

## BIOGEOCHEMISTRY OF WETLANDS - SWS 6448

DE Section No: 0958 and 1379

### Contacts:

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## Instructions for Distance Education Students

SOS 6448; Section No: 0958 and 1379

Biogeochemistry of Wetlands is a graduate level course taught in the Soil and Water Science Department of the University of Florida. The course is offered during the Fall Semester of each year.

This course is offered in a web-based environment; the format of which involves self-guided learning by systematically following an image and an accompanying image narrative. The course consists of 10 modules, an outline can be found in the course syllabus. Both sections, on campus and off campus, will be taught in parallel. Taking the course via distance education requires self discipline and rigorous adherence to the lecture schedule set up by the instructor. The following instructions should help with organizing the distance education, please read the instructions before proceeding to the first lecture.

Although the conveniences associated with distance education are evident, this teaching format does entail a series of unique drawbacks that we hope to overcome by utilizing a series of internet tools. Classical educational format includes an important element that must be virtually simulated in distance education; the interaction between the instructor and the student as well as the interaction between students in the class-room. By using elements such as e-mail, chat rooms, etc. we hope to overcome this inconvenience. In order to communicate, frankly to teach, we encourage students in distance education to be as “noisy” as possible in every possible way, for that is the only way we will be able to tell if the course format and schedule suits the students and how you as a student are doing with the material.

Initially, we need from you:

- Your e-mail and a contact phone number
- A recent photograph sent either electronically or by regular mail. The intent is to create a class setting and have a face with a name. The picture will only be placed on a password protected site.

### Course Format

The course is taught in 10 modules that will be released at a set schedule. Each module consists of 50 -100 images and associated texts presented as book chapters. This combination represents the bulk of the class material; additional information can be obtained in the references. Make your own notes on each module.

The course modules will be released on accordance to a set schedule. You will have access to one module at a time. At the beginning of each week, the instructor will assign the number of slides to be studied over the period of that week. In order for you to remain on schedule, the study of this material must be completed during that week. Even though the entire module is released and available, we strongly recommend you limit yourself to the material assigned by the instructor so as to gain a reasonable understanding of the material. Associated to each module will be the reading material that may elucidate the material in the texts or slides.

*The material for the course can be accessed at <https://swsde.ifas.ufl.edu/>. You need Gator Link account and password to login.*

### Technology Checklist

The technology checklist provides recommendations for students enrolled in the Distance Education Graduate Track in Environmental Science. It is the responsibility of the student to have access to a personal computer (or laptop), the Internet, and maintain the functionality of peripherals (e.g. web cam and audio system) to successfully participate in distance education courses offered by the Soil and Water Science Department.

- Personal computer or laptop with sufficient hard drive space to store course materials and speakers
- Operating system: Windows XP, Vista
- Software: MS Office Suite (incl. Word, Excel, and Power Point); Adobe Akrobat (to view pdf files), and a web browser
- High-speed internet access (e.g. broadband, DSL, satellite modem, cable modem)
- Web camera (optional)
- External microphone (e.g. headset with build-in microphone, voice over IP device) is required.

Internet access and an internet browser. The course material is presented at:

<https://swsde.ifas.ufl.edu/>

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- I. COURSE DESCRIPTION: Environmental and ecological significance of biogeochemical properties of wetlands and aquatic systems in relation to elemental cycling.
  - II. COURSE OBJECTIVES: To provide students with the basic concepts involved in biogeochemical cycling nutrients in wetlands and aquatic systems.
  - III. COURSE FORMAT: Internet- Chat sessions.
  - IV. FREQUENCY TAUGHT: Fall Term
  - V. CHAT SESSION ATTENDANCE: Required.
  - VI. GRADING SYSTEM:

Associated to each module will be an assignment that must be completed. This assignment will consist of a series of study questions and an open ended problem. A second set of assignments will be released associated to the reading material. Timely submission (one week after the release of the assignment) of the assignments is critical for proper grading and credit. Each student is required to submit a term paper, instructions as to the format and content of which will be released during the first week of the semester. All project reports are due by November 29, 2009.

