Summer Semester 2004

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Course Description:

Environmental chemistry is the study of the processes that affect the fate and transport of specific compounds that act as contaminants on local- to global-scale levels. In general, the compounds under consideration tend to be anthropogenic contaminants (those compounds, both organic and inorganic, released into the environments from human activities). The behavior of contaminants is influenced by physical, chemical, and biological processes naturally occurring within various ecosystems. This course describes these processes and the extent to which they affect different classes of contaminants.

However, environmental chemistry does not limit itself to the study of processes that affect synthetic or human-produced compounds (their reaction rate, speciation, degradation, sorption, etc.). In the context of this course, we consider the term “environmental chemistry” in a broader geochemical context. Indeed, we recognize that in some areas of the world, the speed and scale of environmental perturbations seem to be of such a magnitude that they have led to regional and global geochemical disruptions with subsequent releases of naturally occurring surface/subsurface materials that can generate a certain amount of toxic burden within an ecosystem.

The environmental chemistry section of the course is divided into three subsections of the global environment: Water, Soils and Sediment, and Atmosphere. Within each subsection, we will first describe the system in terms of physical processes and chemical constituents. Using case studies of selected contaminants potentially found in each system, we will then explore the fate (i.e. reactions) and transport modes that may affect the potential availability of these contaminants (or how environmental quality criteria are adversely affected) and lead to toxicological effects at the ecosystem level.
Environmental toxicology is the study of the effects of different contaminants on the health of all organisms within an ecosystem, with a particular focus on human health. While toxicologists study a wide variety of toxicants, from naturally occurring poisons (venoms) to synthetic chemicals, this course will emphasize anthropogenic toxicants. Factors that influence the absorption, distribution, metabolism, and excretion of toxicants as well as individual susceptibility to intoxication based on behavioral and genetic traits will be addressed to provide context for the idea of dose-response. While these principles will be presented using human subjects as examples, the fundamentals may be applied to a diversity of organisms. This course will focus on the scientific basis of toxicology and extend these basic principles to current topics in toxicological research (e.g., genetic toxicology, reproductive toxicology). Additionally, applications of toxicology will be addressed through a comparison of risk assessment and environmental epidemiology.

In both the environmental chemistry and toxicology sections, we have decided to use an “environmental principles” approach rather than describe all the possible alterations for each particular set of anthropogenic contaminants. Using the knowledge gained from this course, each student will be able to estimate the environmental and toxicological fates of groups of compounds given its chemical nature and the system within which the compound is released. Most importantly, this course uses an approach of “authentic inquiry” in its pedagogical approach, namely that students are exposed to authentic methods of scientific inquiry rather than a suite of algorithmic solutions to specific environmental issues. The main goal of this course is to foster an understanding of how environmental scientists think and solve environmental issues and most importantly to develop an expertise in assessing the validity of scientific research and its conclusions.

Course Outline: The approach of the course will follow a general sequence of themes that will 1) define general chemistry concepts, 2) introduce the notion of chemical reactions and transport modes in different environments, and 3) define chemical mobility (and thus potential bioavailability) and reactivity based on the nature of chemicals and the media in which they occur (i.e. water, solids, air). A special session will be devoted to radioactivity (both natural and anthropogenic) and the environment.

Daily Activities: Lecture sessions will include discussion and explanation of reading and/or web material, and how to apply critical thinking to environmental geochemistry and toxicology questions. The schedule below is a preliminary outline of the semester. Reading assignments will be provided and should be completed before the stated lecture date. Additional reading or reference material may be suggested during the course of the lecture. Laboratory sessions will involve both hands-on and minds-on exercises that will require either individual or small group work/reporting.

Evaluations:
1. Lab exercises will involve hands-on/minds-on exercises with reports due at a subsequent lab meeting.
2. A final semester analytical paper/project will be given in the Environmental Chemistry section. This project will involve analyzing specialist literature on selected scientific research areas that are linked to current or recent environmental policy issues. The goal of the project is to a) determine hypotheses on the general issue selected based on 1-2 current articles, b) collect evidence from the specialist literature (peer-reviewed) supporting/refuting the initial hypothesis(es), and c) formulating a conclusive statement with regards to this issue and develop arguments on how it is linked (or should be linked) to environmental and public policy. It will
be critical in this work to determine the inconsistencies in the science (if existing at all) and how these inconsistencies should (should not) prevent policy actions. Approximately 7-8 weeks will be given to each group to perform this analysis and produce a paper. Each group paper will then be given 2 weeks to review the paper of another group in the same manner that scientists review the publications and research proposals of their peers. The peer revisions of the papers will be graded according to pre-set and well-defined criteria. The final papers will be due on Tuesday August 03. The peer review will be due on Tuesday August 17.

3. The “Toxicology” section will only include lab exercises based on case studies.

Policy on Late Submissions of Labs and Papers:
Ten percent (10%) of the grade will be deducted per day if the lab reports and group papers are submitted past the due date. Materials that are submitted more than one week late will not be accepted.

Grades will be based on the following:
- 70% on Environmental Chemistry
- 30% on Environmental Toxicology.

