Environmental Nanotechnology

Tuesday-Thursday 12:30-1:45

Instructor: Peter Vikesland, pvikes@vt.edu

Course Synopsis

This course 1) will introduce the basic science and engineering concepts of nanoscience and nanotechnology and 2) will discuss the societal and cultural issues surrounding the introduction of nanotechnology into the global market place. Students will discuss the opportunities for nanotechnology to improve our quality of life, as well as the potential negative consequences of this emergent science on the environment and on human health. The primary goal of the course is to increase student awareness of how nanomaterials interact in natural and engineered environments. We will examine both the potential benefits of nanomaterials/nanotechnology for environmental applications (groundwater remediation, drinking water production) and the potential environmental and toxicological hazards associated with nanomaterials/nanotechnology.

Course Objectives

Upon completion of the course, students will be able to:

- Describe the basic concepts of nanoscience and nanoengineering and have the ability to convey those concepts to the general public.
- Evaluate mechanisms that define nanomaterial fate and transport, nanomaterial toxicity, and ecological effects in natural and engineered environments.
- Understand the near term and future applications of nanomaterials and nanoscience, as well as the benefits and pitfalls of widespread use of these materials in society.
- Actively and collaboratively engage in the discussion of environmental nanotechnology.

Course Format

This class will be taught primarily via in-class discussions of materials from readings, videos, and lectures. *Participation in these discussions is a requirement for successful completion of the course*. Due to the collaborative nature of the course, reading assignments should be completed in advance of the class period during which they will be discussed. Some materials will be presented via Powerpoint or chalkboard lectures; however, these lectures are intended to foment in-class discussions. This is your course – you will collectively dictate how it proceeds during the semester.

Primary Text

None. Readings will be assigned throughout the semester. (Note: If you would like to purchase a companion textbook for the course, the text *Environmental Nanotechnology* by Wiesner and Bottero (2007) is good. We will use this book as the source of some of our readings.) Readings will be posted on CourseWork in advance of the class they will be discussed.

Grading

Class participation (20%), homework (15%), one exam (10%), presentations (25%) and a research proposal/project (30%). Policy on class participation: Participation in this course is central to the objectives of the course. **A student's participation grade will be lowered by a full letter grade for every unexcused absence in excess of two.** A student's participation grade is based upon attendance, contributions to the course discussion, and periodic presentations summarizing assigned readings to the rest of the course participants.

Regular reading assignments and periodic homework assignments will be given. Homework assignments will include both quantitative and qualitative problems, as well as summaries of reading assignments. One proposal will be submitted by each student registered for 3 units. Details of this assignment will be provided in class.

Office Hours

By appointment. [Although I will be around most afternoons in my office in 415 Durham Hall.]

Potential Topics of Interest

(as the semester proceeds we will alter this list as necessary):

1. What is nanotechnology? Perceptions of course participants, consensus on definition of nanotechnology, distinguishing fact from fiction.

2. Types of nanomaterials and their synthesis methods
   - Carbon-based materials-tubes, fullerenes, etc.
   - Metals and metal oxides-TiO_2, Fe-oxides, magnetic fluids
   - Q-dots
   - Polymeric nanowires-dendrimers and conductive polymers
   - Surface modification

3. Surface chemistry and unique colloidal aspects of nanomaterials

4. Occurrence, Fate and Transport of nanomaterials in the environment
   - LCA (are the benefits of nanotechnology worth the risk?)
   - Use and end of life effects (Emissions, Fate, Alterations)
   - Factors controlling the transport and ultimate fate of nanomaterials
   - Biodegradation

5. Toxicity and Ecotoxicity of nanomaterials
   - Contamination and risks
   - Exposure routes-inhalation, potential toxicity
   - Sustainable Nanotechnology
   - Regulating nanomaterials

Honor System

All aspects of the coursework for this class are covered by the Viginia Tech Honor System. Unless specified otherwise, the **homework** should be completed individually. Students are encouraged to review the Honor Code.

Special Needs

If you need adaptations or accommodations because of a disability (e.g. learning, attention deficit disorder, psychological, physical, etc.), if you have emergency medical information to share with me, or if you need special arrangements in case the building must be evacuated, please make an appointment or email me prior to Sept. 4, 2014.

Course Project

The project will consist of a written research proposal and an oral presentation on a topic selected by the student and approved by the instructor. A request for proposals with specific guidelines will be handed out the third week of class. Project presentations will be done in-class the last few weeks of the semester. The following deadlines will be followed to ensure the successful completion of the project proposals:

Sept. 9	Proposal topic due (one paragraph describing the general topic area and stating why the topic is of interest)
Sept. 30	Submit (via dropbox) 4 page (max), 1.5 spaced pre-proposal. A reference list must be provided and is in addition to the 4 pages.
Oct. 28	Submit draft proposals for feedback.
Nov.18	Revised (final) proposals due (12 point font, 1 inch margins, 1.5 inch spacing, maximum 15 pages of text plus one page abstract, list of references and budget).
Dec. 2	Final, narrated Powerpoint presentation is due.

Course Presentations – Description

Each of you will be required to prepare a Powerpoint (or Keynote if you are a Mac person) presentation of 10-15 minute duration. These presentations will be given in class during the final month of the semester.

The presentation at a minimum should convey the following information:

1) What is the problem your proposal seeks to address?
2) What are the hypotheses directing your effort?
3) How will you test your hypotheses?
4) What makes your approach to solving this problem the most appropriate?

This presentation is an important component of the project and should be taken seriously. Additional details regarding the project, the presentations and their requirements will be available shortly.

Fall Semester 2014 - Schedule (approximate and subject to change)

Week	Date	Topics	Reading
1.		Defining nanotechnology and evaluation of preconceived notions. Overview of nanomaterials in the environment. Student interests/background with nanomaterials.	1) Klaine et al. *Env. Tox. and Chem.,* **2008**, 27, pp. 1825-1851. 2) Peralta-Videa *J. Haz. Mat.,* **2011**, 186, pp. 1-15
2.		Nanomaterial fabrication	3) Jolivet and Barron Chapter 4) Kroto et al. *Nature,* **1985**, 318, pp. 162-163. 5) Yin and Alivisatos *Nature,* **2005**, 437, pp. 664-670.
3.		Nanomaterial fabrication Characterization of nanomaterials	6) Domingoes et al., *ES&T*, **2009**, Vol. 43, pp. 7277-7284. 7) Hasselhov and Kaegi, *Analysis and Characterization of Manufactured Nanoparticles in Aquatic Environments* from Environmental and Human Health Impacts of Nanotechnology, **2009**, eds. Lead and Smith, Blackwell Publishing.
4.		Characterization of nanomaterials Surface chemistry and colloidal aspects of nanomaterials	8) Brant et al. Chapter (Transport, Aggregation, and Deposition)
5.		Surface chemistry and colloidal aspects of nanomaterials	9) Petosa et al. *ES&T* (2010), 44, pp. 6532-6549.
6.		Toxicity and ecotoxicity	10) Arora et al. *Tox. & App. Pharm.* (2012), 258, pp. 151-165. 11) Zhao et al. *Small* (2011), 7, pp. 1322-1337.
7.		Toxicity and ecotoxicity	12) Gaiser et al. *Env. Tox. & Chem.* 31, pp. 144-154.
8.		Applications of nanomaterials.	13) Vikesland and Wigginton *ES&T* (2010) 44, 3656-3669. 14) Halvorson and Vikesland *ES&T* (2010), 44, pp. 7749-7755.
9.		Applications of nanomaterials.	
10.		Ethical issues of nanotechnology	