

Environmental Chemistry U6220

June 1 – July 10<sup>th</sup>

Summer 2023

Instructor: Steven Chillrud [snc2@columbia.edu](mailto:snc2@columbia.edu) (please put in “U6220” into the subject heading).

Week	IAB 413 (Thurs 9 am – 12 noon)	Afternoon Lab/HW- Schermerhorn 417
Week 1. Thursday Jun 1st	<ol style="list-style-type: none"> <li>1) Introduction</li> <li>2) Population Growth &amp; Sustainability &amp; Discussion</li> <li>3) Review of chemistry</li> <li>4) <b>How to read a journal article:</b></li> <li>5) Journal reading: Chillrud et al 1999</li> </ol>	<ol style="list-style-type: none"> <li>1. <b>More Chemistry &amp; Math review</b>, unit conversions (fractions math), solving equations, introduction to box models</li> <li>2. <b>Lab 1 HW sheet</b></li> <li>3. <b>Hand out/prepare sampling materials needed for Week 2 lab:</b> Particle fluxes in NYC</li> </ol>
Week 2 Thursday Jun 8th	<ol style="list-style-type: none"> <li>1) <b>The Atmosphere – part I</b></li> <li>2) Guest speaker- Dr. Jacqueline Klopp Columbia University</li> <li>3) Case Study: Central Park Lake Metals &amp; Discussion</li> </ol>	<ol style="list-style-type: none"> <li>1. Intro to statistical testing for significance (TAs will lead)</li> <li>2. Lab 2: Particle fluxes in NYC</li> <li>3. Assign HW Journal reading: Gould et al paper 2022 + Supplement.</li> </ol>
Week 3. Thursday Jun 15 <sup>h</sup>	<ol style="list-style-type: none"> <li>1) <b>The Atmosphere- part II</b></li> <li>2) Guest speaker - Dr Godwin Opinde, Kenyatta University, Nairobi, Kenya</li> <li>3) Case study- Household air Pollution Intervention &amp; Discussion</li> </ol>	<ol style="list-style-type: none"> <li>1. Part 2 of lab 2 on Particle fluxes in NYC</li> <li>2. Group meetings with instructor on topic for final project</li> <li>3. Assign HW Journal reading: TBD</li> </ol>
Week 4. Thursday Jun 22th	<ol style="list-style-type: none"> <li>1) <b>Intro to field trip (meet at IAB 402)</b></li> <li>2) Field trip to Gowanus Canal</li> </ol>	<ol style="list-style-type: none"> <li>1. Field trip to Gowanus Canal</li> <li>2. Hand out take-home practice exam</li> </ol>
Week 5. Thursday Jun 29th	<ol style="list-style-type: none"> <li>1) <b>The Hydrosphere- part I</b></li> <li>2) Guest speaker: Dr. Beizhan Yan, Columbia University, on Microplastics and partitioning of chemicals</li> <li>3) Case Study on PCBs in Hudson River</li> </ol>	<ol style="list-style-type: none"> <li>1. Lab 3: PFAS lab and water quality standards</li> <li>2. Journal reading HW: review paper on: Pollution and Health: a progress update: Fuller et al 2022 <a href="https://doi.org/10.1016/S2542-5196(22)00090-0">https://doi.org/10.1016/S2542-5196(22)00090-0</a></li> </ol>
Week 6. Thursday Jul 6th	<ol style="list-style-type: none"> <li>1) <b>The Hydrosphere – part II</b></li> <li>2) Guest Speaker: TBD</li> <li>3) Class Discussion of Fuller et al</li> <li>4) Case Study- geogenic groundwater contaminants</li> <li>5) Final paper due by 13:00</li> </ol>	<ol style="list-style-type: none"> <li>1. Final Presentations of group projects</li> <li>2. Hand out of take-home exam</li> </ol>
Week 7: Final exam due date: Monday July 10 <sup>th</sup> 23:59	<ol style="list-style-type: none"> <li>1) Take home Final exam due date: Monday Jul 10<sup>th</sup></li> <li>2) note your first day of 2nd semester is 11<sup>th</sup> of July</li> </ol>	N/A

