Master of Science in Sustainability Science

SUSC PS5130 Improving Health through Environmental Measurements in Water, Soil and Air
TBD
3 Credits

Instructors:

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Office Hours: TBD

Response Policy: Students can expect a response within 24 hours, 7 days a week. Email is our preferred mode of communication.

Course Overview

Starting from a global perspective on the leading environmental contributors to the burden of disease, this course will lead participants through a series of case studies of environmental contaminations of natural or man-made origin. Airborne particulate matter from natural and anthropogenic sources, soil contamination with lead from mining and other industrial activities, and natural well-water contamination with arsenic are some of the topics to be covered. One of the goals of the course will be to develop the critical sense needed to distinguish indisputable harm from poorly substantiated claims and concerns by both reading the primary environmental and public health literature and analyzing existing data sets. The course will cover cases of egregious exposures in developing countries, as well as some environmental issues in and around New York City. The course will provide students with the opportunity to learn how to use and deploy several field kits and monitors for analyzing water, soil, and air, and assess the quality and implications of their own data. An emphasis on empowerment through measurement, mapping, and sharing of information will lead to a discussion of regulation, policies, and mitigation to reduce the burden of disease caused by environmental exposures in both industrialized and developing nations.

The course will provide students with the methods and tools to understand, monitor, and analyze current environmental health threats in water, soil, and air, and explore strategies for solving these at times complex challenges. Students will leave the course with a stronger sense of the power, and limitations, of environmental data and better equipped to evaluate and communicate the effectiveness of new interventions. After completing the course, students will more confidently apply core scientific concepts to evaluating and addressing public health challenges posed by, for instance, air, soil, and water contamination with lead.

This course is approved to satisfy the Area 4: Scientific Tools for Responding to Sustainability Challenges requirement for the M.S. in Sustainability Science Program.

Learning Objectives

Students will be expected to gain a quantitative understanding of the main processes that lead to contamination of water, soil, and air, based on the presented case-studies and their own measurements, as well as the ability to conduct back-of-the-envelope calculations and design a sampling campaign to gauge the new situations they may encounter in their career. Specific learning outcomes include:

L1. Identify and apply the tools and methods used to gauge the health impacts of environmental exposures.

L2. Collect, analyze and model scientific data to quantify environmental burdens on human health and address uncertainties that might lead to dispute.

L3. Use portable kits and instrumentation to quantify hazards in real-world environments

L4. Use environmental data to evaluate existing and new strategies for addressing public health challenges.

Readings

- Ali Z, Bhaskar SB. Basic statistical tools in research and data analysis. Indian Journal of Anaesthesia 2016; 60:662-9. Pages 662-669
- BGS/DPHE (British Geological Survey, Dept. of Public Health Engineering). Arsenic Contamination of Groundwater in Bangladesh. Kinniburgh, D. G. and Smedley P. L. (Editors). Volume 2: Final Report, British Geological Survey Report WC/00/10. Executive Summary and Chapters 6 and 8. British Geological Survey, Keyworth (2001). Pages xvii, 77-104, 151-160
- Berner, Elizabeth Kay, and Robert A. Berner. *Global environment: water, air, and geochemical cycles*. 2nd Ed., Princeton University Press, 2012. Pages 151-185
- Cheng, Z., A. Paltseva, I. Li, T. Morin, H. Huot, S. Egendorf, Z. Su, R. Yolanda, K. Singh, L. Lee, M. Grinshtein, Y. Liu, K. Green, W. Wai, B. Wazed, R. Shaw. Trace metal contamination in New York City garden soils. Soil Sci 2015;180: 00–00. Pages 167-174
- Chillrud, SN, RF Bopp, HJ Simpson, J Ross, EL Shuster, DA Chaky, DC Walsh, CC Choy, LR Tolley and A. Yarme, Twentieth century metal fluxes into Central Park Lake, New York City, *Environ. Sci. Technol.* 33, 657-662, 1999. Pages 657-662
- Cohen AJ, Brauer M, Burnett R, Anderson HR, et al., Forouzanfar MH. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. Lancet 2017; 389:1907-18. Pages 1907-1918
- Dooyema CA, Neri A, Lo YC, Durant J, Dargan PI, Swarthout T et al. Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria, 2010. Environ Health Perspect 2012;120: 601–7. Pages 601-607
- Drexler, J. W. & Brattin, W. J. An In Vitro Procedure for Estimation of Lead Relative Bioavailability: With Validation. Hum. Ecol. Risk Assess. 13, 383–401 (2007). Pages 383-401
- Edwards, M. Fetal death and reduced birth rates associated with exposure to lead-contaminated drinking water. Environmental Science & Technology 48, 739-746 (2013). Pages 739-746
- Flanagan SV, Johnston RB, Zheng Y. Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. Bulletin of the World Health Organization 90, 839-46 (2012). Pages 839-846
- Flanagan, S.V., Spayd, S.E., Procopio, N.A., Chillrud, S.N., Braman, S., and Zheng, Y. 2016. Arsenic in private well water Part 1 of 3: Impact of the New Jersey Private Well Testing Act on household testing and mitigation behaviors. *Science of the Total Environment*, 562: 999–1009. Pages 999-1009
- George, CM, Y Zheng, JH Graziano, SB Rasul, JL Mey, A van Geen, Evaluation of an arsenic test kit for rapid well screening in Bangladesh, Environmental Science and Technology 46, 11213–11219, 2012. Pages 11213-11219
- Henry, H., MF Naujokas, C Attanayake, NT Basta, Z Cheng, GM Hettiarachchi, M Maddaloni, C Schadt, and KG Scheckel. Bioavailability-Based In Situ Remediation To Meet Future Lead (Pb) Standards in Urban Soils and Gardens. Environ. Sci. Technol. 2015, 49, 8948−8958. Pages 8948-8958
- Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL, Schnaas L, Wasserman G, Graziano J, Roberts R. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. Environ Health Perspect. 113, 894-899 (2005). Pages 894-899
- Lim, Stephen S., et al. "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010." *The Lancet* 380.9859 (2012): 2224-2260. Pages 2224-2260

