

CHEMISTRY OF THE SOIL ENVIRONMENT
SOILS 4130/5130
Fall 2011

Instructor: Dr. George F. Vance
Office: 1007 Agricultural Building, 766-2297
Office Hours: Tuesday and Thursday 12:30-1:30, Wednesday 1:00-2:00, by appointment,
or whenever I am in my office.

Course Goals:

- 1) Understand how MASTER VARIABLES influence chemical reactions and processes that occur in soil environments that influence mineral weathering, water and contaminant chemistry, plant growth, and environmental quality.
- 2) Evaluate how chemical reactions can be applied to the solution of practical problems.

Course Objectives:

- 1) Review and apply basic chemical principles to soil environmental systems.
- 2) Characterize and evaluate the interactions between soil solution, solid, and gaseous phases.
- 3) Explore the role of nutrient and trace element availability is important to soils and plants.
- 3) Examine the genesis and reclamation of problem and mine soils.
- 4) Investigate the chemistry of indigenous and anthropogenic pollutants of environmental significance.

Text: *SOIL AND WATER CHEMISTRY: AN INTEGRATED APPROACH*. 2004. Michael E. Essington . CRC Press.

Reference Texts:

The Chemistry of Soils, 2008. G. Sposito. Oxford University Press
Introduction to Soil Chemistry: Analysis and Instrum., 2005. A.R. Conklin. Wiley-Interscience
Chemical Processes in Soils, 2005. D.L. Sparks and M.A. Tabatabai, Soil Sci. Society of America.
Environmental Soil Chemistry, 2nd Edition, 2003. D.L. Sparks. Academic Press.
Chemical Equilibria in Soils, 2001. W.L. Lindsay. The Blackburn Press
Soil Chemistry, 2001. B.L. McNeal, H.L. Bohn and G.A, O'Connor. John Wiley & Sons Inc.
Principles of Soil Chemistry, 1998. K.H. Tan. Marcel Dekker, Inc.
Environmental Chemistry of Soils, 1994. M.B. McBride. Oxford Press
Soil Solution Chemistry: Appl. Environ. Sci. and Ag., 1994. J.D. Wolt. John Wiley and Sons, Inc.

Reference Materials: Reference materials will be used in addition to the text. Additional materials will be distributed in class.

Semester Project: On separate handout.

Grading: Quizzes (Best 10 out of 12 @ 10 pts each), Homework Assignments (6 @ 50 pts each),
Lecture Exams (2 @ 150 pts each), Final (150 pts), Research Paper and Presentation (150 pts).

Grade Scale: *SOIL 4130* A = 850-1000 pts, B = 750-849 pts, C = 650-749 pts, D = 550-649 pts, F ≤ 549 pts
SOIL 5130 A = 900-1000 pts, B = 800-899 pts, C = 700-799 pts, D = 600-699 pts, F ≤ 599 pts

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Research Paper/Project Guidelines

All students are required to review a particular soil chemistry topic and either write a research paper or conduct a project. For the research paper, the text must be 6 to 10, 1½-spaced, typed pages (does not include tables and figures). For the projects, you will need to develop a laboratory exercise and procedure, conduct the experiment, and write up the findings. Students will need to include at least 8 references from refereed sources (not web site information). I will review the projects on a regular basis (e.g., every 2-3 weeks), but if you write a research paper you must submit a draft by **November 17**. Deadline for final paper/project submission is **December 1**.

Specific requirements are:

1. The subject must be within the area of Environmental Soil Chemistry. A topic that is related to your research area or interest would be preferable for the paper or project.
2. The format of the **research paper** must conform to the following:
 - a. Title page with pertinent information.
 - b. Text (8 to 10, 1½-spaced, typed pages).
 - c. Tables and figures (on separate pages from text). All information must be cited, unless it is your only research data.
 - d. References cited - use a citation format that can be found in major journals, so long as you include author(s), year, title of article, name of journal, and page numbers.
3. Guidelines for writing the **Experiment Report** are:
 - a. Cover page: experiment title, your name, date experiment was performed.
 - b. Introduction: include a brief introduction and a discussion of the purpose of the experiment (objectives).
 - c. Materials and methods: describe all materials (soils, solutions, etc.) and methods (instrumentation) used.
 - d. Results and discussion: present the results in tables and figures, and discuss their significance. Make sure calculations are clearly presented and don't forget to indicate units. Discuss how your data conformed to the literature, expectations, and/or real life situations.
 - e. Conclusions: summarize your findings and indicate what you learned from the experiment. Indicate the relevance of the experiment to your field of interest or from a practical perspective. Make recommendations on ways to improve the experiment.

