UNIVERSITY OF TORONTO SCARBOROUGH

Groundwater Hydrochemistry and Contaminant Transport

EES1113H
Class: Wednesday 14:00 – 17:00
Course Website

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Instructor

Prof. Cody A. Ross
Email: cody.ross@utoronto.ca
Office: EV443
Office Hours: TBD

Location & Time

- *Lectures are on Wednesdays 14:00 – 17:00 (room IC 120)*
- *Workshops are on Thursdays 9:00 – 11:00 (room TBD)*

Overview

In Groundwater Hydrochemistry and Contaminant Transport (EES1113H) we will explore the movement of water and contaminants through Earth's subsurface. The course will cover soil water and groundwater in the hydrologic cycle, the theory and supporting equations of groundwater flow and contaminant transport, and the fundamentals of modelling these processes. These materials will be delivered through a combination of lectures, computer workshops, interactive activities, and critical evaluations of contemporary scientific literature. While a variety of case studies from different environments will be used, the course will routinely return to a Canadian context, especially regarding legislation and guidelines surrounding groundwater quality and contamination. This course will allow you to establish a theoretical understanding of groundwater processes while concurrently developing in-demand technical and critical thinking skills.

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Learning Objectives

By the end of EES1113H, you will be able to:

- Interpret and critically evaluate peer-reviewed journal articles on groundwater and contaminant transport.
- Synthesize scientific literature from multiple sources.
- Identify and describe aquifer properties and the subsurface pools and fluxes of the hydrologic cycle.
- Understand the principal mechanisms and equations governing groundwater flow and contaminant transport.
- Understand the variety of groundwater contaminants and their sources.
- Sample groundwater monitoring wells for chemical analysis.
- Select and construct appropriate visualizations for communicating groundwater chemistry.
- Implement basic flow and contaminant transport models.

Expectations

What I expect of you:

- Treat peers, the TA, and me with respect.
- Take full responsibility for your own learning.
- Recognize you are not merely a spectator of your education.
- Be present, on time, and prepared for every class.
- Complete all work on time with significant effort.
- Ask questions.
- Contribute to a positive learning environment.

What you can expect of me:

- Clear instructions for assignments, course activities, and the final project.
- Prepared for every class.
- Available during office hours.
- Lectures and activities planned to help you meet the course learning objectives.
- Empathy about the difficulty of the subject and the time needed to gain confidence with it.
- Timely, detailed, and constructive feedback.

Textbook and Resources

Detailed course notes will be provided, and mandatory seminar-style readings are prescribed on the course website and in the tentative schedule below. There is no mandatory textbook, however, the form of lectures and the suggested readings are from two textbooks:

- Contaminant Hydrogeology by Fetter, Boving, & Kreamer
- Applied Hydrogeology by Fetter & Kreamer

Of the two textbooks, more of the course materials are from Contaminant Hydrogeology. I understand that textbook prices can be prohibitive. Previous versions of these textbooks are less expensive and many of the topics can be found in Groundwater by Freeze & Cherry. that was made freely available online by the Groundwater Project.

Evaluation

Your course grade will comprise participation in course discussion and oral presentations, assignments, and a term project. The deadlines are listed in the tentative schedule table.

Participation in discussion and activities	15%
Oral synopsis or critique of journal article	10%
Groundwater monitoring activity	10%
4 assignments	30% total, 10% each*
Term paper	35%

** There are 4 assignments. The best 3 assignments will count towards your final grade.*

Participation (15 %): there will be opportunities for discussion during lectures and workshops (15%).

Oral synopsis or critique (10 %): some lectures have mandatory readings and you will present a verbal synopsis (~5-10 min) or a critique (~5-10 min) of one article (10%).

Groundwater monitoring activity (10 %): an applied workshop involving the sampling of a groundwater well will be performed during class. Your attendance and participation in this hands-on activity will be worth 10% of your final grade. No special equipment is needed.

Assignments (30 %): there are four assignments throughout the course worth 10% each. Your best three assignments will contribute to your grade. The due dates for the assignments are described in the schedule below. The assignment instructions and submission are on Quercus. Any questions about the assignments can be directed to me by email.

Final project (35 %): a project involving the evaluation of two peer reviewed journal articles. One article will be theoretical and documenting groundwater observations. One article will be on an analytic or modeling approach that could be applied to better understand the observations. 5% will be for a very brief proposal/presentation on the papers, the underlying issue, and why you chose the papers. 10% will be for a 10-minute presentation during our last scheduled class. 20% will be for a brief 5-10 page report summarizing the articles. Details and instructions about the final project will be posted on Quercus.

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Tentative Schedule and Key Dates

Minor changes to the schedule are possible and will be posted on Quercus in advance.

Week 1 *Lecture: Sept. 13*	Lecture Topic: • Course introduction • The hydrologic cycle • Subsurface architecture • Groundwater contaminants Mandatory readings: • Gleeson et al. (2016) – The global volume and distribution of modern groundwater Suggested textbook readings: • Contaminant Hydrogeology: 1.2, 1.5 • Applied Hydrogeology: 1.3, 1.5, 3.2
Week 2 *Lecture: Sept. 20*	Lecture topic: • Soil moisture • Flow in the vadose zone • Mass transport in the vadose zone • Introduction to assignment 1 Mandatory readings: • Condon et al. (2020) – Where is the bottom of a watershed? Suggested textbook readings: • Contaminant Hydrogeology: 4.2-4.12 • Applied Hydrogeology: 6.1-6.7
Week 3 *No Lecture Sept. 27 MEnvSc retreat*	Mandatory readings: • Dahan (2020) – Vadose zone monitoring as a key to groundwater protection
Week 4 *A1 due Oct. 3 by 11:59 PM* *Lecture: Oct. 4*	Lecture topic: • Aquifers • Groundwater flow Suggested textbook readings: • Applied Hydrogeology: 3.3-3.12, 4.3-4.7,4.9-4.14
Week 5 *Lecture: Oct. 11*	Lecture topic: • Groundwater flow • Groundwater models • Introduction to assignment 2 Mandatory readings: • Government of Canada – Groundwater quality