- McBride, Murray B. *Environmental Chemistry of Soils*. Oxford University Press, 1994. 416 pages
- Peel, JL and Smith, KR. "Mind the Gap." Environmental Health Perspectives. 2010; 118 (12): 1643-1645. Pages 1643-1645
- Pieper, K. J., M. Tang, M. A. Edwards. Flint water crisis caused by interrupted corrosion control: Investigating "Ground Zero" home. Envi. Sci. Technol. 51, 2007−2014 (2017). Pages 2007-2014
- Wilson, Richard, and John D. Spengler, eds. *Particles in our air: concentrations and health effects*. Harvard University Press, 1996. 265 pages

Resources

Columbia University Library
Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online: http://library.columbia.edu/.

SPS Academic Resources
The Office of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: http://sps.columbia.edu/student-life-and-alumni-relations/academic-resources.

Air monitors. Several air monitors that collect data in real-time will be available for student use, including black carbon monitors (https://aethlabs.com/microaeth), particulate monitors for personal (RTI microPEMs (https://www.rti.org/sites/default/files/brochures/rti_micropem.pdf) , Airbeams (Aircasting.org)) or for fixed site indoor or outdoor use (PurpleAir.org).

Arsenic kit. Students will learn how to use a widely-used for measuring As in drinking water based on the 19th century Gutzeit method. Samples returned of well-water returned on regular basis from rural New Jersey through another project will provide an opportunity for using the kit and comparing the results to laboratory measurements (George et al., 2012)

Lead kit. Students will have the opportunity to use a qualitative (high, medium, low) kit for estimating bioaccessible lead in soil that is simplification of the standard EPA method (Drexel and Brattin, 2007). Results from this kit will also be compared to laboratory measurements.

Course Requirements (Assignments)

Three take-home quizzes on Water, Air, and Soil contaminants (L1, L2, L4)

The homework will gauge to which extent students are able to apply the material presented in class and the additional readings. The quizzes will each consist of 5 short problems requiring students to analyze and interpret data sets related to but not identical to the case-studies covered in class.

Final Group Project: Environmental Measurements (L1, L2, L3, L4)

The group reports will be derived from the environmental measurements conducted in the NYC area during the last two weeks of the course. The format of the presentations will follow the following format: 1) identify the problem, 2) quantify human health impact, 3) propose field measurements to inform the problem, 4) form hypothesis on potential strategy to address the challenge, and 5) sample/measure locally and use appropriate tools and methods. One example of a student project could be to conduct a soil survey for lead in some under-sampled part of New York City. Students will use various instruments or kits to measure environmental contamination in air, water, and/or soil and the importance of replication and calibration. The group will be formed based on selected topics and individual interests. Starting on the third lecture (02/05), example topics will be suggested in the class. On 04/02, details about the topics, requirement, and approach for designing the study, collecting data, and data analysis will be discussed. The presentations will be given on 04/23 and 04/30. The presentation from each group will last about 30 minutes, followed by a 15 to 30 mins of discussion. The final report will be about 15-20 pages in length with double line spacing, and should include introduction, method, results, and discussion parts. The final report will be due on May 4.

Participation (L1, L2)

Class participation: students will come to class with readings completed and ready to participate in classroom discussions.

Evaluation/Grading

Take-home problem sets/quizes: Air, Water, Soil (each 20%)
Problem sets will be scored on a scale of 0-100.
This problem set will be graded by the quality of the answers, including whether knowledge learned from class and readings are used correctly, clearness of the answers, etc.