Your understanding of the material will be tested with two tests during the semester. All test will be open book but time limited. In order for us to achieve this, we will agree upon a specified time. The exam will be released and the completed exam will be expected back within a set timeframe. As indicated initially, the amount of interaction is also important. Chat session attendance and participation are required. Special permission should be obtained, if the student is not able to attend the chat session.

Special project [EcoLearnIT]	20%
Exam # 1	25%
Assignments	10%
Exam # 2	25%.
Presentations	15%

All assignments, further instructions (such as for the term paper) and exams will be posted at: <http://swsde.ifas.ufl.edu/faculty/classes.asp>

## VII. TEXTBOOK

K. R. Reddy and R. DeLaune. 2007. Biogeochemistry of Wetlands: Science and Applications. Pp. 774.

## VIII. UNIVERSITY REQUIRED ANNOUNCEMENTS:

**Academic Honesty:**

As a result of completing the registration form at the University of Florida, every student has signed the following statement: "I understand that the University of Florida expects its students to be honest in all their academic work. I agree to adhere to academic honesty and understand that my failure to comply with this commitment may result in disciplinary action up to and including expulsion from the University".

**UF Counseling Services:**

Resources are available on-campus for students having personal problems or lacking clear career and academic goals which interfere with their academic performance. These resources include:

1. University Counseling Center, 301 Peabody Hall, 392-1575, personal and career counseling;
2. Student Mental Health, Student Health Care Center, 392-1171, personal counseling;
3. Sexual Assault Recovery Services (SARS), Student Health Care Center, 392-1161, sexual assault counseling; and
4. Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling.

**Software Use**

All faculty, staff and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate.

*We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.*

## IX. COURSE OUTLINE:

**Course Objectives**

- The objective of this course is to provide participants with the basic concepts involved in biogeochemical cycling of nutrients, metals, and toxic organic compounds in wetlands and aquatic systems.
- The Environmental and ecological significance of biogeochemical processes will be described in relation to elemental cycling, water quality, carbon sequestration, and global climate change

**Learning Objectives**

- Define biogeochemical features of wetlands
- Understand the differences among different wetland soils
- Describe oxidation-reduction reactions in wetlands
- Understand the organic matter decomposition processes and long-term storage of carbon, nutrients and contaminants
- Determine the role of nitrogen, phosphorus, and sulfur cycling processes in regulating water Quality
- Determine the role of elemental cycles in greenhouse gas emissions
- Understand the role of metals in regulating nutrient mobility and reactivity
- Define the role of exchange processes between soil and water column on water quality
- Identify key biogeochemical indicators for wetland assessment

**Module – I: Characteristics of Wetland Soils**

1. The extent and nature of wetland ecosystems in the earth's biosphere.
2. Overview of the significance of wetlands and the role of soils as a key component of wetlands.
3. Importance of wetland soils in the context of agronomic, ecological, limnological and environmental conditions.
4. Importance of biogeochemical cycles in wetlands and their role in the overall function of wetlands.
5. A discussion of the general properties of wetland soils as compared to upland soils.
  - a. Accumulation of organic matter.
  - b. Absence of molecular oxygen.
  - c. Restricted gaseous exchange.

- d. Presence of marsh plants.
- e. Changes in electrochemical properties (pH, redox potential and conductivity) of soils.
- f. Presence of reduced chemical species.
- g. Criteria used to classify wetland (hydric) soils.

## **Module– II: Electrochemical Properties**

1. A discussion on key physico-chemical properties that are influenced by hydrologic fluctuations of (temporary or permanent flooding) of wetlands.
2. pH and redox potential, ranges in values in natural systems. Principles, theory and techniques involved in the measurement of these properties. Seasonal changes as a result of hydrologic fluctuations.
3. Soil reductive processes showing the sequential reduction of oxidized compounds. The intensity and capacity aspects of energy yields due to reductive processes. Relationship between pH and Eh and concentrations of oxidized and reduced species of inorganic redox systems. Eh-pH stability fields for various soil redox .
4. The role of oxidized redox components as electron acceptors in microbial metabolic pathways. Vertical stratification of oxidized and reduced species and their importance in diagenetic processes.
5. Experimental techniques to measure soils reductive processes. Reactors to control Eh and pH of soil suspensions and techniques to measure vertical stratification of redox species.
6. Characteristics of wetland plants. Development of aerenchyma and role in gas exchange through plants.