References need to be from refereed journal articles, book chapters, or methods manuals that are germane to your paper topic. Several journals that are likely to have recent articles that can be used as a starting point are included on another handout. See me if you need help on an idea, acceptability of a topic, or any problem associated with this assignment. All students must turn in their research paper or project title by **September 29**.

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Tentative Lecture Outline

Textbook - *Soil and Water Chemistry: An Integrated Approach* by Michael E. Essington

<u>WEEK</u>	<u>TOPIC</u>	<u>TEXT READING</u>
1	Soil Chemistry Overview Course Objectives Philosophy, Units, Measurements Review of Thermodynamic Principles a. Spontaneity, H, S, and G b. Equilibrium constants c. Redox reactions and the Nernst equation d. Activity versus concentration	Chap 1
2	Master Variables Soil pH a. S oxidation b. Al chemistry c. Cation exchange - base saturation d. Aqueous CO ₂ chemistry e. Controls on calcareous soils f. Controls on sodic soils Oxidation-Reduction (REDOX) a. Chemical species b. Microbial processes Ionic Strength a. Concept b. Calculations	
2/3	Soil Inorganic Components (e.g., Minerals) Pauling's Rules Soil Surfaces Mineralogy a. Primary minerals b. Secondary minerals c. Oxides and hydroxides d. Carbonates and sulfides	Chap 2
4	Chemical Weathering a. Chemical controls of weathering b. Ion activity c. Mineral stability d. Weathering scheme	Chap 3
5	Soil Organic Matter a. Surface charge b. Soil organic matter composition c. Functional groups and metal complexation d. Organic carbon analysis	Chap 4

FIRST EXAM (Chapters 1-4) - Thursday, September 22

- 6 Soil Solution - Solid Phase Chemistry Chap 5
- a. Reaction chemistry
 - b. Weathering processes
 - c. Soil solution speciation
 - d. Soil solution sampling
 - e. Chemical analysis

Research Papers Titles Due, September 29

- 7 Solubility Chemistry of Soil Minerals Chap 6
- a. Basic principles
 - b. Ion Activity Products (IAP)
 - c. Solubility products (K_{sp})
- Mineral solubility and solution composition
Stability Diagrams
- 8 Soil Surface Characteristics and Reactions Chap 7
- a. Soil functional groups
 - b. Surface complexes
 - c. Electric double layer
- 9 Sorption/Desorption Processes
Adsorption Processes
- a. Adsorption isotherms and equations
 - i. Freundlich
 - ii. Langmuir
 - iii. Initial Mass Isotherm
 - b. Cation and anion adsorption
 - c. Organic adsorption reactions
- 10 Ion-Exchange Reactions and Equilibria Chap 8
- a. Exchange capacities
 - b. Exchange isotherms
 - c. Cation and anion exchange models
 - d. Analysis of exchange reactions
- 11 Oxidation-Reduction Processes in Soils Chap 9
- a. Electron activity (Eh and pE)
 - b. Redox diagrams
 - c. Redox reactions of Fe, Mn, Se, As, N, and S

SECOND EXAM (Chapters 5-8) - Thursday, November 5

- 12 Chemistry of Soil Acidity Chap 10
- a. Measurement of pH
 - b. ANC and buffering intensity
 - c. Exchange acidity

- d. Lime requirement
- e. Acid mine spoil

13 **Submit DRAFT RESEARCH PAPERS, Thursday, November 17**

Chemistry of Soil Salinity and Sodicity

Chap 11

- a. General definitions (SAR, ESP, etc.)
- b. Chemistry and genesis
 - i. saline
 - ii. saline-sodic
 - iii. sodic soils
- c. Irrigation water quality
- d. Coalbed Methane (CBM) co-produced water

14 Soil Fertility

Phosphorus and Potassium

- a. Aqueous species
- b. Solubility and stability of P minerals
- c. Adsorption of phosphorus
- d. Polymers and reduced species

Watershed Chemistry

Pollution and Future Directions

15 Course Summary and Student Presentations

RESEARCH PAPERS/PROJECT REPORTS due December 1

FINAL - Thursday, December 8, 10:15-12:15