Water Quality and Health – EOS 524

Spring 2020

Course Syllabus

Course details: Tu-Th - 10:05AM to 11:20AM, 2102 GH.

Instructor:
Avner Vengosh, office: Old Chemistry 205; office hours: email to set an appointment.
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Teaching Assistant:
Zhen Wang, office: Old Chemistry 202; email to set an appointment. Contact : email: zhen.wang143@duke.edu

Overview:
The course provides basic concepts of the relationships between water quality and health. The course provides some introduction on the global water cycle, global water demand and availability, basic hydrogeology, principles of water chemistry, aquatic geochemistry, geochemical tracers for identification of sources and mechanisms of water contamination, exposure and health implications. The course highlights the relationships between water quality and human activities (*anthropogenic* sources; e.g., the water-energy-food nexus) and naturally occurring (*geogenic*) sources. The course also addresses some policy implications related to conflicts over water resources and the impact of energy production on water resources. Examples from different hydrological settings worldwide are given with emphasis on new research and environmental impacts in different countries.

Course Contents
Topics include: The course includes (1) fundamental elements of global hydrology: global changes in water availability and quality; (2) basics of hydrogeology and subsurface water flows; (3) basics on water chemistry and geochemistry; (3) water quality and sources of contaminants in water; (4) the water-energy nexus; (5) the relationships between water geochemistry, levels of contaminants, exposure, and health implications; and (6) case studies from the developed and developing world. 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 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 while working on homework or the project; however, the materials that are handed in 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.

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 and assignments will be presented on-line on Sakai web site. Students are strongly advised to follow the course web site. **Grade distribution: participation in class: 10%, take-home assignments: 30%, Final take-home exam: 60%.**

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.

Water Quality and Health

COURSE OUTLINE

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 Hydological 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.
   - 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 hydrochemical 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. **Water quality, 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 in groundwater: occurrence, sources, isotope fingerprints and human health
- Barium in water: occurrence, sources, and human health
- Naturally occurring radioactive material (NORM): 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 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)
- India alluvium aquifers (uranium, fluoride, salinity, disinfection byproducts)
- Occurrence and distribution of oxyanions-forming elements (arsenic, hexavalent chromium, vanadium, uranium) in groundwater in the eastern U.S.