Winter 2024

ESM 202 Environmental Biogeochemistry

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OH: open door policy/email appt.

Lectures: In Bren 1414 8:00 to 9:30 am Tuesday and Thursday

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

- Major disturbances to cycling of elements in the environment
- Pollution and its implications
- A range of approaches to understand and develop solutions to these problems
- How this is relevant in your daily life as well as for your career

Course Coverage

The course provides future environmental managers an understanding of the major human-driven disturbances to 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 negative consequences. The course also covers persistent organic pollutants, pesticides, emerging organic contaminants, microplastics and other chemicals used by society. In addition to understanding the basic chemistry, students learn about the major sources and drivers of these impacts, human and ecological toxicological implications, the range of technical and policy solutions available, and the potential unintended consequences of some solutions. While not all MESM students will use these concepts in their careers, this knowledge is important when making decisions that affect these cycles, and also for personal choices.

Skills Taught

Basic chemical principles – Taught in the context of water 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). We briefly discuss the regulatory framework (USA, EU, UN/IPCC) for these sources and their short-comings.

Effects – Student learn about the implications of the disturbances to biogeochemical cycles, such as inability of marine organisms to form shells when pH decreases in the ocean, 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	Why is biogeochemistry relevant for solving environmental problems? Understanding water quality: Part I
Week 2	Understanding water quality: Part II Eutrophication and P cycle
Week 3	N Cycle – sources, processes and effects Understanding Air quality
Week 4	Sulfur cycle – sources, processes and effects Acid mine drainage
Week 5	Carbon cycle dynamics (major drivers of emissions) Terrestrial and oceanic carbon processes
Week 6	Wetland biogeochemistry MIDTERM (Feb 15, in class)
Week 7	Trace elements – sources, processes and effects Lead and mercury
Week 8	Emerging organic pollutants Ecotoxicology
Week 9	Micro and nano pollutants Modeling Biogeochemistry to Inform Policy Decisions
Week 10	Biogeochemistry and you Synthesis and interactions
March 18	FINAL EXAM (8-11 am, in class)

DISCUSSIONS

TAs: Yuki Floyd
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 4, #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
- Weekly short quizzes, to motivate you to keep up with the course.
  - There is no downside to the quizzes: if you do them, you can improve your final grade, but if you don't get them correct it will have no negative impact on your final grade.
  - We will post them every Thursday and you are expected to complete them by the following Monday evening.
  - If you can answer them without even looking at your notes, you are doing great. If you need to look at your notes, that is good. If you are stumped even after looking at your notes, then it is time to bring the questions to the Discussion Section or Office Hours.
- Midterm: 20%
- Final: 35%

Homework #1	1/15 to 2/2
Homework #2	2/2 to 2/23
Midterm	2/15
Homework #3	2/26 to 3/15
Final	3/18

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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

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	Chapters 5, 9 and 11	Chapter 5, 13.4	
6	Wetlands	Chapter 7		
7	Trace Elements		Ch 18.5	Article on Trace Elements
8	Pb & Hg Emerging Contaminants		Ch 5.7, 15.6, 15.8	Article on Emerging Contaminants
9	Micro & nano Toxicity		Ch 15.6, 17, 18	Article on Ecotoxicology
10	Synthesis	Chapter 14		

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

Homework assignments will be posted in Gauchospace.