ESC 315

Environmental Toxicology

3 Credits

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Environmental Toxicology

Calendar Description

This course provides an introduction to the principles of toxicology. Emphasis is placed on natural and human made toxicants of environmental concern. Students learn how to classify toxic agents and how these affect living organisms (their mechanisms of action), how we collect and analyze environmental samples for toxic agents using standardized toxicity test methods, and what the environmental fate is for various toxic agents. Students are briefly introduced to the application of toxicology in risk assessment, and occupational health and safety.

Rationale

This is a required course for students in the Bachelor of Applied Science: Environmental Management program. Professional environmental practitioners must understand the principles of toxicology (how and when contaminants affect living organisms) and the application of toxicological principals (fate, exposure, dose, effect) to ecological systems. This knowledge and understanding allows the practitioner to develop and implement site investigation and monitoring plans that produce useful and reliable data. Practitioners must also be aware of hazards through potential exposure to workers and themselves in the performance of their environmental duties.

Prerequisites

None

Co-Requisites

None

Course Learning Outcomes

Upon successful completion of this course, students will be able to

1. describe and assess the basic toxic responses from lethal to various sub-lethal effects;
2. evaluate dose-response relationships and deduce the types of interactions between compounds;
3. explain the concept of dose-response and use these to predict environmental risk;

4. explain the derivation and limitations of various endpoints of toxicity that are found in the literature, as well as their use in the construction of environmental guidelines;
5. describe the various routes of exposure;
6. perform toxicity tests and use bioindicators to evaluate environmental health;
7. explain why variation in biological response requires the use of "a battery of tests" when managing environmental health;
8. describe the value of various approaches for classifying toxicants in terms of their use for assessing environmental health;
9. explain the difference and significance of threshold vs. non-threshold toxicants (i.e. cancer-causing compounds);
10. describe how toxicants affect organisms at the molecular or biochemical level and extrapolate how these effects can/cannot give rise to those at the physiological, behavioral, individual, population, community and ecosystem level; and
11. describe the toxicity, availability, uptake by various routes of exposure, transformation, excretion and effects of:
    - inorganic gaseous pollutants;
    - heavy metals;
    - petroleum hydrocarbons;
    - halogenated compounds such as PCBs, dioxins and furans; and
    - pesticides.

Essential Employability Skills

Essential employability skills are critical for workplace success and lifelong learning. Lakeland College prepares its graduates for the workplace and lifelong learning by integrating and promoting essential employability skills development in its curricula. Each credit course offered at Lakeland College emphasizes one or more of the following five essential employability skills:

A. **Communication Skills** that enable individuals to listen, interpret, express, and convey knowledge and ideas so that they are received and understood.
B. **Teamwork Skills** that enable individuals to respect the thoughts and opinions of others as they work together to plan activities, meet deadlines, complete projects, and contribute to an organization's goals.
C. **Critical Thinking Skills** that enable individuals to conceptualize and analyze issues from various perspectives while rationally evaluating the strengths and limitations of each perspective and deciding what action to take.
D. **Adaptability Skills** that enable individuals to respond quickly, willingly, and positively to new conditions and changing times.
E. **Positive Attitude and Behavioural Skills** that enable individuals to be confident about themselves and to deal with people, problems, and situations with honesty, integrity, and personal ethics.

Please refer to the Knowledge/Skills Matrix of this course outline to review the essential employability skills emphasized in this course.

Resource Materials

Required Texts:
There are presently no required texts for this course, although there are numerous reference texts as found below which were used in the preparation of this course material.

***Reference Texts*:**
Landis, W.G., and M.H. Yu. 1999. Introduction to environmental toxicology. 2nd ed. Lewis Publishers, Florida.

Cockerham L.G., and B.S. Shane. 1994. Basic environmental toxicology. CRC Press (V & L Information Resources), Florida.

Derlanko, M.J., and M.A. Hollinger. 1995. CRC handbook of toxicology. CRC Press (V & L Information Resources), Florida.

Lewis, R.A. 1996. Lewis' dictionary of toxicology. CRC Press (V & L Information Resources), Florida.

