

Water Quality and Health – ECS 524

Spring 2025

Course Syllabus

Dates: 01/08/2025 - 04/16/2025

Course schedule: Monday-Wednesday 1:25PM - 2:40 PM , LSRC A158

Instructor:

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Office: LSRC A-317

Office hours: Wednesday, noon to 1 PM (by appointment through email).

Teaching Assistant:

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Overview:

The course provides basic concepts of the relationships between water quality and health. The course includes an introduction of the global water cycle, availability, and demand, basic concepts of hydrogeology, principles of water chemistry and water quality, geochemical tracers for identification of sources and mechanisms of water contamination, exposure science, and health implications. The course highlights the distinction between human activities (*anthropogenic* sources) and naturally occurring (*geogenic*) contaminants and their impacts on the quality of natural water resources. The course introduces the energy-water nexus and highlights the possible impacts of energy mining and production (fossil fuels, renewable) on the quantity and quality of water resources. Examples are given for worldwide hydrological settings and water quality issues, with emphasis on new research for understanding the sources and mechanisms of water contamination the relationships between water quality and health.

Course Contents

Topics include: The course includes the following chapters (1) fundamental elements of global hydrology: global and climate change effects on water availability and quality; (2) basics of hydrogeology; (3) basics on water chemistry and geochemistry; (3) water quality and sources of contaminants in water; (4) water geochemistry and identification of sources of contamination; (5) nutrients; (6) salinization; (7) metals and metalloids; (8) radionuclides in water; (9) the water-energy nexus; and (10) exposure science. The course will be based on formal lectures and take-home exercises.

Course Format and Policy

The course is offered in the form of lectures and take-home exercises. Through the semester there will be weekly to bi-weekly homework assignments to practice concepts presented in class. Students are allowed to interact with each other, but homework work should be

conducted individually and the materials that are submitted must be the student's individual work. On every assignment, the student must sign the Duke University Honor Code (see below). Failure to hand in an exercise on time (without legitimate reason) would reduce the grade by 50% on that exercise. A mid-term exam will be scheduled towards to middle of the semester. The final take-home exam will be given at last meeting of the class on April 16, 2025. The exam must be the student's individual work and student will have to demonstrate in the exam their own individual work and sign the Duke Community honor code (see below).

Course Performance and grade

Assignments and examinations will include elementary calculations and essay questions regarding concepts discussed in class. Students are recommended to use Excel spread Sheets. The course material including PowerPoint presentations, reading materials, and homework assignments will be presented on-line on Canvas web site. Students are strongly advised to follow the course web site.

Grade distribution:

Active participation in class: 10%,

Take-home assignments: 30%,

Mid-term exam (in class): 30%

Final take-home exam: 30%.

THE DUKE COMMUNITY STANDARD (honor code)

Full text available at: <http://www.integrity.duke.edu/ugrad/student.html>

- 1. I will not lie, cheat, or steal in my academic endeavors, nor will I accept the actions of those who do.*
- 2. I will conduct myself responsibly and honorably in all my activities as a Duke student.*

Covid-19 Response and Information

[Duke United](#) is the one-stop online resource for information on reopening the campus and many other aspects of the 2020-21 academic year, including campus operations, public health measures, and community responsibilities in light of the Covid-19 pandemic.

The [Duke Novel Coronavirus \(Covid-19\)](#) online site provides the Duke community with important updates related to the COVID-19 pandemic, including the latest updates important to students as provided by the University administration.

[Keep Learning: Student Expectations](#) – find details on our new [Duke Compact](#), and what the university expects of its students with regards to the Covid-19 pandemic.

Academic Support

Get all of your computing and networking support through the [Duke Office of Information Technology](#). Now, more than ever, if you have questions about connectivity, computer issues, software, downloads, Zoom, or problems with Sakai, Duke Box, or Warswire, these folks are there to help.

The [International House](#) provides assistance to all Duke international students, on campus or off campus, with all of the myriad challenges that international students might face with settling into a new culture, academics, and logistical support such as obtaining a driver's license, banking, and medical insurance.

The Duke [Academic Resource Center](#) (ARC) offers free services to all students during their undergraduate careers at Duke. Services include Learning Consultations, Peer Tutoring and Study Groups, ADHD/LD Coaching, Outreach Workshops, and more. Because learning is a process unique to every individual, the ARC works with each student to discover and develop their own academic strategy for success at Duke. Contact the ARC to schedule an appointment. Undergraduates in any year, studying any discipline can benefit!

Health Support

University life can be an exciting and stimulating environment. However, balancing the demands of school, work, and life can be a challenge, especially for first-year students. Valuable support services that will help you find the right balance are available through the following:

[DuWell](#) (Duke Wellness) helps students focus on their individual wellness by looking at the integration of many areas of their life through areas of wellness promotion and risk mitigation. They engage students through a variety of wellness experiences across campus in an effort to reduce stress and anxiety while emphasizing self-care.

[CAPS](#) (Counseling and Psychological Services) helps Duke Students enhance strengths and develop abilities to successfully live, grow and learn in their personal and academic lives. We offer many services to Duke undergraduate, graduate, and professional students, including brief individual and group counseling, couples counseling and more.