Environmental Chemistry:
- 40% on labs and assignments
- 40% on final paper
  - Literature review (40%)
  - Multidisciplinary analysis of issue (40%)
  - Presentation (20%)
- 20% on peer review

Environmental Toxicology:
- 100% on labs and assignments

Attendance Policy:
Attendance of lectures is strongly encouraged since complementary material, in addition to required readings, will be presented in lectures and included in examinations/discussions.

Course Outline

Environmental Chemistry Section

1) Class 1: June 03, Introduction - Scientific Method - General Chemistry

Objectives: (Louchouarn Lead)
- Introduction of course: goals and objectives, etc.
- The scientific method (hypothesis testing, deduction, what’s in a number, etc)
- Basic concepts of general chemistry.

Read: Library Folder #1

Lab 1: Math review #1
2) Class 2: June 10, Mass Balance - Solutions

**Objectives: (Louchouarn Lead)**
- Review of chemical reactions and mass balance concepts
- Solutions

**Read:** Library Folder #2
Williams Sections 1.10, 7.4-7.8

**Lab 2: Chemical Equations - Analytical Chemistry: Measuring contaminants**

3) Class 3: June 17, pH - Acid Rain

**Objectives: (Louchouarn Lead)**
- Solution equilibrium (distribution of species in water): pH
- Acid Rain

**Read:** Library Folder: Acids & Bases
Williams Sections 7.9-7.11

**Lab 3: Scientific Inquiry: pH & Alkalinity**

4) Class 4: June 24, Atmosphere

**Objectives: (Louchouarn Lead)**
- Tropospheric chemistry (gases, aerosols, particulate matter)
- Chemistry of urban and indoor atmospheres

**Read:** vanLoon Chaps. 6-7

**Lab 4: MTBE Atmosphere to Aquifer Transfer**

5) Class 5: July 01, Aquatic Media

**Objectives: (Louchouarn Lead)**
- NOM and Eh: Power of Ecosystems
- O₂ vs BOD
- Metal Speciation
- Fate of contaminants in dissolved phase

**Read:** vanLoon’s Chaps. 10, 13

**Lab 5: Contaminant Modeling in a Reservoir (applications to freshwater management)**

6) Class 6: July 08, Solids: Soils, Sediments, and subsurface systems

**Objectives: (Louchouarn Lead)**
- Environmental chemistry of colloids and surfaces
- NOM and Eh: Power of Ecosystems

**Read:** Folder: Colloids
vanLoon Chaps. 14, 18

**Lab 6: Sediment and Contaminant Dispersion in a River-Estuary System**

7) Class 7: July 15, Radioactivity

**Objectives: (Louchouarn Lead)**
- Natural and anthropogenic radionuclides in the environment
Read: vanLoon Chap. 7.3 (p. 142-146)

Lab 7: Radon in Basement

Toxicology Section

8) Class 1: July 22, Overview Of Human Health Risk Assessment – Environmental Epidemiology

Objectives: (Williams Lead)

- Benefits/Limitations
- Regulatory Roots
- Epistemology Of Risk Assessment

Read: Chaps. 1-4

Lab 1: Epidemiology Lab

Environmental Chemistry Final Papers Due: Tuesday August 03

9) Class 2: July 29, Basic Exposure Assessment Methods and Design

Objectives: (Williams Lead)

- Basic Epidemiological Principles
- Types Of Studies
- Role in Exposure and Risk Assessment
- Dose-Response Assessment
- Definitions, Routes, Determinants Of Exposure
- Generalized Dose Equations

Read: Chaps. 1-4.

Methods Of Assessing Risk To Health From Exposure To Hazards Released From Waste Landfills. Report From A WHO Meeting Lodz, Poland, 10 - 12 April 2000.

Lab 2: Toxicology Lab

10) Class 3: August 5, Hazard Identification - Basic Toxicology - Biomarkers

Objectives: (Williams Lead)

- Identification Of Chemicals Present That May Affect Human Health
- Identification Of Unwanted Health Effects Of Chemicals That Are Emitted Or Released.
- Fate And Transport
- Absorption, Distribution, Elimination
- Biotransformation
- General Mechanism Of Action
- Modifying Factors
- Biologic Markers Of Exposure (e.g., effect and susceptibility)


Lab 3: Toxicology Lab

Peer Review of Environmental Chemistry Papers Due: Tuesday August 17

11) Class 4: August 12, Exposure and Risk Assessment Data - Risk Characterization

Objectives: (Williams Lead)
• Data Quality
• Data Analysis and Presentation
• Quantifying Carcinogenic Versus Non-Carcinogenic Effects
• Slope factors
• Combining Data For Mixtures Of Chemicals Or Routes Of Exposure
• Uncertainty And Variability

Read: -) Chapters 6-7.
-) Methodologic Issues in Epidemiologic Risk Assessment By Markku Nurminen, Tuula Nurminen, and Carlos F. Corvalan (1999) by Epidemiology Resources Inc.

Lab 4: Risk Characterization

READINGS

Required:
1) "Human Exposure Assessment" (2001) - by M. Berglund, C-G. Elinder, and L. Järup. World Health Organization. (Available online on our course website)

2) Several scientific articles will be posted on the course web site during the semester.

Supplementary (these books are suggested to complement class material but are NOT required - Most of these readings are available in Reserve in Lehman Library):