Moltmann, J.F., and J.Römbke. 1995. Applied ecotoxicology. CRC Press (V & L Information Resources), Florida.

Newman, M.C., and C.H. Jagoe. 1996. Ecotoxicology: A hierarchical treatment. CRC Press (V & L Information Resources), Florida.

Molak, V. 1996. Fundamentals of risk analysis and risk management. CRC Press (V & L Information Resources), Florida.

Kamrin, M.A. 1988. Toxicology: A primer on toxicology principles and applications. Lewis Publishers, Michigan.

Keith, L.H. 1991. Environmental sampling and analysis: A practical guide. Lewis Publishers, Michigan.

Manahan, S.E. 2001. Fundamentals of environmental chemistry. 2nd ed. Lewis Publishers, Florida.

Manahan, S.E. 1992. Toxicological Chemistry. 2nd ed. Lewis Publishers, Florida.

Richardson, M. 1993. Ecotoxicology monitoring. VCH Publishers, New York.

Lankford, P.W., and Jr. W.W. Eckenfelder. 1990. Toxicity reduction in industrial effluents. Van Nostrand Reinhold, New York.

Liu, D., and B.J. Dutka. 1984. Toxicity screening procedures using bacterial systems. Marcel Dekker, Inc., New York.

Wells, P.G., K. Lee, and C. Blaise. 1998. Microscale testing in aquatic toxicology - advances, techniques, and practice. V & L Information Resources, New York.

***Required Materials*:**
Laboratory coats & Safety glasses

Conduct of Course

This course includes lectures, and laboratory sessions with assignments. Students work in groups for most laboratory sessions. Students must have laboratory coats and safety glasses for the laboratory sessions.

Evaluation Procedures

The final grade is an aggregate of the following components:

Midterm exam	30%
Final exam	40%
Laboratory Assignments	30%
Total	100%

Lab/field trip assignments are generally due one week after each lab or trip unless otherwise discussed in class. Late reports will **NOT** be accepted; they will be assigned a mark of zero.

Knowledge/Skills Matrix

Students apply and demonstrate their knowledge and skills to use

A. Communication Skills

A1.	**by listening, reading, interpreting information, and communicating effectively**
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10
A2.	**by using written, spoken, and/or visual formats and media to communicate and meet needs of each particular audience**
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10
A3.	**by using libraries, Internet, technical publications, journals and other sources to find pertinent information**
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6

B. Teamwork Skills

B1. by using interpersonal skills to create an atmosphere that maximizes the strengths of group members to accomplish tasks	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
B2. by using interpersonal skills to resolve conflict, relate to others, and assist others	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
B3. by contributing and listening to others as group determines realistic objectives, prioritizes tasks, and identifies resources and timelines	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
B4. by treating other members of the group open-mindedly and fairly	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
B5. by developing tactics/strategies to accomplish tasks	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6

C. Critical Thinking Skills

C1. by seeing critical thinking as a lifelong process of self-assessment	
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10; Final exam/Goal 11
C2. by examining problems closely	
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10; Lab assignments/Goal 6; Final/Goal 11
C3. by examining beliefs, assumptions, and opinions, and weigh them against the facts	
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10; Lab assignments/Goal 6; Final/Goal 11
C4. by seeking out the truth	
	Evaluation(s)/Goal(s): n/a
C5. by finding solutions; make decisions	
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10; Lab assignments/Goal 6; Final/Goal 11; Lab assignments/Goal 6; Final/Goal 11
C6. by incorporating new ideas that may not necessarily agree with previous thought on the topic	
	Evaluation(s)/Goal(s): n/a
C7. by seeing connections between topics and use knowledge from other disciplines to enhance reading and learning experiences	
	Evaluation(s)/Goal(s): Midterm and final exam, lab assignments/Goals 1-5, 7-10; Lab assignments/Goal 6; Final/Goal 11; Lab assignments/Goal 6; Final/Goal 11

