Spring 2025

ESM 202 Environmental Biogeochemistry

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OH: T/R 3:30 – 5 pm, or by appt (including off hours Zoom as needed)

Lectures: In Bren 1414 9:30 – 10:30 am Tuesday and Thursday

The goal of this course is to provide you with a scientific basis to understand:

- Cycling of elements in the environment
- Biotic and abiotic factors
- Human alterations
- Problems and solutions

Course Coverage
The course provides an understanding of biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur, and trace elements, that result in greenhouse-gas driven climate change, ocean acidification, stratospheric ozone depletion, acid rain, acid mine drainage, air/water/soil pollution, decreased human and ecological health, and many other consequences. The course also covers persistent organic pollutants, pesticides, emerging organic contaminants, microplastics and other chemicals used by society. In addition to understanding basic chemistry, students learn about the major sources and drivers, human and ecological toxicological implications, technical and policy solutions available, and the potential unintended consequences of some solutions. The material is basic to most major environmental problems including climate-amplified disasters, pollution, waste management, and implications of other environmental management strategies in conservation, and natural resources.

Skills Taught

Basic chemical principles – Taught in the context of water, soil, and air quality, students learn about the importance of key parameters that influence biogeochemical cycles or increase/decrease toxicity of chemicals, such as pH, redox conditions, dissolved oxygen, alkalinity and the presence/absence of sequestering ions such as sulfide. These key concepts are important for understanding important tipping points (equilibria) in various biogeochemical cycles, as well as in the design of solutions.

Major drivers of change – Designing and implementing solutions to these major environmental problems, requires a clear understanding of the drivers, their magnitude (who are the major emitters?), the type of emissions (In what form is carbon or nitrogen being emitted?), at what stages in a life cycle (extraction, processing, use, disposal), and from what sources (major point and non-point sources). Regulatory frameworks (USA, EU, UN/IPCC) may be invoked for these sources and their shortcomings.

Effects – Student learn about the implications of disturbances to biogeochemical cycles, such as hypoxia, toxicity of ammonia vs. nitrate and nitrite, difference in warming potential between different greenhouse gases, trade-offs between older chlorofluorocarbons and their

replacements to reduce stratospheric ozone depletion, human toxicity, approaches for determining ecotoxicity (from molecular processes to ecosystems).

Solutions – What are some of the proven solutions? What are the leading-edge proposed solutions to reduce emissions or mitigate impacts?

Critical Analysis – What are the unintended consequences of many "solutions"? Why is policy important for implementing solutions? What are EJ considerations of impacts and solutions? What can be done at the personal level? How do corporations play a role? What does "the dose makes the poison" mean? How long will it take to see the benefits of the solutions? How to form a critical perspective without despairing?

LECTURES

Week 1	Introduction: relevancy of biogeochemistry Understanding water quality: Part I
Week 2	Understanding water quality: Part II Eutrophication and phosphorous
Week 3	N Cycle – sources, processes and effects Understanding Air quality (AK)
Week 4	Sulfur cycle – sources, processes and effects (AP) Acid mine drainage
Week 5	Methane biogeochemistry (JM) Carbon cycle (terrestrial)
Week 6	Carbon cycle (oceanic) (AP) MIDTERM (May 8, in class)
Week 7	Wastewater treatment Pathogens in the environment
Week 8	Trace elements – sources, processes and effects Lead and mercury
Week 9	Industrial ecology (RG) Emerging pollutants (AK)
Week 10	Ecotoxicology Review / synthesis
June 10	FINAL EXAM (8-11 am, in class)

DISCUSSIONS

TAs: Leo Feitosa
Liviu Iancu

Week	Topics
1	Chemistry boot camp (Or what I really need to know to make the most of this course)
2	Water quality concepts
3	N & P biogeochemistry
4	Air quality concepts & Sulfur cycle
5	Carbon cycle
6	Review for midterm
7	Trace elements
8	Emerging pollutants
9	Open topic
10	Review for final

GRADING

- Assignments: 3 x 15% each (#1 Due Week 3, #2 Due Week 8, #3 Due Week 10, on Fridays)
  - The assignments are INDIVIDUAL, and be careful when using information from a published source to express it in your own words after you analyze it
- Midterm: 20%
- Final: 35%

Homework #1	4/1 to 4/25
Homework #2	4/6 to 5/23
Midterm	5/8
Homework #3	5/24 to 6/6
Final	6/10

Reading Materials

Textbook 1: Biogeochemistry: An Analysis of Global Change (3rd Edition), by Schlesinger and Bernhardt

Available from Amazon to buy or rent

Textbook 2 : Solve, by Purvis-Roberts and Spiro

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Students who identify themselves as being enrolled at UCSB, may order a print copy of SOLVE for the discounted price of $49. Shipping will be extra. Students may order by calling our warehouse at 703-661-1572.

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Week		Textbook 1 (Biogeochem)	Textbook 2 Solve	Additional
1	Intro & WQ1	Chapter 1	Chapters 1 & 12.1-12.4	Article on Water Quality
2	WQ2, N&P	Chapters 6 and 12	Chapter 14, 15.1-15.3, 16.1	
3	N & Air Q	Chapter 3	Chapter 9 & 10	
4	S	Chapter 13	Chapter 12.5	
5	C and Wetlands	Chapters 5, 9 and 11	Chapter 5, 13.4	
6	C	Chapter 7		
7	Wastewater Pathogens		Ch	Article on Pathogens
8	Trace Elements Pb & Hg		Ch 5.7, 15.6, 15.8, 18.5	Article on Trace Elements
9	Industrial Ecology Contaminants		Ch 15.6, 17, 18	Articles on Contaminants & Toxicology
10	Synthesis	Chapter 14		

Additional articles will be posted to the course website in Canvas.

Homework assignments will be posted in Canvas.