Final Group Project: Environmental Measurements (30%)
The final group presentation and report will be scored combined on a scale of 0-100.
Presentation will be graded based on a list of criteria, including whether the problem of hypothesis is clearly stated, the study design, methods are data analysis are explained, and whether the results and interpretation can be followed, as well as whether, the student(s) display knowledge during question and answering session. Each group member must have a defined role. Final report will be graded on the depth of their understanding, the merit of the writing, etc.

Participation (10%).
Participation in class discussions and the final group presentation will count towards 10% of final grade. Students are expected to attend class and contribute at least one substantive comment every other week. Substantive comments include answering questions, defending your point of view, and challenging the point of view of others. Students must have contributed in the final group presentation.

The final grade will be calculated as described below:

FINAL GRADING SCALE

Grade	Percentage
A+	98–100 %
A	93–97.9 %
A-	90–92.9 %

B+	87–89.9 %
B	83–86.9 %
B-	80–82.9 %
C+	77–79.9 %
C	73–76.9 %
C-	70–72.9 %
D	60–69.9 %
F	59.9% and below

ASSIGNMENT	**% Weight**
Quiz 1: Air	20
Quiz 2: Soil	20
Quiz 3: Water	20
Environmental Measurements Group Project	30
Participation	10

Course Policies

Participation and Attendance
You are expected to complete all assigned readings, attend all class sessions, and engage with others in online discussions. Your participation will require that you answer questions, defend your point of view, and challenge the point of view of others. If you need to miss a class for any reason, please discuss the absence with the session's lead instructor in advance.

Late work
There will be no credit granted to any written assignment that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor.

Citation & Submission
All written assignments must use [citation format], cite sources, and be submitted to the course website (not via email).

School Policies

Copyright Policy
Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

Academic Integrity

Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility
Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: http://health.columbia.edu/services/ods/support.

Course Schedule/Course Calendar

Date	Topics and Activities	Readings (due on this day)	Assignments (due on this date)
1/22	**Overview of Global Burden of Disease and approach** 1. Overview of where environmental exposures fall within top 20 causes 2. Deaths and disability-adjusted life years (DALYS) 3. Concentration and bioavailability	Lim, Stephen S., et al. "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010." *The Lancet* 380.9859 (2012): Pages 2224-2260.	
1/29	**Water and health.** 1. Microbial pathogens 2. Geogenic and anthropogenic contaminants **Air and health.** 1. Ambient PM2.5 and cardiovascular disease 2. Indoor PM2.5 and cardiovascular health (mind the gap paper)	Lim, Stephen S., et al. "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010." *The Lancet* 380.9859 (2012): Pages 2224-2260	

	Soils and health. 1. Flemming and the development of antibiotics from soil 2. Organic contaminants and inorganic contaminants.		
2/5	**Statistics of sampling and measurements** 1. Measurement accuracy 2. Measurement precision 3. Spatial and temporal variability 4. Hands on evaluation of data sets	Ali Z, Bhaskar SB. Basic statistical tools in research and data analysis. Indian Journal of Anaesthesia 2016; Pages 662-669.	
2/12 – This class will be taken as a field trip, location TBD	**Overview of available hands-on tools for class projects** 1. Water: Arsenic kit based on Gutzeit method 2. Air: light scattering nephelometer (PM2.5), light absorption for BC and ETS, Filter based measurements for chemical analysis. 3. Soil based: hand-held XRF, Pb extraction in glycine 4. SurveyCTO app for data collection	George, CM, Y Zheng, JH Graziano, SB Rasul, JL Mey, A van Geen, Evaluation of an arsenic test kit for rapid well screening in Bangladesh, Environmental Science and Technology 46, Pages 11213-11219. Drexler, J. W. & Brattin, W. J. An In Vitro Procedure for Estimation of Lead Relative Bioavailability: With Validation. Hum. Ecol. Risk Assess. 13, 383–401 (2007).	
2/19	**Laboratory** Class will be divided into smaller groups to measure and map (Google Earth) some form of contamination in the NY area e.g.: • Air pollutant measurements of different types of restaurants or transportation modes using air monitors described above • Well-water arsenic measurements in New Jersey • Soil Pb measurements in playgrounds and parks • Alternatively – analysis of large existing data set, or final summary push on global burden of disease (e.g. well-water arsenic in Bangladesh)	Chillrud, SN, RF Bopp, HJ Simpson, J Ross, EL Shuster, DA Chaky, DC Walsh, CC Choy, LR Tolley and A. Yarme, Twentieth century metal fluxes into Central Park Lake, New York City, *Environ. Sci. Technol.* 33, 657-662, 1999. Flanagan, S.V., Spayd, S.E., Procopio, N.A., Chillrud, S.N., Braman, S., and Zheng, Y. 2016. Arsenic in private well water Part 1 of 3: Impact of the New Jersey Private Well Testing Act on household testing and mitigation behaviors. *Science of*	