	https://agriculture.canada.ca/en/environment/wells-and-groundwater/groundwater-quality • Government of Canada – Canadian drinking water guidelines https://www.canada.ca/en/health-canada/services/environmental-workplace-health/water-quality/drinking-water/canadian-drinking-water-guidelines.html • Government of Canada – Guidelines for Canadian Drinking Water Quality - Summary Tables https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html Suggested textbook readings: • Applied Hydrogeology: 4.3-4.7,4.9-4.14, 13.1-13.7
Week 6 *A2 due Oct. 17 by 11:59 PM* *Lecture: Oct. 18*	Lecture topic: • Groundwater monitoring • Groundwater sampling Mandatory readings: • Srinivasamoorthy et al. (2008) – Identification of major sources controlling groundwater chemistry from a hard rock terrain; a case study from Mettur Taluk, Salem District, Tamil Nadu, India Suggested textbook readings: • Contaminant Hydrogeology: 8.1-8.7 • Applied Hydrogeology: 10.3-10.5
Week 7 *Lecture: Oct. 25*	Lecture topic: • Groundwater chemistry Mandatory readings: • Auld et al. (2004) – Heavy rainfall and waterborne disease outbreaks: the Walkerton example Suggested textbook readings: • Contaminant Hydrogeology: 6.1-6.10, 7.1-7.9 • Applied Hydrogeology: 9.1-9.14
Week 8 *A3 due Oct. 31 by 11:59 PM* *Lecture: Nov. 1*	Lecture topic: • Groundwater chemistry Mandatory readings: • Abiriga et al. (2020) – Groundwater contamination from a municipal landfill: Effects of age, landfill closure, and season on groundwater chemistry

	Suggested textbook readings: • Contaminant Hydrogeology: 6.1-6.10, 7.1-7.9 • Applied Hydrogeology: 9.1-9.14
Week 9 *Lecture: Nov. 8*	Lecture topic: • Introduction to assignment 4 • Mass transport in saturated media Mandatory readings: • Clark & Raven (2004) – Sources and circulation of water and arsenic in the Giant Mine, Yellowknife, NWT, Canada. Suggested textbook readings: • Contaminant Hydrogeology: 2.1-2.10 • Applied Hydrogeology: 10.6
Week 10 *Term Paper Proposal due Nov. 14 by 11:59 PM* *Lecture: Nov. 15* *Workshop: Nov. 16*	Term Paper proposal presentations Lecture topic: • Mass transport in saturated media • Transformation, retardation, and attenuation Suggested textbook readings: • Contaminant Hydrogeology: 2.1-2.10, 3.1-3.11 • Applied Hydrogeology: 10.6 Workshop: • Groundwater/contaminant models
Week 11 *Lecture: Nov. 22* *Workshop: Nov. 23*	Lecture topic: • Groundwater/contaminant modelling Mandatory readings: • Mackie et al. (2022) – Groundwater as a source and pathway for road salt contamination of surface water in the Lake Ontario basin; a review Workshop: • Groundwater/contaminant models
Week 12 *Lecture: Nov. 29* *Workshop: Nov. 30* *A4 due Dec. 1 by 11:59 PM*	Lecture topic: • Groundwater/contaminant modelling Mandatory readings: • Vázquez-Tapia et al. (2022) – Occurrence of emerging organic contaminants and endocrine disruptors in different water compartments in Mexico – A review Workshop: • Groundwater/contaminant models
Week 13 *Lecture: Dec. 6*	Term Paper presentations

Week 14 *Term Paper due Dec. 12 by 11:59 PM*	

Academic Integrity

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/Assets/Governing+Council+Digital+Assets/Policies/PDF/ppjun011995.pdf) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

In papers and assignments:

- Using someone else's ideas or words without appropriate acknowledgement;
- Submitting your own work in more than one course without the permission of the instructor;
- Making up sources or facts;
- Obtaining or providing unauthorized assistance on any assignment.

On tests and exams:

- Using or possessing unauthorized aids;
- Looking at someone else's answers during an exam or test;
- Misrepresenting your identity; and
- When you knew or ought to have known you were doing it.

In academic work:

- Falsifying institutional documents or grades;
- Falsifying or altering any documentation required by the University, including (but not limited to) doctor's notes; and
- When you knew or ought to have known you were doing so.
- All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If students have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, they are expected to seek out additional information on academic integrity from their instructors or from other institutional resources.

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference

database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq)

⚠ In this course, generative AI can be used in certain instances or specific ways.

Students may use artificial intelligence tools for creating an outline for an assignment, but the final submitted assignment must be original work produced by the individual student alone.

Accessibility

Students with diverse learning needs are welcome in this course. I strive to create a classroom environment that is welcoming and inclusive and have considered this as I designed the course. However, if you still find you need accommodations due to a disability/health consideration please feel free to approach me and/or the Access*Ability* Services Office as soon as possible.

Access*Ability* Services staff (located in Rm AA142, Arts and Administration Building) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations 416-287-7560 or email ability.utsc@utoronto.ca. The sooner you let me know your needs the quicker I can assist you in achieving your learning goals in this course.

Equity at the University of Toronto

The University of Toronto is committed to equity and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, you may contact the UTSC Equity and Diversity officer at edio.utsc@utoronto.ca or the University of Toronto Scarborough Students' Union Vice President Equity at equity@scsu.ca.