key environmental compartments and processes

- Apply equilibrium concepts and equilibrium partitioning relationships for chemicals in different environmental media

classify different situations of environmental contamination as describable using chemical equilibrium concepts
identify limitations in applicability of chemical equilibrium assumptions
recognize and state the thermodynamic concepts relating molecular structure with quantitative indices of chemical behavior such as thermodynamic equilibrium constants and rate constants
perform calculations of chemical concentration based on equilibrium conditions

- Apply these thermodynamic relationships to key processes of environmental importance such as volatilization, sorption, or chemical reaction.
- Demonstrate familiarity with common groups of environmental pollutants, and summarize the reasons for the environmental significance of each.
- List and compare several approaches for obtaining estimates of chemical properties for chemicals of environmental concern
- Write rate equations for a given chemical degradation mechanism and classify it as to kinetic order, and apply first order kinetic concepts to calculate overall removal rates or half-lives.
- For pollutants introduced into surface water, subsurface water, air or in soils:

identify the major transport mechanisms and perform basic calculations of transport velocity
identify environmental partitioning behaviors of probable environmental importance and apply equilibrium parameters to determine limiting environmental concentrations
apply concepts of advection, dispersion, phase partitioning and chemical reaction and formation to calculate environmental concentrations with time or distance from source.

- Identify conceptual approaches for environmental fate modeling and simplifying assumptions, and be able to construct simple models.
- Analyze problem descriptions, frame computational approaches and solve for resulting concentrations or other system variables using the concepts and relationships presented.

Course Format and Requirements

The course will meet 2 times per week in a 80-minute lecture format (MW 3:30 – 4:50), and one 50-minute session on Fridays (note locations shown at top of page). I plan to record and post each session, as a "Panopto" file. The final exam is scheduled for 2:30-4:20 p.m., Thursday, June 7, 2018 in E-216 HSB. We may provide an on-line and/or take home final exam instead.

1. Reading & Lectures:

We will follow the text and supplementary materials reasonably closely; major departures will be material skipped or omitted. Students are responsible for the content of any reading assigned from a required text or handout.

Reading is assigned for each lecture (see accompanying schedule) and should be completed before the lecture. I will not be going over all aspects of the reading, so it is important that you read this material and come with questions or a good understanding and/or questions.

Reading should be completed before the lecture. I will try to post slides in advance and to post PanOpto films of lectures afterward.

Supplementary materials, some in the form of recorded videos, will accompany some sessions. Some of these have mini-quizzes attached. These should be viewed and the associated quiz taken prior to the class session for which they are assigned. Optional supplements are not required.

2. Homework:
Important comments about homework: (1) the purpose of the homework is to solidify your understanding of the concepts and their application - getting stuck on a problem is ok, if it leads to improved understanding; (2) as with any skill-building exercise, you get out of it what you put into it - doing lots of optional problems is a good thing; (3) spending hours of time struggling with a single problem is not a good thing. If you don't solve a problem in half an hour or so, stop and try to figure out what the problem requires. If that doesn't help, get help.

THE MOST COMMON ERROR IN DOING HOMEWORK IS SPENDING TOO MUCH TIME IN FRUITLESS CALCULATION.

The objective of this course is to provide the conceptual theory of environmental science and then develop skills in applying these concepts to actual situations, through the working of problems. Homework problems will be assigned for each lecture from the text on a roughly 2 week basis. (Due dates are indicated on the course schedule).

The "examples" (i.e. supplementary text and worked problems) should be read and understood; these are usually foundational to the assigned problems. We'll try to allow time to discuss problems and will schedule extra sessions if necessary. It is important for your success in the course to keep up with the problems (including the worked examples). Occasionally, “problem sessions” will be held during class periods. These will cover major segments of the course; teams of students may be responsible for presenting solutions to the problems covered. "Optional questions" noted in reading schedule or provided in lecture will usually not be collected (any exceptions will be announced).

Homework problems are key to building the skills to apply the material in class. Up to three students may collaborate on homework problem sets; all collaborations should be indicated on the work turned in. Students are free to confer with each other on homework problems, but in general are encouraged to try first to work each problem alone. However, students should spend no more than 3 or 4 hours on any one problem set (30-60 minutes per problem). If the approach to the problem is not clear after that amount of time and any hints provided have been considered, STOP and seek help from classmates or from me via office hours, email, discussion board, telephone, etc. It may occasionally be beneficial or even necessary to interact with me once or multiple times to resolve any conceptual misunderstandings. I recommend posting your questions on the Class Discussion page. Late work will be penalized.

"Flip" sessions are scheduled for most weeks of the quarter: these are workshop sessions where class members present solutions to problems, discuss applications, and otherwise share information about concepts and quantitative aspects of the class. In many cases, assigned homework will be the basis of "flip" examples.

3. Quizzes:
This class will make routine use of "PollEverywhere": short in-class queries displayed in lectures. Responses require a text-message capable cell phone, or a smartphone, laptop, or tablet. For more information about how this resource works, go **HERE**. Online quizzes will be assigned roughly every other week, to be completed by 10AM on the date due. Students must work independently within the stated time limit. For calculation problems, I will routinely accept a worksheet completed while taking the quiz, to award partial credit. This should be turned in during the fist class session following the due date for the quiz. If there are any unforeseen circumstances that prevent you from submitting your answers, please contact me and I will provide a second login opportunity. Answers to quizzes will be discussed in class.

