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 land 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, Subsurface 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.
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. Several assignments will be given during the course of the semester. These will consist of take home exercises due at a subsequent lecture meeting.
2. Lab exercises will involve hands-on/minds-on exercises with reports due at a subsequent lab meeting.
3. A final group presentation-paper that will be take form as a scientific communication during a mock symposium at the end of the semester.
4. The “Toxicology” section will have a final exam scheduled for the end of the section and will be composed of short answers and critical thinking questions.

Grades will be based on the following:

* 70% on Environmental Chemistry.
* 30% on Environmental Toxicology.

Environmental Chemistry:
- 60% on labs and assignments
- 40% on final project
  - Methodology (10%)
  - Analysis/Report (20%)
  - Presentation (10%)

Environmental Toxicology:
- 60% on labs and assignments
- 40% on final project

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. Discussion periods will also require in class participation from all students.
Environmental Chemistry Section

Class 1: June 12 – 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: June 13 – Math review #1

Class 2: June 19 – Reactions and Transport

*Objectives: (Louchouarn Lead)*

- Review of chemical reactions
- Contaminant transport

*Read:* Library Folder #2
  vanLoon’s Chap. 1

Lab 2: June 19 – Analytical Chemistry: Measuring contaminants

Class 3: June 26 – Water: Solubility, pH

*Objectives: (Louchouarn Lead)*

- Chemical and physical properties of water
- Solution equilibrium (distribution of species in water): pH

*Read:* vanLoon’s Chaps. 9, 10

Lab 3: June 26 – Contaminant Transport in a River-Estuary System

Class 4: July 03 – Water: pH, Eh

*Objectives: (Louchouarn Lead)*

- Solution equilibrium (distribution of species in water): pH, Eh
- Organic matter in water

*Read:* vanLoon’s Chaps. 10, 12

Lab 4: July 03 – Water Quality Lab

Class 5: July 10 – Solids: Soils and Sediments (Differences/Similarities)

*Objectives: (Louchouarn Lead)*

- Differences and similarities of soils and sediments: Their role in environmental chemistry/geochemistry

  vanLoon’s Chaps. 17, 18

Lab 5: July 10 – Contaminant Modeling in a Reservoir
Class 6: July 17 – Solids: Reactions, Sorption, Bioavailability
*Objectives: (Louchouarn Lead)*
  - Environmental chemistry of colloids and surfaces
*Read:* vanLoon’s Chap. 14

Lab 6: July 17 – First presentation of Final Projects – Assignment #1

Class 7: July 24 – Radioactivity
*Objectives: (Louchouarn Lead)*
  - Natural and anthropogenic radionuclides in the environment
*Read:* Library Folder #3

Lab 7: July 24 – Radioactivity

Class 8: July 31 – Air: Local to Global Atmospheric Pollution
*Objectives: (Louchouarn Lead)*
  - Photochemistry, tropospheric chemistry
  - Chemistry of urban and indoor atmospheres
*Read:* vanLoon’s Chaps. 4, 7

Lab 8: July 31 – Preparation of methodology for Final Projects – Assignment #2

**Toxicology Section**

Class 1: August 7 – 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: August 7 – Epidemiology Lab

Class 2: Aug. 11 (AM) – 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.
Class 3: Aug. 11 (PM) – Hazard Identification (Morningside Heights)
- Identification Of Chemicals Present That May Affect Human Health
- Identification Of Unwanted Health Effects Of Chemicals That Are Emitted Or Released.
- Fate And Transport

Class 4: Aug. 14 – Basic Toxicology - Biomarkers
Objectives: (Williams Lead)
- Absorption, Distribution, Elimination
- Biotransformation
- General Mechanism Of Action
- Modifying Factors
- Biologic Markers Of Exposure (e.g., effect and susceptibility)


Lab 2: Aug. 14 – Toxicology Lab

Class 5: Aug. 18 – 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 3: Aug. 18 – Risk Characterization

Final Examination: August 21.