D. Adaptability Skills

D1. by working independently or as part of team	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
D2. by carrying out multiple tasks or projects	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
D3. by being innovative and resourceful: identify and suggest alternative ways to get the job done	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6

D4. by being open and respond constructively to change and uncertainty	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6

E. Positive Attitude and Behavioural Skills

E1. by dealing with people, problems, and situations with honesty, integrity, and personal ethics	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
E2. by showing interest, initiative, and effort	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
E3. by affirming the need for positive solutions and encourage positive interaction and feedback	
	Evaluation(s)/Goal(s): Lab assignments/Goals 1 and 6
E4. by balancing personal and family activities with job-related activities	
	Evaluation(s)/Goal(s): All exams and assignments /All goals

Grade Equivalents and Course Pass Requirements

A minimum grade of D (50%) (1.00) is required to pass this course.

Letter	F	D	D+	C-	C	C+	B-	B	B+	A-	A	A+
Percent Range	0-49	50-52	53-56	57-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-100
Points	0.00	1.00	1.30	1.70	2.00	2.30	2.70	3.00	3.30	3.70	4.00	4.00

Students must maintain a cumulative grade of C (GPA - Grade Point Average of 2.00) in order to qualify to graduate.

Attendance

Classroom and laboratory attendance is considered vital to the learning process and as significant to the students' evaluation as examinations and reports, therefore absenteeism is recorded.

a. Students having a combination of excused and/or unexcused absence of 20 percent or higher for the scheduled course hours can be required to withdraw and would then automatically receive a "RW" (required withdrawal) for the course, regardless of any other evaluation results. (RW is a failing grade).

b. An excused absence is one that is verified with your instructor. Verification should be prior to the absence or the next class day following the absence. Verification of the absence may take the form of a note from your doctor/College nurse regarding illness, or a note from another instructor regarding a field trip or other activity, or authorization by your instructor following an in-person meeting. Be sure to contact your instructor and ask what they will require from you as verification of each absence. An unexcused

absence is anything NOT verified by the instructor prior to the absence or the next class day following the absence.

NOTE: Any exceptions to the above attendance policy (e.g. timetable conflicts, work-related issues) must be approved in writing by the Department Chair prior to the beginning of the course.

It is the students' responsibility to know their own absentee record.

Normal hours are 8:30 a.m. to 6:30 p.m., with potential for evening courses, exams or extended field trips. Students are expected to be available for classes during these times.

Course Units/Topics

Lecture

1) **Introduction to Environmental Toxicology**
   a) As an interdisciplinary science
   b) History and background

2) **Introduction to Toxicity Testing**
   a) The Dose-response relationship
   b) Elements of toxicity testing
   c) Exposure regime
   d) Types of toxicity tests
   e) Standardized toxicity testing protocols (OECD, GLP, EPA, AEUB, EC)
   f) Toxicity identification evaluations (TIEs)
   g) Toxicity reduction evaluations (TREs)
   h) Characterization of dose-response curves
      i) toxicity threshold
      ii) extrapolating the curve - the risks
      iii) NOEC, NOEL, LOEC, LOEL, NOAEL and LOAEL toxicity test endpoints
   i) Toxicity data
      i) standard reference material and literature
      ii) toxicity test battery concept

3) **Principles of Environmental Toxicology**
   a) Ecological Principles
   b) General principles from toxicology
      i) lethal and sublethal effects
      ii) toxicological responses

iii) interaction between compounds
iv) effects of exposure
(1) characteristics
(2) routes of exposure

4) Classifying Toxicological Effects

a) Physical-chemical characteristics
b) Bioaccumulation/biotransformation/biodegradation
c) Receptor and mode of action
d) Biochemical and molecular effects
e) Physiological and behavioural effects
f) Population effects
g) Community effects
h) Ecosystem effects
i) Alternative methods of classification

5) Routes of Exposure and Modes of Action

a) Inhalation, Ingestion, Dermal (root/shoot) uptake
b) The damage process
c) Atmospheric pollutants and plants
d) Mechanisms of Action
e) Common modes of Action in Detail
f) Introduction to QSAR