**Instructor:** Steven Chillrud **Office Hours:** monday, 7–9 pm, location Zoom  
or by appt via email

**Office hours location:** We are trying to find a room still for in person office hours:

**The back up plan will be zoom;** *I hope to see each of you in my office hours to discuss any questions you have, your progress, and anything else that comes to mind. My office hours are above which were chosen given the time zones that people are spread across initially and so will; in addition appointments can be made by email most weekdays during the 8 pm – 10 pm time slot, but only by zoom.*

**Email:** [snc2@columbia.edu](mailto:snc2@columbia.edu) (please put in “U6220” into the subject heading).

**TAs:** Kritanjali Chaurasia [kc3613@columbia.edu](mailto:kc3613@columbia.edu) ((office hours – Fridays 7 -9 pm )

Desikan Jayaram [dj2658@columbia.edu](mailto:dj2658@columbia.edu) (office hours – Sat 3 – 5 pm )

Ngoc Truong [bnt2118@columbia.edu](mailto:bnt2118@columbia.edu) (office hours – Sun 3 – 5 pm)

Can email to ask questions but put U6220 in subject

**Class liasons:**

**Course works:**

<https://courseworks2.columbia.edu/courses/157591>

**Textbook:**

*An Introduction to Environmental Chemistry, 2<sup>nd</sup> Edition* by Julian E Andrews, Peter Brimblecombe, Tim D. Jickells, Peter S. Liss, Brian Reid. Blackwell Publishing

*None of these books are required readings but you may find them useful resource, especially for those of you who want a text for reviewing or learning fundamental principles of environmental chemistry or as a resource in the future.*

**Other text books:**

**For review of basic chemistry concepts –**

**Khan Academy** (<https://www.khanacademy.org/science/chemistry>)

skip the mass spec unit, and we don't do much on thermodynamics or kinetics either so those units can be skipped

***Principles of Environmental Geochemistry*** by G. Nelson Eby: Chapters 1 - 4

**For an easier to read text book:**

***Environmental Chemistry- A global perspective*** by Gary W. vanLoon / Stephen J. Duffy

**For more depth in each subject**

***Environmental Chemistry*** by Colin Baird & Michael Cann, 5<sup>th</sup> Edition\_

***Earth System Science: From Biogeochemical Cycles to Global Change*** by Michael Jacobson, Robert J. Charlson and Henning Rodhe. 2000 There is a Columbia E-book for this. This book is primarily useful for its description of the global cycles of C, N, S, P.

**Assigned journal article readings will be uploaded to Course works- full citations at end of syllabus**

**Week 1 reading:** Atmospheric Deposition: Chillrud et al 1999

**Week 2 reading:** Household Air Pollution: Gould et al 2022 + Supplement

**Week 3 reading:** TBD (micro plastics)

**Week 4 reading:** Gowanus Canal Superfund Site background readings

**Week 5 reading:** review paper on pollution and health: Fuller et al 2022

**Schedule:** Thursdays, 9:00 am -12:00 pm (Eastern Daylight Time)  
 Lab A: 1:00 – 3:30 pm ; Lab B: 3:30 – 6:00 pm (Eastern Daylight Time)

LOCATION OF LECTURES: - IAB 413

LOCATION OF LABS: A: 1- 3:30 or B: 3:30 – 6 pm : Schermerhorn 417

**Expectations:** Each student is required to attend the morning lecture/discussion period and will be assigned to one of the lab sessions every week. Some case studies will be recorded so that they can be watched asynchronously. Homework and/or group reports are due the following Monday by 11:59 pm. Assignments are graded on a point scale. We may have short quizzes every couple of weeks to test your understanding, and to provide the instructor and TAs with feedback so we can decide what topics need additional attention in office hours.

### Weekly Report Submission Deadlines

#### 1. Summer Sessions (Jun 3 to July 8)

	Monday	Tuesday	Wednesday	Thursday	Friday
Climatology		■			▶
Environmental Chemistry	▶			■	
Principles of Ecology		▶			■
Environmental Policy			▶	■	

Environmental chemistry assignments are given on Thursdays and due on Mondays, etc.