## **Module- III: Biogeochemistry of Carbon**

1. Sources and nature of soil organic matter in wetland soils.
2. The role of soil organic matter as electron donor in the microbial respiratory activities.
3. Mechanisms regulating organic matter accumulation in wetland soils. Role of plants in accumulation of organic matter under various ecosystems. Techniques to measure historical organic accumulation rates.
4. Decomposition of organic matter and the role of different electron acceptors (oxygen, nitrate, manganese, iron, sulfate and CO<sub>2</sub>). Kinetics of organic matter decomposition. Turnover rates of organic matter as influenced by different climatic and hydrologic regimes.
5. Methanogenesis - role in organic matter decomposition. Mechanisms involved in methanogenesis in wetlands. Influence of plants and methane fluxes from wetlands.

6. Carbon budgets for wetlands in different ecosystems. Discuss the use of mathematical models to synthesize various carbon processes in wetlands.

### **Module – IV: Biogeochemistry of Oxygen**

1. Oxygen/H<sub>2</sub>O redox couple
2. Soil aeration
3. Establishment of aerobic (oxygen reduction zone) zone at the soil and floodwater interface and plant root-soil water interface.
4. Oxygen transport through the floodwater and consumption by wetland soils. Oxygen production benthic photosynthetic algae and its role in oxygen diffusion and consumption.
5. Oxygen transport through wetland plants and its role in rhizosphere oxidation. Mechanisms (diffusion and mass flow) governing oxygen through the plants.
6. The role of aerobic zone on exchange of nutrients and gases between soil and the overlying water column (include the works of Mortimer and Pearsall).
7. Oxygen budget in wetlands. Present the use of mathematical models describing the reactions associated with oxygen consumption in wetlands.

### **Module – V: Biogeochemistry of Nitrogen**

1. Distribution, sources and forms of nitrogen. Describe in detail nitrogen cycle in different wetland ecosystems.
2. Mineralization and immobilization processes under different redox (aerobic, facultative and anaerobic) conditions.
3. Nitrification-denitrification reactions at the aerobic -anaerobic interface at the soil surface and in the rhizosphere of wetland plants in natural and constructed wetlands and rice paddies. Environmental and soil factors regulating these reactions. Conditions under which nitrification-denitrification is minimized and maximized.
4. Ammonia volatilization as a nitrogen loss mechanism in wetlands. Influence of photosynthetic algae and other submerged macrophytes on floodwater pH and ammonia volatilization. Conditions under which this loss mechanism is minimized and maximized.
5. Biological nitrogen fixation in wetlands. Significance of this process to supply the nitrogen requirements of wetland plants and its contribution to overall nitrogen budget.
6. Exchange (diffusion and mass flow) of dissolved nitrogen species between soil and water column. Discuss the significance of these processes in nitrogen biogeochemistry.
7. Role of plants in nitrogen cycling (storage by assimilation and release during decomposition).
8. Nitrogen budget in different wetland ecosystems. Present nitrogen models to simultaneously discuss the processes involved in nitrogen cycling of wetlands.

## **Module - VI: Biogeochemistry of Phosphorus**

1. Distribution, sources and forms of phosphorus.
2. Mineralization of organic phosphorus in soil and the overlying water column. Role of phosphatase on breakdown of soil organic P.
3. Inorganic phosphate reactions including adsorption, desorption and precipitation.
4. Phosphorus solubility as influenced by redox potential and pH.
5. Exchange (diffusion and mass flow) of dissolved phosphorus species between soil and water column. Discuss the significance of these processes in phosphorus biogeochemistry.
6. Role of wetland plants in phosphorus cycling (storage through assimilation and release during decomposition).
7. Phosphorus budget in different wetland ecosystems. Present phosphorus models to simultaneously discuss the processes involved in phosphorus cycling of wetlands.