4. Participation:
Asking questions and stimulating discussion during lectures is strongly encouraged. Preparation for flip sessions should include reviewing example problems and (when provided) looking at the questions to be covered in class.

Evaluation

Course grades will be based on the following:

• (35%) Homework & Quizzes
• (15%) Flip session and other in-class participation
• (20%) Midterm exam
• (30%) Final exam

Disability Accommodation: Students with disabilities are welcome to request academic accommodations due to a disability. To request academic accommodations due to a disability, please contact Disability Resources for Students, 448 Schmitz Hall, 206-543-8924 (V/TTY). If you have a letter from Disability Resources for Students indicating that you have a disability which requires academic accommodations, please present the letter to me so we can discuss the accommodations you might need in this class.

Text and resource materials

Required:
• Chemical Fate and Transport in the Environment (3rd ed.), Hemond and Fechner-Levy, Academic Press, 2015. (ISBN: 978-0-12-398256-8)

comments: this is a quantitative but simplified overview, and is organized by major parts of the environment (surface water, groundwater, air). It emphasizes predictive models, and does not cover much chemistry. The main strength of the book is in sections describing environmental distribution and transformation processes by environmental medium (air, water, soil). The book is 90% similar to the 2nd edition, but I will be referencing info in the new edition only.The combination of the Schwarzenbach text (below) to supply the basis for chemical properties and behavior, and this book to apply that information quantitatively is a good introduction to the overall topic of environmental fate of pollutants.

A limited number of copies were ordered by the UW Bookstore, Health Sciences branch. The text is available new or used via Amazon, and also as an e-text for purchase or rent. Online prices: $30 - $80, plus shipping. There is one copy in the Engineering library, reference reserves.

Other resources:

• *Environmental Science & Technology*, Journal: American Chemical Society, 1967-present
• *Journal of Exposure Science & Environmental Epidemiology*,

comments: In order to update the material in the above text, we will read and discuss recent articles in ES&T. This journal publishes the latest environmental research through a critical peer-review process and has the highest impact factor for environmental scientists and engineers. Another journal we will refer to is the Journal of Exposure Science & Environmental Epidemiology. It publishes research important to exposure assessment for toxic substances, environmental epidemiology that includes a strong exposure analysis component & related disciplines that advance the exposure assessment process.Access is available through UW library system and the course website. From UW computers, you should have full access.

ES&T URL: http://pubs.acs.org/journal/esthag

JES URL: http://www.nature.com/jes/index.html

Other (non-required) Texts
• **Integrated Environmental Modeling** (http://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_bookid=1727) - Pollutant Transport, Fate, and Risk in the Environment, by Ramaswami, Milford, Small. Wiley & Sons 2005.

comments: this textbook is available as an e-text via course reserves at UW libraries (and the SCC bookstore may have a limited number of hardcopies). You can read it on line or download it, by chapters. It is strong on covering the range of topics from basic science to risk calculation and regulation. The book is intended as a guide to environmental modeling packages, but we will not emphasize that aspect. We will focus on the book's presentation of the underlying processes and relationships that are used by the various models to simulate environmental behavior.

• Environmental Organic Chemistry, Schwarzenbach, Gschwend and Imboden, Wiley Interscience, 1993 or 2002.

comments: this text emphasizes basic chemistry concepts and the accompanying workbook provides numerous problems and examples. The book is very rigorous in its grounding in physical chemistry, and is pretty encyclopedic (the current edition runs about 1300 pages!!). I use it as a reference, but if you are looking for extra practice problems to supplement the homework, you can find them in this book. This text assumes a strong chemical background.

• Pollution Science, Pepper, Gerba, Brusseau (Eds.) Academic Press, 2006 or 1996.

comments: this text is less focused on physical chemistry principles and gives more coverage to other natural sciences that influence pollution processes. It is more descriptive and less rigorous than Environmental Organic Chemistry, but offers greater breadth and more "real world" examples. It also gives better coverage of inorganic pollutants.

• Multimedia Environmental Models, MacKay, Lewis Publishers, 2001 or 1991.

comments: this book is great at emphasizing the physical distribution processes and modeling approaches, but does not present much chemistry. It also mainly reflects MacKay's system for using the thermodynamic property fugacity as a basis for the calculations. It would be a good text for a follow-up course to 552. You may find it useful for its introductory chapters.

• Aquatic Chemistry, Stumm and Morgan, Wiley-Interscience; 3rd edition (1996).

• Water Chemistry, Benjamin, McGraw-Hill (2001).

• Environmental Chemistry, Baird and Cann, W. H. Freeman (2008)

• Lastly, if you like the hands-on aspects of modeling, but don't want to learn to use the fully-developed and fairly complex models in current professional use (as the Ramaswami book details), a good book to look at is Andrew Ford's Modeling the Environment (Island Press, 2010). This book shows you how to construct models using two model-building packages, Vensim and Stella. There is a good graphical feature in each package, so you can plot outcome variables and tweak inputs and/or model algorithms.

NOTE: THE QUARTER SCHEDULE SHOWN BELOW IS SUBJECT TO CHANGE AND WILL REFLECT THE MOST RECENT AND ACCURATE INFORMATION WHEN VIEWED ON-LINE. DOWNLOADED VERSIONS OF THE SYLLABUS MAY NOT HAVE CURRENT SCHEDULE INFORMATION. REVISIT THE LIST TO CONFIRM ASSIGNMENTS AND OTHER KEY DATES.