UNIVERSITY OF CALIFORNIA, MERCED
ES 292 – Dynamics of Organic Matter in Soils and Sediments (3 Credits)
Fall 2021

Instructor: Asmeret Asefaw Berhe
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Class hours: Mondays and Wednesdays 9:00 - 10:15AM
in Classroom and Office building (COB) 281

Office hours: Wednesday 10:30AM - 11:30AM or by appointment
Office hours will be virtual until further notice (using course zoom link provided on Catcourses).

Prerequisites: Graduate standing or approval of instructor.

Course Description: ES 292 is a reading group that focuses on the dynamics of organic matter in soil and sediments designed for graduate students in the Environmental Systems graduate group and other related fields of study. The course will explore the formation, storage, loss, and transformations of organic matter (OM) from physical, chemical, and biological perspectives. Lecture and discussions will cover linkages of OM dynamics with atmospheric composition of greenhouse gases and their future climatic implications.

Course Goals and Outcomes:
Course Goals: ES 292 is designed to provide students with the necessary background needed to understand and interpret how OM content in soils and sediments varies across environmental gradients, macromolecular composition and reactivity of soil organic matter (SOM), its associations with soil mineral constituents, and implications of changing storage or mechanisms of SOM stabilization for maintenance of the climate system. In addition, students in ES 292 will also examine how storage of OM and mechanisms of OM stabilization could be affected by processes such as fire and erosion.

Learning Outcomes: By the end of the semester, student that have successfully completed the class will be able to: (1) understand the main processes and drivers in the global carbon cycle, (2) independently identify factors regulating storage and stability of OM in soils and sediments across multiple environmental gradients and management practices, (3) interpret organic matter data derived using a variety of analytical tools, and (4) employ the concepts they learned in this course in development of M.Sc. or Ph.D. research proposal.

Format and Procedures: Class time will include lectures, discussion, and exercises. One lecture each week (after week 2) will be dedicated to lecture and the second class time for student-led discussion on primary research and review articles.

Course Requirements:
Class attendance and participation policy: The student is expected to be present at ALL sections.
Course readings: There is no required textbook for this course. Each week, about 3 manuscripts and/or book sections will be provided for the students to read prior to class (uploaded in

UCMCROPS, additional supplemental readings will also suggested). Each students is required to do all the readings and lead short discussions on two or more topics of their interest over the course of the semester. **Student led discussions are expected to include a comprehensive review of latest advances, major research findings, in the topic of the week. Discussion leaders can suggest additional or replacement papers for discussion. I expect students to present a review of the findings, not to go over sections of papers as is.**

Course assignments and projects I encourage everyone to make every effort to reduce paper waste. All materials related to this course will be posted online. Students are strongly encouraged to read papers online. Student are required to submit term paper electronically.

The course is structured as a weekly seminar, and students will be graded based on attendance and participation in class discussion. The graded exercises will include a term paper, presentation of term paper research results, and presentation and participation in discussion of assigned readings in class. Note that, to earn a passing grade of B, students will need to present and actively participate in discussions, complete all exercises satisfactorily by the deadline.

Grading Procedures:
Both letter grading and pass-fail options will be available. For grading on a pass-fail basis, 70% considered a passing grade. The grade in this course will be calculated as follows:

1 Term paper	40 %
(including 5 pts each for submission of topic [+ annotated bibliography], outline [+ annotated bibliography], first draft)	
2 In-class presentations @ 12.5% each	25 %
Participation in class discussions @ 10%	10 %
Presentation of term paper results	25 %
Total	100 %

My Assumptions: This course will cover both quantitative and qualitative materials. Students in this class are expected to have basic knowledge of soil science, geochemistry, analytical chemistry, and biology. If needed, review of scientific principles that are important for the understanding of course material can be provided during office hours or on the courses webpage at CatCourses.

My Expectation: I expect students to: come to class on time, be attentive and engaged during lectures and discussions (spending adequate time to understand the material), read all assigned readings at least before the Wednesday class time, seek help when appropriate, and refrain from using any electronic devices (with the exception of ones used for note-taking).

Academic Integrity: The student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work. You are encouraged to discuss information and concepts covered in manuscripts and discussion with other students or researchers. You can also give "consulting" help to or receive "consulting" help from such students/researchers. However, this permissible cooperation should never involve one student taking credit for work done by someone else. Penalty for violation of this policy can include failure of the course and University disciplinary action.

Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations

COVID-19 RELATED ADJUSTMENTS

In this seminar, we will always treat each other with **respect** and **dignity**. We are here to learn. There is no such thing as a "stupid" or "basic" question. I will address each student's needs and concerns to the best of our ability; and I am committed to providing accommodations that students need to succeed in the class and development of the assignment materials.

In addition, we should all acknowledge that this is not a normal year. There is a lot going on that we have to deal with. I want you to know that I recognize the gravity of the situation that many of you find yourselves in. I want to remind you to be kind to yourself and others you interact with. Don't hesitate to reach out to me if you have any concerns.