## **Module - VII: Biogeochemistry of Iron and Manganese**

1. Distribution, sources and forms of iron and manganese.
2. Reactivity of iron and manganese as influenced by pH and redox potential.
3. Role of iron and manganese as an electron acceptor in organic matter decomposition and nutrient release.
4. Exchange (diffusion and mass flow) of dissolved iron and manganese species between soil and water column. Discuss the significance of diagenetic processes in manganese biogeochemistry.
5. Iron and Manganese budget in different wetland ecosystems.

## **Module – VIII: Biogeochemistry of Sulfur**

1. Distribution, sources and forms of sulfur.
2. Reactivity of sulfur forms as influenced by pH and redox potential.
3. Role of sulfate as an electron acceptor (dissimilatory sulfate reduction) in organic matter decomposition and nutrient release.
4. Exchange (diffusion and mass flow) of dissolved iron species between soil and water column. Discuss the significance of diagenetic processes in iron biogeochemistry.
5. Formation of metal sulfides and stability of metal sulfides under various physico-chemical environment.
6. Sulfur budget in different wetland ecosystems. Present sulfur models to simultaneously

describe the processes involved in sulfur cycling of wetlands.

### **Module – IX: Biogeochemistry of Toxic Organic Compounds**

1. Toxic organic compounds of ecologic and environmental significance (list selected compounds of importance).
2. Distribution, sources and forms of toxic organic compounds.
3. Reactivity of toxic organic compounds as influenced by pH and redox potential. Present solubility, hydrolysis and microbial breakdown of organic compounds.
4. Role of different electron acceptors (oxygen, nitrate, manganese, iron, sulfate and CO<sub>2</sub>) on breakdown of toxic organic compounds.

### **Module – X: Case Studies**

1. Identify important and unique freshwater and saltwater wetland ecosystems in the world. (example Florida's Everglades).
2. Discuss the importance of biogeochemical properties and processes in selected freshwater and saltwater wetlands.
3. Discuss biogeochemical processes as indicators to determine anthropogenic impacts on wetlands.
4. Discuss biogeochemical processes as indicators to determine recovery of wetlands, after anthropogenic impacts are curtailed.
5. Discuss the effects of environmental and hydrologic fluctuations on biogeochemical processes in these systems.
6. Present types of wetlands (natural and constructed) used for treating nutrient enriched water and for bioremediation.
7. Discuss the role of biogeochemical processes in regulating nutrient removal efficiency and water quality.
8. Methane production from wetlands and the factors affecting its production and movement into the atmosphere.
9. Environmental impact of disposal of contaminated dredged sediments and ways to decontaminate the sediments using biogeochemical processes.

### **Text Books**

Coyne, M. S. and J. A. Thompson. 2006. Math for Soil Scientists. Thomson Delmar Learning. New York. Pp. 285.

Reddy, K. R. and R. DeLaune. 2008. Biogeochemistry of Wetlands: Science and Applications

CRC Press. Pp 774.

## Reference Books

1. Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. New York: Van Nostrand Reinhold. Chapter 1, 2, 3 and 5.
2. Kozlowski, T. T. 1984. Flooding and Plant Growth. Academic Press, Inc. Chapter 8.
3. Zehnder, A. J. B. 1988. Biology of Anaerobic Microorganisms. John Wiley and Sons, Inc. Chapter 1.
4. Brock, T. D. and M. T. Madigan. 1993. Biology of Microorganisms. New Jersey: Prentice Hall Publishers.
5. Brady, N. C. 1992. The Nature and Properties of Soils. New York: Macmillan Publishing Co.
6. Pankow, J. F. 1991. Aquatic Chemistry Concepts. Lewis Publishers. Chapter 19.
7. Butcher, S. S., R. J. Charlson, G. H. Orians, and G. V. Wolfe. 1992. Global Biogeochemical Cycles. Academic Press.
8. Stumm, W., and J. J. Morgan. 1981. Aquatic Chemistry. John Wiley & Sons.
9. McBride, M. B. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.
10. Garrels, R. M., and C. L. Christ. 1965. Solutions, Minerals and Equilibria. Harper and Row. Chapter 5 and 7.
11. Stevenson, F. J. 1994. Humus Chemistry. John Wiley & Sons. Chapter 1, 5 and 16.