		the Total Environment, 562: Pages 999-1009. Henry, H., MF Naujokas, C Attanayake, NT Basta, Z Cheng, GM Hettiarachchi, M Maddaloni, C Schadt, and KG Scheckel. Bioavailability-Based In Situ Remediation To Meet Future Lead (Pb) Standards in Urban Soils and Gardens Environ. Sci. Technol. 2015, 49, Pages 8948−895.	
2/26	**Water** 1. The hydrologic cycle 2. Total Dissolved Solids in sea, surface, and groundwater 3. Impact of redox conditions on natural waters	Berner, Elizabeth Kay, and Robert A. Berner. Global environment: water, air, and geochemical cycles. 2nd Ed., Princeton University Press, 2012. Ch. 4. Chemical weathering. Pages 151-185	Students submit group project ideas for approval
3/5	**Water** 1. Global Burden of Disease- details on assumptions and calculations for Water 2. Case Studies: a. Microbial pathogens and sanitation b. Arsenic in groundwater of the Bengal Basin **c.** Lead in drinking water	BGS/DPHE Executive Summary and Chapters 6 and 8. Pages xvii, 77-104, 151-160 Flanagan SV, Johnston RB, Zheng Y. Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. Bulletin of the World Health Organization 90, 839-46 (2012). Edwards, M. Fetal death and reduced birth rates associated with exposure to lead-contaminated drinking water. Environmental Science & Technology 48, 739-746 (2013). Pieper, K. J., M. Tang, M. A. Edwards. Flint water crisis caused by interrupted corrosion control: Investigating "Ground Zero" home. Envi. Sci. Technol. 51, 2007−2014 (2017).	

3/19	**Air** 1. Air circulation and mixing, physics of particle formation, primary and secondary pollutants 2. Natural and anthropogenic sources of airborne particles; Outdoor fine particulate matter (PM2.5) and cardiovascular disease	Wilson, Richard, and John D. Spengler, eds. *Particles in our air: concentrations and health effects*. Harvard University Press, 1996. 265 pages.	Take-home 1: Water
3/26	**Air** 1. Global Burden of Disease- details on assumptions and calculations for Water 2. Case Studies: a. Improved cookstoves in developing countries b. Indoor VOCs and green solutions c. Atmospheric deposition of Pb and other contaminants in Central Park	Cohen AJ, Brauer M, Burnett R, Anderson HR, et al., Forouzanfar MH. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. Lancet 2017; 389: Pages 1907-1918. Peel, JL and Smith, KR. "Mind the Gap." Environmental Health Perspectives. 2010; 118 (12): Pages 1643-1645. Chillrud, SN, RF Bopp, HJ Simpson, J Ross, EL Shuster, DA Chaky, DC Walsh, CC Choy, LR Tolley and A. Yarme, Twentieth century metal fluxes into Central Park Lake, New York City, *Environ. Sci. Technol.* 33, 657-662, 1999.	

4/2	**Proposal Presentations of Group Projects** 1. Identify the problem 2. Quantify human health impact 3. Proposal of field measurement to inform the problem and 4. Hypothesis on potential solution/policy change 5. Local sampling/measurement plan using provided kits if appropriate		Students present group project proposals to class
4/9	**Soil** 1. What is a soil? Soil forming factors, processes, distribution of specific soils. 2. Processes that affect soil contamination risk and dose. 3. Role of speciation in controlling bioavailability.	McBride, Murray B. *Environmental Chemistry of Soils*. Oxford University Press, 1994. 416 pages	Take-home 2: Air
4/16	**Soil** 1. Global Burden of Disease- details on assumptions and calculations for Soil 2. Case studies: a. Superfund sites. b. Soil lead (Peru mining, Brooklyn backyards) c. Acid mine drainage d. Parkinsonism and manganese.	Dooyema CA, Neri A, Lo YC, Durant J, Dargan PI, Swarthout T et al. Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria, 2010. Environ Health Perspect 2012;120: Pages 601-607. Cheng, Z., A. Paltseva, I. Li, T. Morin, H. Huot, S. Egendorf, Z. Su, R. Yolanda, K. Singh, L. Lee, M. Grinshtein, Y. Liu, K. Green, W. Wai, B. Wazed, R. Shaw. Trace metal contamination in New York City garden soils. Soil Sci 2015;180: 00–00. Pages 167-174	
4/23	**Presentations**		Take-home 3: Soil Group Project Presentations

4/30	**Presentations**		Group Project Presentations
5/4	**No Class Session- Assignment Due Date**		Group Final Report Due