6) Factors Modifying the Activity of Toxicants

a) Physicochemical Properties of Toxicants
b) Time & Timing of Exposure
c) Environmental Factors
d) Interaction of Pollutants
i) Toxicity of Mixtures
e) Biological Factors Affecting Toxicity
f) Nutritional Factors

Midterm Exam

7) The Toxicity of Inorganic Gaseous Pollutants

a) Sulfur Oxides **(SO_x)**

i) sources, characteristics & effects on plants, animals & humans

b) Nitrogen Oxides **(NO_x)**

c) Ozone **($O_{3)}$**

d) Carbon Monoxide **(CO)**

e) Flouride **(F)**

8) The Toxicity of Heavy Metals

a) Lead

i) properties and uses

ii) exposure

(1) atmospheric lead, waterborne lead, in food, in soils

iii) toxicity

(2) effects on plants, animals, & humans

iv) Biochemical Effect

b) Cadmium

c) Mercury

9) The Toxicity of Petroleum Hydrocarbons

a) Petroleum & Environmental Impacts

b) Petroleum Composition

c) Petroleum Characteristics

d) Weathering

e) Toxicity and Routes of Exposure

f) Mitigation Methods

10) The Toxicity of Halogenated Compounds (PCB?s, PCDD?s & PCDF?s)

a) Halogenation

b) Halogenated hydrocarbons

c) Halogenated Aromatics

d) PCBs, PCDFs and PCDDs

i) production, usage, and dispersion

ii) physical, chemical & biological factors

e) Composition and Analysis

f) Experimental Toxicology

11) The Toxicity of Pesticides

a) Agricultural Demographics and Pesticide Use

b) Classification of Pesticides

i) organochlorine insecticides

ii) organophosphate and carbamate insecticides

iii) pyrethroids
iv) biological insecticides

c) Pesticide Regulation in the US
d) Biomagnification
e) Aquatic Toxicity
f) Ground Water
g) Effects on Wildlife
h) Effects on Microbes

12) Biotransformation, Biodegradation, Detoxification and Activation

a) Metabolism of environmental chemicals: biotransformation
b) Microbial degradation
c) Bioremediation
d) Isolation and engineering of degradative organisms

Final Exam

Laboratory Content

Week #

1. Dose-response exercise and assignment

The learning objectives of this exercise are:

i) To acquire skill in entering data and constructing dose (or concentration) response graphs in Excel;
ii) To develop judgment and critical thinking skills in looking at graphs and deciding if one or more data points should be excluded from the interpretation of dose-response for a specific toxicant;
iii) To determine the LC50 and the slope of the linear portion of the curve surrounding the LC50;
iv) To develop critical thinking skills when comparing both the toxicity and the danger of various toxicants;
v) To be able to correctly interpret whether two (or more) toxicants might have the same (or different) mode of action based on the slopes of their dose-response; and
vi) To be able to correctly comment on the confidence of a statistical endpoint determined from various statistical procedures.

2. Introduction to the Microtox Toxicity Test System – data interpretation & assignment

The learning objectives of this exercise are:

i) To acquire an understanding of the operation of the Microtox test system;
ii) To assess the toxicity of two chemical standards and tap water, using the basic test (a highest concentration of 45%); and

iii) To describe and discuss the results with emphasis on the toxicity patterns and levels of the tested chemicals.

3. TIEs/TREs using the Microtox Toxicity Test System – data interpretation & assignment

The learning objectives of this exercise are:

i) To **assess the toxicity** of Vermilion tap water;
ii) to assess the toxicity of Vermilion tap water that has been treated using Sodium Thiosulphate ($Na_2S_2O_3$);
iii) to **assess the toxicity** of the Sodium Thiosulphate alone as a treatment control.

4. Determining Octanol/Water Coefficient – assignment

5-7. Poster presentations on classes of toxicants (the remainder of the semester)

The learning objectives of this exercise are:

i) To acquire some skill in reviewing the technical and scientific literature;
ii) To develop your integrative thinking and communication skills through the formulation of and presentation of a poster that summarizes information related to the toxicity of a compound.

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