E544(E400) Subsurface Microbiology and Bioremediation

School of Public and Environmental Affairs
Indiana University
Fall 2003

Course Time:	11:15 AM - 12:35 PM , M W	
Location:	SPEA 275	
Instructor:	Flynn Picardal	Email: PICARDAL@INDIANA.EDU
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Office Hours: Tuesday 2-4 PM, and by appointment

Course Description:

Improper disposal of hazardous waste, leaking underground storage tanks, and other activities have resulted in widespread pollution of the environment by inorganic and organic chemicals. Bioremediation involves using microorganisms, i.e., bacteria and fungi, in the subsurface or soil to degrade or detoxify such pollutants. Bioremediation is often considered the technology of choice when considering alternatives for remediation of hazardous waste sites. Bioremediation frequently offers the potential for (i) complete destruction, (ii) immobilization, or (iii) detoxification of a contaminant, often without the production of hazardous ash, sludges, or other waste products. A thorough understanding of the process requires knowledge about the microorganisms present in the subsurface, the physiology and biochemistry of degradation processes, rates of degradation, and the control and enhancement of these processes in environmental matrices.

In general, this course will explore how microorganisms and microbial processes affect the transformation of organic and inorganic chemicals in the subsurface. Emphasis will be given to the biodegradation of man-made organic pollutants and in situ bioremediation of waste sites. Specifically, the course will include study of the following topics:

1) Microbiology of the subsurface including:
   - methods of counting microorganisms in the subsurface;
   - measurement of subsurface microbial activity;
   - relevant aspects of microbial physiology, genetics, and degradation kinetics.
2) Geochemical interactions and microbial iron cycling.
3) Biodegradation and bioremediation of aliphatic and aromatic hydrocarbons.
4) Biodegradation and bioremediation of chlorinated organic compounds.
5) Bioremediation of metals and radionuclides.

Required Text:

- Groundwater Microbiology and Geochemistry 2nd Edition, 200,1 F. H. Chapelle, John Wiley

- Additional required reading will be placed on reserve in the SPEA library or distributed in class.
- Copies of overheads used in class will be distributed in class, placed on reserve, or available for purchase at a local copy center.

Recommended Text(s):

Microbial Transformation and Degradation of Toxic Organic Chemicals, L. Y. Young and C. E. Cerniglia, editors (1995)

The course will include a brief review of microbial physiology and biochemistry. Some students may also find it helpful to have an additional microbiology text to help review relevant topics. There are many texts which would be suitable. Some suggestions are:

1) General Microbiology. Hans G. Schlegel. Cambridge University Press
2) Bacterial Metabolism Gerhard Gottschalk. Springer-Verlag
3) The Microbial World Stanier et al. Prentice-Hall
4) Biology of Microorganisms Brock et al. Prentice-Hall

Assignments

Periodic homework assignments will be given. At least one week will be allowed to complete the assignments. Late homework will be accepted for a period of two weeks after the due date, but late homework will be subject to a penalty. If turned in within one week after the due date, the grade for that assignment will be reduced by one letter grade. If turned in within 2 weeks, the grade for that assignment will be reduced by two letter grades. For example, a perfectly completed assignment turned in ten days late would receive a 'C' rather than an 'A'. After two weeks the assignment will not be accepted.

Students in E544 will be required to make one 10-minute presentation. This will consist of a critical review of a research paper focusing on microbial:metal interactions. This review will involve a summary of (i) objectives of the work, (ii) methods, (iii) results, and (iv) discussion and criticism. Everyone will need to read the paper prior to the presentation.

Grading Policy:

Grades will be assigned as follows:

20% homework, 10% presentation, 35% midterm, 35% final

Attendance Policy:

It is acknowledged that individual students learn in different fashions. For some, attendance at all classes is necessary to learn the subject and achieve a good grade. For others, attendance at all classes may be less critical. It is assumed that all students are aware of what works most effectively for them. Attendance, therefore, will not be taken during class unless required for administrative purposes. Be aware, however, that you are responsible for what is covered in class. This will vary substantially from what is in the text. It is suggested, therefore, that you attend class. You are also required to (i) turn in assignments when due , (ii) be aware of any announced changes in the syllabus schedule, and (iii) take all tests on the scheduled dates.

Extra Credit:

There will be no extra credit assignments.

Tentative Schedule: (Dates are approximate)

Date	Topic	Reading
September 1	Introduction and course overview	
Sept 3	Soil and subsurface environments	Chapters (1), 2
Sept 8 - 17	Subsurface microbial populations. How to study them. Bacterial classification systems, enumeration methods Measurement of microbial and enzymatic activity. Detection of catabolic gene sequences in environmental samples	Chapters 3,5,7,8 Paper 1 (Sinclair & Ghiorse) Paper 2 (Fredrickson & Onstott)
Sept 22 - 24	Growth and enzyme kinetics	Chapter 4
Sept 29 - Oct 13	Microbial metabolism and energy production Thermodynamics and bioenergetics Substrate level and oxidative phosphorylation Anaerobic respiration	
Oct 15	Catch-up, Review, Misc. Topics	
Oct 20	MIDTERM	
Oct 22 -27	Geochemical interactions and microbial iron cycling	Chapter 9 Paper 3 (Nealson & Saffarini) Paper 4 (Lovley)
Oct 29 - Nov 19	Biodegradation and bioremediation of aliphatic and aromatic hydrocarbons Biochemical pathways. Bioventing, land treatment, biopiles, slurry-phase treatment Case history reviews	Chapters 11,12
Nov 24 - Dec 3	Biodegradation and bioremediation of chlorinated cmpds. Aerobic and anaerobic degradation Review of remediation case studies PCB biodegradation and PCBs in Bloomington	Chapter 13
Dec 8 - 10	Bioremediation of metals and radionuclides, review	DOE booklet