CHEMICALS IN THE ENVIRONMENT

ENVS 823

2019-2020 Term 2, Beijing Normal University

Instructor: Dr. P.D. Jones
E-mail: paul.jones@usask.ca

Course Objectives

Goal: When confronted with a scenario of a chemical release to the environment, deliberate or accidental, large scale or small scale, the graduate of this class should have learned what chemical and environmental information is critical to the management of the situation. Depending on the nature and extent of the chemical release the manager of such a situation will need to consider a wide variety of issues including science, regulation, law, society, culture, economics and politics. The graduate of this class will firstly know where to get the scientific information and they will know how that information can be used to predict the environmental fate and persistence of the chemical. They will also have an understanding of the complexity of the 'non-science' issues that can accompany the release of chemicals to the environment. Armed with this knowledge the graduate will be able to advise stakeholders on the variety of management options available.

This course will supply the student with an understanding of the processes that control the movement of organic and inorganic contaminants in the environment. The structure and uses of monitoring programs to evaluate environmental contamination, and temporal and spatial trends in chemical contamination will be discussed. Local and global methods for chemical regulation and management will be addressed in the context of society and economics. Finally, the use of modelling methods to predict the environmental fate and effects of chemical contaminants will be presented.

Prerequisites

Computer access and familiarity is required. This course makes extensive use of the University of Saskatchewan “Blackboard” learning system. All class reading materials will be provided electronically; therefore it is highly recommended that students have access to a laptop or personal computer where these materials can be downloaded, stored and accessed. All assignments and exercises will be submitted electronically so access to and familiarity with Microsoft Office applications (Word, Excel and PowerPoint) is also recommended although other applications may read or produce suitably formatted files. When specialized modelling applications or other software are required this will be provided to students but students will be required to install and run these applications on a suitable computer. Finally, students are expected to have access to and familiarity with the internet and world-wide-web.

Model

The class will consist of three hours of lectures per week. The weekly lectures will be consolidated into a single 3 hour session with three portions, the middle portion being used for discussion and practical exercises or guest lectures, as appropriate.

Assigned Readings

The only assigned text reading for this class is the book “Silent Spring” by Rachel Carson, this text is available electronically from the vendors listed below. A collection of additional readings, or links to them, will be provided on the course Blackboard page. Core materials will be provided at the beginning of the course, supplementary materials will be made available during the course. The readings will include book chapters, articles and other materials. The readings will be referred to and will complement the material provided in class lectures. All lecture materials will also be provided on the Blackboard system.

The location where each section’s lecture notes will be available will be announced in class. Extensive use of web-based materials will be made. One portion of the course will involve using the web to locate information on chemicals and their interactions with society and the environment.

Assignments

Students will be required to undertake two written assignments during the course. Each assignment will be between 5-10 pages (double spaced 10-12pt font) long and will demonstrate the students grasp of the materials presented in lectures and readings. The first assignment will involve the students focusing their learning on a detailed assessment of the environmental fate and effects of a chosen "pet chemical" assigned to each student at the beginning of the course. The assignment will cover the chemical and physical properties of the chemical and how these affect its environmental fate and effects. The second assignment will cover the history and societal impacts of the chemical including but not limited to environmental concerns and regulation, issues of global transport and equity, potential alternatives and societal pressures leading to and impacting use patterns.

Assignments will be graded on comprehensiveness, use of appropriate internet and other resources, ability to integrate materials presented in class with the assignment topic. For assignment two grading emphasis will also be placed on the student’s ability to recognize different points of view and to weigh the relative merits of different courses of action.

Grading Policy

Grades will be based on a one-hour mid-term (open-book, short-answer) examination (20%) a two-hour (open-book, short-answer) final examination (40%) and two class assignments (15% each). Examinations will be based on material presented in lectures, lecture notes and assigned readings; the mid-term will cover the material presented in the first half of the course. 50% of the material on the final examination will come from the second half of the course, with the other 50% being comprehensive from the entire course. The final 10% of the student’s final grade will be allocated based on class participation including participation in discussions, asking questions and active

engagement in the learning process. The last criterion will be assessed by using electronic communication tools provided by the Blackboard Learning System such as quizzes and short answer assessment questions or may be assessed based on other as yet unspecified class activities.

Academic Honesty

Students are expected to be academically honest in all of their scholarly work, including course assignments and examinations. Every student registered in this course is expected to have read and understood the rules regarding student academic dishonesty posted on the University website (http://www.usask.ca/secretariat/student-conduct-appeals/academic-misconduct.php).

Lectures/Examinations

Day 1-2 CHEMICAL-PHYSICAL PROPERTIES

The first portion of the class will provide a basic understanding of the chemical principles that determine the properties of chemicals that are relevant to environmental fate and effects.