**Homework:** The major assignments that will be performed in this course will be weekly lab/Homework sets, which will be completed in small groups. We may have additional exercises that are given during the term, including some that will be evaluated by your peers. Group work can be turned in by a single group member, but all group members should be clearly indicated on what is turned in. All assignments will be turned in using Courseworks in the Assignments tab.

**Exams:** Material from lectures, labs and readings will be covered on the mid-term exams and the final. To avoid complicated scheduling, the mid-term exam will be given out during the regular class period of Week 3, and turn in by email to me within 24 hours. It should not be overly complicated to complete within 1-2 hours and will be of a similar format to that of the final which will be a longer assignment. *Both midterm and final will likely be take home exams. The midterm will be done in groups of 2. The final will be independent.*

Grading:	Model
Group Lab Assignments:	30% (5% lab 1, 15% lab 2, 10% lab 3)
Individual Take home Midterm Exam:	10%
Group Final Project Presentation	15%
Group Final Project Paper	10%
Individual Take home final exam:	20%
Participation/Attendance:	<u>15%</u>
	100%

Participation will be based on attendance during the morning and lab periods (unless there is an excused absence), participation in lectures and discussions on journal readings, and the field trip,

which all students are expected to attend, as well as actively participate in guest lectures Q&A and each others presented final projects.

Past classes have used slack to answer each others questions, ask TAs questions, etc. However, the instructor is NOT a slack user. If you need to contact Steve, email [snc2@columbia.edu](mailto:snc2@columbia.edu) and **put in U6220 into the subject heading** so I can search for class related emails. I get a lot of email.

Group work: For the Lab/HWs and Final projects will all be done in small groups which will be different each week; you will be assigned to the groups by the TAs. Professionals largely work in groups. You will largely be working in groups of 5 people for the most part.

Grading will use the standard 100-90, 80-89, 70-79 grading scale.

**Final Course Term Project and Presentation :** A group (teams of 5) term project will be due that examines **solutions to pollutions** through a mini-review of the literature such as a successful case study. This will consist in both a **written paper and a ppt presentation**. Each group will be randomly formed by the TAs but you can ask to be switched to a different group if you find someone who wants to switch the other way and by reaching out to the instructor with a rationale (who will decide if a switch is approved or not). The topics will be chosen by the groups by week 3 or one will be assigned to the group by the TAs.

The final paper should be 5 pages text plus abstract, figures and references. The paper abstract should summarize the paper in 250-500 words. You should use a minimum of 5 references but try and keep it below 10 references. ***If you want, the paper can be written using Chat GPT or equivalent as long as you cite what program you used as one of the authors, proof read, edit and and correct any incorrect statements and add appropriate citations to support any claims it made- which might mean you have to track down additional referernces; your group will also have to hand in the original chat GPT article and then a 3rd version that shows how you corrected and improved it using microsoft editing tool or the microsoft comparison tool. You do not have to use such a program but the generative AI future is here so it might be a good opportunity to see if it is useful or not.***

The presentation will be a 10 minute group presentations on your term project to the entire class followed by 6 minutes of group questions and discussion, and 4 minutes when your peers will fill out a feedback form based on a grading schematic that will be provided. At minimum of two people from the group should take part in the presentation and all 5 members available to help during the Q&A.

**You will be randomly assigned to your groups; topics should be chosen by week 3; If your group doesn't choose a topic, a topic will be assigned.**

**To ensure that reasonable progress is made towards this goal, I expect that each of your groups (to be assigned randomly by the TAs within lab group A or B) will reach out to me to discuss your proposed project topic and your literature search with me before the 3<sup>rd</sup> week by zoom; We will meet in the 3<sup>rd</sup> week lab session to discuss your proposed sources at that time to ensure that your topic is sufficiently focused and achievable. You should also feel free to reach out to the instructor or TA to set up separate zoom meetings.**

You can choose any topic but examples of case studies you could focus on include:

- [Save Lamu campaign in Kenya](#) that has blocked a dirty coal plant
- No till agriculture and its role in decreasing erosion while increasing crop yield and carbon storage. How does aeration work without tilling
- Eutrophication and decreasing levels of exported nutrients due to improved control and regulations on fertilizer use. Pick a specific country or region where decreasing overall fertilizer use in corresponds to continued increases in crop yield
- Green chemistry innovations: a shift towards a carbon negative environment

- Natural experiments such as closing of a power plant, the pandemic, etc that impacted water or air quality.
- Biodiesel production using waste products. Algal based production
- Bioremediation of heavy metals ( bioaccumulation) or organics.
- The role of monitoring in the VW diesel gate scandal.
- For India, Thailand and some other countries, use of CNG/LPG in transit and its role in decreasing traffic emissions.
- Geoengineering – there are three big approaches- modifying the atmosphere or surface of the earth to reflect more light (energy); modifying the ocean or land surface so organisms take up more CO<sub>2</sub> or various approaches for direct carbon capture for long term storage. Pick one of these, ideally where someone has done pilot scale studies (smaller scale studies that can show potential but are not to the scale needed to affect the global climate yet). In the discussion you can focus on the potential and controversy of scaling this approach up- is there potential to scale up large enough to be impactful to global climate and does this outweigh negative consequences- are the negative consequences equitably shared across the globe.
- Rickshaw conversion in Delhi from diesel to LNG and electric
- Mexico City- improvements in ozone levels
- Major air pollution improvements in recent years in Seoul, Beijing (Beijing-Tianjin-Hebei region more generally)
- the leapfrogging of solar technology into developing countries--not needing to take the same routes the global north and SE Asia did as they electrified and relied heavily on fossil fuels.
- In western cities like NYC and London
  - Airpollution improvements starting in the 1960s but with major improvements in recent years due to Clean heat policy in NYC (e.g., PM<sub>2.5</sub>, sulfate, BC, NO<sub>2</sub> levels and sources) based on use of New York City Community Air Survey source apportionment studies
  - SO<sub>2</sub> and Sulfate levels in the NE USA related to pollution control and economic forces.
  - Low emission zones in London and other european cities
  - Phase out of hazardous chemicals (DDT, PCBs, Pb, etc) from industrial and consumer products

**For these success stories, you should review scientific and policy peer reviewed literature and more trusted popular press articles (ones that site the primary work or reports they are based on) that document what the key policies or interventions were and the changes (ie. improvements) and how was shown that the intervention or policy was cause the improvement. How strong are those conclusions? If possible, it should also comment on whether the solution was equitable across society or whether it had disparate impacts for communities of color or low SES communities.**

Sources should be primarily from the primary research literature (i.e. not wikipedia, etc, though that can be a place to find sources on a topic). **Use at least 5 published papers or 2 in depth popular press articles and 3 scientific published papers.**

**Suggestions on how to read journal papers in search of one to cover:** read the abstract, look at each figure and table to get one to two major points from each. If not interesting, move on to another paper. If interesting, read the rest of the paper (intro for why, methods for what was done, results to see if they got the same major points you got looking at figures and tables, and discussion to see what authors believed the implications were- and whether you agree with them? Review papers are different since they summarize many papers without reporting the details on methods for each individual paper, etc; however, still good to look at abstract and the figures and tables are still good way to start.

**Journals to read-** Environmental Science and Technology, Environment International, Science, Nature, Lancet, Chemical Geology, Journal of Water, Air, Soil Pollution, Environmental Health Perspectives, Applied Geochemistry, Atmospheric Environment, Environmental Science and Policy, Indoor Air, Journal of Exposure Science and Environmental Epidemiology, Environmental Research, etc.

Think about the environment that was affected by that problem, the chemistry that is of interest to the problem or solution, how humans affect it, the stakeholders involved, is the solution equitable to all groups that were impacted especially communities of color or of low SES, and what is left to do (hardly are success stories 100% effective). The TA's and I will be available to consult with you regarding your progress throughout the term. It is best to get started early, as it will both help the quality of the project, and your final grade on it.