[DukeReach](#) (Duke Reach) directs students, faculty, staff, parents, and others to the resources available to help a student in need. Are you concerned about your physical or mental health? Has a fellow student's behavior caused you to worry about his or her potential future actions? We hope to provide you with the resources you need to assist that student or to get the appropriate help so that someone else may do so. All of us at Duke care deeply about the success and well-being of our students.

[Sexual Assault Resources](#) – If you have experienced sexual assault, sexual harassment, gender violence, relationship violence, or stalking, there are several resources around campus to support you, which are summarized [here](#).

[CMA](#) (Center for Multicultural Awareness) promotes community engagement, multicultural education, leadership development, and social justice education among the student population. Our programs and services aim to empower students and their organizations to create a vibrant and inclusive community. As one of many campus resources available, CMA would like to facilitate your reporting bias incidents. CMA hopes you do not have to, but in the event please utilize their [Bias Incident Report](#).

[Duke Vans](#) provide free, on-demand transportation for students and employees. Rides are available to and from most Duke facilities, dorms, etc. between 6:00pm-2:00am. Stay safe after dark!

[Duke Campus Police](#) provides 24-hour police and security services to Duke's academic campus and hospital.

Water Quality and Health

COURSE OUTLINE

(additional reading materials will be posted on Canvas website)

1. Introduction

- Course overview and introduction to global water and health
(*reading*: Hiscock, chapter 1-17, pp. 18-46)
- General Introduction – A global prospective on water stress
(*reading*:
(1) Oki and Kanae, 2006, Global Hydrological Cycles and World Water Resources, *Science*, 313, 1068-1072)
(2) Gleick, P, Water in Crisis: Paths to sustainable water use. *Ecological Applications*, 8(3), 1998, pp. 571–579
- Global water resources and Climate change
(*reading*: Vorosmarty et al., 2000, Global water resources: Vulnerability from climate change and population growth. *Science*, 289, 284-288)

2. Hydrogeology, Hydrochemistry and water quality

- Basics of Hydrogeology: lithology and permeability, aquifer types, groundwater flow
- Chemical constituents of groundwater: water properties, dissolved major and trace elements, chemical composition of groundwater (*reading*: Freeze & Cherry, Chapter 3, pp. 81-132).
- Sequence of geochemical evolution of groundwater
- Drinking water standards, EPA, World Health Organization, MCLs, MCLGs
- Water quality: salinization, (*reading*: Vengosh, A. (2003). *Salinization and Saline Environments*. In: Sherwood Lollar, B. (ed.), *Environmental geochemistry* (volume 9), *Treatise in Geochemistry*. Executive Editors: Holland, H.D. and Turekian, K.T., Elsevier Science (<http://www.TreatiseOnGeochemistry.com>).
- Water quality: nitrate pollution,

- Water quality: metals and metalloids distribution in water, speciation, redox state, and oxyanions (emphasis on arsenic, selenium, lead, uranium, and hexavalent chromium).
- Water quality: naturally occurring radioactive elements,
- Water quality: major organic contaminants, trace organics, and emerging organic contaminants (disinfection byproducts, pharmaceuticals)

3. Contaminants, exposure and health

- Biological contamination of surface waters and their effects in developing countries ((Reading: Linda Nash, 1993. *Water quality and health*, Chapter 3. In: Peter H. Gleick, *Water in Crisis*, 1993)
- Sewage treatment systems and capability to protect human health
- Water treatment, chlorination, disinfection byproducts
- Arsenic in water: occurrence, sources, speciation, toxicity and human health
- Fluoride in water: occurrence, sources, toxicity and human health (*reading*: Rango et al., 2010; 2011; 2012)
- Lead in water: occurrence, sources, isotope fingerprints and human health
- Uranium in groundwater: occurrence, sources, isotope fingerprints and human health
- Radium nuclides and radioactivity in groundwater: occurrence, sources, isotope fingerprints and human health
- Heavy metals in water: occurrence, sources, and human health
- Hexavalent chromium in drinking water: occurrence, sources, and human health

4. The water quality-energy nexus:

- The effect of mountaintop mining on stream chemistry and ecology (*reading*: Lindberg et al., 2011; Bernhardt et al., 2012; Vengosh et al., 2013);
- Contaminants in coal combustion products and their effect on the environment (*readings*: Ruhl et al., 2009, 2010; 2012; Lauer et al., 2015)
- The impacts of unconventional energy (shale gas, tight oil) development and hydraulic fracturing (fracking) on the environment (*reading*: Osborn et al., 2011; Warner et al., 2012; Warner et al., 2013; Vengosh et al., 2014; Jackson et al., 2014; Kondash et al., 2018; 2019).

5. Case studies from the world

- The Middle East and Australia (salinity)
- The Ethiopian Rift Valley (fluoride, arsenic, salinity)
- The Mekong delta, Vietnam (arsenic)

- The Fossil aquifers of the Middle East, Jordan, Israel, and Saudi Arabia (naturally occurring radioactive materials – NORMs; radium nuclides)
- Shallow aquifers from Morocco (salinity, radioactivity)
- Northwestern India (uranium, fluoride, salinity, disinfection byproducts)
- Occurrence and distribution of oxyanions (arsenic, hexavalent chromium, vanadium, uranium) in groundwater in the eastern U.S.
- Lithium mining in the Lithium Triangle of South America and potential water quality effects.