Specific Topics: Atoms bonds and molecular structure, dipole moment and polarization, dissociation constants, solubility, heat of vaporization, vapor pressure, solubility in solvents, octanol water partitioning coefficient, bioconcentration factors.

Day 3-4 ENVIRONMENTAL PROCESSES

The second portion of the class will discuss the characteristics of different environmental compartments and how these characteristics can influence chemical fate and effects.

Specific Topics: Adsorption processes on soils and sediments, partitioning to organic matter, volatilization from water and soil, diffusion coefficients in air and water, atmospheric residence time, reaction rates, hydrolysis, photolysis biodegradation, intermedia partitioning, fugacity.

****
First Assignment Due (Properties and Fate of 'pet' chemicals – see details above)
****

Day 5-7 DYNAMICS OF MAJOR ENVIRONMENTAL POLLUTANTS

Each class of chemical compounds has it own characteristics in common that govern their environmental fate. These compound classes provide excellent examples of the principles of chemodynamics - using knowledge of chemical properties to predict environmental fate.

Specific Topics: Dynamics of Polyhalogenated and Polycyclic Aromatic Compounds in the Environment, Organochlorines - Sources, Properties, Distribution, Polycyclic

Aromatic Hydrocarbons (PAHs) - Sources properties, organometallics - properties and fate, Metals - Properties sources distribution, Mercury/Arsenic/Selenium, Sulfur & Nitrogen Cycles - Acidification, radioisotopes.

****

Midterm Examination

****

Day 8-10 Monitoring and Managing Environmental Fate

There are a variety of approaches to monitoring the distribution of chemicals in the environment. Many of these approaches are based on the physico-chemical properties of the chemical in question. Specific monitoring programs, such as the global "Mussel Watch" program and several Great Lakes monitoring programs will be discussed with reference to the chemicals in question and the aims of the monitoring effort. This section of the course will also address aspects of the management of chemicals in the environment. Specifically, national and international chemical management programs will be assessed from variety of scientific, societal and economic perspectives.

Specific Topics: Geological Matrices - Air Sediments/Soil Water, Biological Matrices - Plants, Phytoplankton, Macrophytes, Animals - Benthic Invertebrates Mollusks Worms & Insects, fish, Birds, humans. Bioavailability, Fish Consumption Advisories, PBT criteria, CEPA, UNEP, Stockholm convention, Montreal protocol, ecological risk assessment.

Day 11-12 Predicting Environmental Fate

With the knowledge we have gained, it is now possible to predict, with a reasonable degree of certainty where chemicals will go in the environment and how long they will be there. There are a variety of modelling approaches currently used and these will be discussed. One of the most valuable sources of information for this section is the Canadian Centre for Environmental Monitoring and Chemistry (http://www.trentu.ca/academic/aminss/envmodel/). We will also discuss and use several models from the US EPA (http://www. epa.gov/epahome/models.html)

Specific Topics: Environmental Pharmacokinetics, curve Fitting, Predictions, Mechanistic Simulation Models - Structure utility & Limitations, requirements, Air Soil water, Exercise Bioaccumulation of lead

****

Assignment 2 due at the end of the last class period – assignment details provided above.

****

****

Final Examination

****

Required Reading

"Silent Spring" Rachel Carson – this book is available online from several vendors – here are two:

http://www.barnesandnoble.com/w/silent-spring-rachel-carson/1100303602?ean=9780547527628

http://www.amazon.ca/Silent-Spring-Rachel-Carson-ebook/dp/B004H1UELS

Examples of other Relevant Web Resources

The CAS Registry:
http://www.cas.org/index
The location for the Chemical Abstracts Service of the American Chemical Society. Provides a unique identification number for each chemical. As of March 2010 database consisted of 52,899,253 unique chemicals

Chemfinder
http://www.chemfinder.com/chembiofinder/Forms/Home/ContentArea/Home.aspx
Provided free by Cambridge Scientific Software permits searching for chemical structures by name and CAS number also provides additional information such as suppliers and chemical properties.

US-EPA
Wealth of information - we will cover specific areas in detail. Two examples are
http://www.epa.gov/envirofw/
http://www.epa.gov/athens/learn2model/part-two/onsite/sparcproperties.html

Centre for Environmental Modelling and Chemistry
http://www.trentu.ca/academic/aminss/envmodel/welcome.html
Based at Trent University this site provides a variety of models to estimate the environmental fate of chemicals.

ACD Lab Systems
http://www.acdlabs.com/home/
Freeware available for molecular modelling and determination of some chemical properties.

ZINC Database:
http://zinc.docking.org/
Database of 13 million "purchasable" chemicals

Canadian Centre for Occupational Health and Safety
http://ccinfoweb.ccohs.ca/chemindex/search.html

Relevant Computer Resources
SciFinder Scholar
ACD Labs Chem Sketch