Structure for paper should mimic journal review article with Abstract, Introduction/background, Methods for the mini-review, Results and Discussion Information that could be included in a background section can include a summary of what the problem was, why it was an important problem, then a section describing who the stakeholders were that came together to solve the issue, what the solution was based on, and what were the key characteristics that made the solution improve the situation. Include in the summary whether the approach used is scalable to other locations or were there special circumstances that made this a unique case. Does more need to be done? Why?

## **School Policies and Expectations:**

**Accessibility Statement** – We want you to succeed in this course.

Contact [disability@columbia.edu](mailto:disability@columbia.edu) for learning accommodations. If you are comfortable talking to me about your accommodations, I encourage you to do so in the first week or two of class. Alternatively, the disability services can inform the class instructors (myself, the TAs and the class liaisons) by e-mail. All communications will remain confidential.

**Names/Pronouns** – You deserve to be addressed in a manner that reflects your identity. You are welcome to tell me your pronoun(s) and/or name (if different from University records) at any time, either in person or via email.

**Discrimination** – We embrace the diversity of gender, gender identity & expression, sex, sexual orientation, race, ethnicity, national origin, age, religion, disability status, family status, socioeconomic background, and other visible and non-visible identities. Columbia University does not tolerate unlawful discrimination, discriminatory harassment, sexual assault, domestic violence, dating violence, stalking, or sexual exploitation and all such conduct is forbidden by Columbia University Policy.

**Duty to Report** – You deserve a University community free from discrimination, harassment, and gender-based misconduct including sexual harassment, sexual assault, domestic and dating violence, stalking, and sexual exploitation. It is therefore University policy to require Columbia faculty and staff to report to EOAA any instance or allegation of prohibited conduct involving any undergraduate or any graduate student that is disclosed to, observed by, or otherwise known to that employee. This requirement to report is in place to help ensure that students are provided appropriate resources and to allow the University to mitigate harm to our community.

**Confidential Resources** - There are confidential resources on campus who do not have a Duty to Report, including:

- Sexual Violence Response & Rape Crisis/Anti-Violence Support Center (SVR)
- Ombuds Office
- Medical Services
- University Counseling and Psychological Services
- University Pastoral Counseling
- Columbia Office of Disability Services

University employees working in a confidential capacity will not report information shared with them.

**Inclusion** - In the Environmental Science and Policy program, faculty and staff are committed to the creation and maintenance of “inclusive learning” spaces – classrooms and other places of learning where you will be treated with respect and dignity, and where all individuals are provided equitable opportunity to participate, contribute, and succeed.

In our classroom, all students are welcome regardless of race/ethnicity, gender identities, gender expressions, sexual orientation, socio-economic status, age, disabilities, religion, regional background, Veteran status, citizenship status, nationality and other diverse identities that we each bring to class.

Assigned Readings – pdfs will be uploaded to course works

- **Week 1 reading:** Chillrud et al 1999-
  - 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. PMID: PMC3155985 DOI: [10.1021/es9807892](https://doi.org/10.1021/es9807892)
- **Week 2 reading:** Gould et al 2022 and Supplement
  - Gould CF, Mujtaba MN, Yang Q, Boamah-Kaali E, Quinn AK, Manu G, Lee AG, Ae-Ngibise KA, Carrión D, Kaali S, Kinney PL, Jack DW, Chillrud SN, Asante KP. Using time-resolved monitor wearing data to study the effect of clean cooking interventions on personal air pollution exposures. *J Expo Sci Environ Epidemiol.* 2022 Oct 23 PMID: 36274187. DOI: [10.1038/s41370-022-00483-0](https://doi.org/10.1038/s41370-022-00483-0)
- **Week 3 reading:** Microplastics review: TBD
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- **Week 4 reading:** Gowanus Canal background
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- **Week 5 reading:** review paper: Fuller et al. 2022.
  - Fuller et al. Pollution and health: a progress update. *Lancet Planetary Health* 2022; 6: 535–47. DOI: [https://doi.org/10.1016/S2542-5196\(22\)00145-0](https://doi.org/10.1016/S2542-5196(22)00145-0)