Principles

1. Nobody signed up for this.
   - Not for the sickness, not for the social distancing, not for the racial violence, not for the fires, not for the sudden end of our collective lives together on campus
   - Not for an online class, not for teaching remotely, not for learning from home, not for mastering new technologies, not for varied access to learning materials

2. The humane option is the best option.
   - We are going to prioritize supporting each other as humans
   - We are going to prioritize simple solutions that make sense for the most
   - We are going to prioritize sharing resources and communicating clearly

3. We cannot just do the same thing online.
   - Some assignments are no longer possible
   - Some expectations are no longer reasonable
   - Some objectives are no longer valuable

4. We will foster intellectual nourishment, social connection, and personal accommodation.
   - Accessible asynchronous content for diverse access, time zones, and contexts
   - Optional synchronous discussion to learn together and combat isolation

5. We will remain flexible and adjust to the situation.
   - Nobody knows where this is going and what we'll need to adapt
   - Everybody needs support and understanding in this unprecedented moment

(gratefully adopted from Brandon Bayne; UNC - Chapel Hill)

Sections and Assigned Reading
(Note that some of the readings will cover overlapping topics. Do a first pass of the papers before you get to in depth reading to save you time that you might spend on repeated topics. If you have never done so, you want to read this helpful note on how to read academic papers https://web.stanford.edu/class/ee384m/Handouts/HowtoReadPaper.pdf)

Topic 1. Overview *(08/25)*

- No readings for this session

Topic 2. Chemistry, Soil Science, Carbon Cycle, and Soil Organic Matter basics *(08/30)*

Reading 2.1. Houghton, RA. 2003. "The contemporary carbon cycle." *Treatise on Geochemistry* 8: 473–513.

Reading 2.2. Baldock, Jeffrey A, and Kris Broos. 2011. "Chapter 11: Soil Organic Matter." In *Handbook of Soil Science: Properties and Processes*, edited by Pan Ming Huang, Yuncong Li, and Malcolm E Sumner, second, 11–1 to 11–52. Boca Raton, FL: CRC Press.

Suggested additional readings:

- Ponce-Espinosa, H., Ponce-Cruz, P., & Molina, A. (2014). Chemical Organic Compounds. In *Studies in Computational Intelligence* (Vol. 521, pp. 31–52). http://doi.org/10.1007/978-3-319-02472-1_2 (this is a quick revision on Organic Chemistry basics)
- Kleber, Markus, and Mark G Johnson. 2010. "Advances in understanding the molecular structure of organic matter: Implications for interactions in the environment." *Advances in Agronomy* (September 29): 1–34.
- Manlay, R. J., Feller, C., & Swift, M. J. (2007). Historical evolution of soil organic matter concepts and their relationships with the fertility and sustainability of cropping systems. *Agriculture Ecosystems & Environment*, *119*(3-4), 217–233.
- Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Hauck, J., Olsen, A., . . . Zaehle, S. (2020). Global Carbon Budget 2020. *Earth Syst. Sci. Data, 12*(4), 3269-3340. doi:10.5194/essd-12-3269-2020

Topic 3. Techniques of determining SOM storage, composition *(09/01, & 09/08)*

Reading 3.1. Billings, S. A., Lajtha, K., Malhotra, A., Berhe, A. A., de Graaff, M. A., Earl, S., . . . Hobbie, S. E. (2021). Soil organic carbon is not just for soil scientists: measurement recommendations for diverse practitioners. *Ecological Applications, 31*(3), e02290.

Reading 3.2.Chenu, C., Rumpel, C., & Lehmann, J. (2015). Methods for Studying Soil Organic Matter: Nature, Dynamics, Spatial Accessibility, and Interactions with Minerals. In *Soil Microbiology, Ecology, and Biochemistry*.

Reading 3.3. Ellerbrock, R. H., & Gerke, H. H. (2013). Characterization of Organic Matter Composition of Soil and Flow Path Surfaces Based on Physicochemical Principles—A Review. *Advances in Agronomy* (1st ed., Vol. 121, pp. 117–177). Advances in Agronomy.

Suggested additional readings:

- Dawson, TE, S Mambelli, AH Plamboeck, PH Templer, and KP Tu. 2002. "Stable isotopes in plant ecology" *Annual Review Of Ecology And Systematics* 33 (1): 507–559.

- Sanjai J Parikh, Goyne, K. W., Margenot, A. J., Mukome, F. N. D., & Calderon, F. J. (2014). Soil Chemical Insights Provided through Vibrational Spectroscopy.
- Post, WM, RC Izaurralde, LK Mann, and N Bliss. 2001. "Monitoring and verifying changes of organic carbon in soil." *Climatic Change* 51 (1): 73–99.
- Kögel-Knabner, I., & Rumpel, C. (2018). Advances in molecular approaches for understanding soil organic matter composition, origin, and turnover: a historical overview. In *Advances in Agronomy* (Vol. 149, pp. 1-48). Academic Press.

09/10 Topic of your term paper due (submit through Catcourses)

Topic 4. Primary production, composition of plant biomass, and Decomposition *(09/13 & 09/15)*

Reading 4.1. Kogel-Knabner, I., & Amelung, W. (2014). Dynamics, Chemistry, and Preservation of Organic Matter in Soils. In *Treatise on Geochemistry* (pp. 157–215). Elsevier.

Reading 4.2. Sanderman, J, and R Amundson. 2003. "Biogeochemistry of decomposition and detrital processing." Treatise on Geochemistry 8: 249–316.

Reading 4.3. Schimel, J. P., & Schaeffer, S. M. (2012). Microbial control over carbon cycling in soil. *Frontiers in Microbiology*, *3*(Article 348), 1–11.

Suggested additional readings:

- Hedges, JI, G Eglinton, PG Hatcher, DL Kirchman, C Arnosti, S Derenne, RP Evershed, I Kögel-Knabner, JW De Leeuw, and R Littke. 2000. "The molecularly-uncharacterized component of nonliving organic matter in natural environments* 1." *Organic Geochemistry* 31 (10): 945–958.
- Kogel-Knabner, I. 2002. "The macromolecular organic composition of plant and microbial residues as inputs to soil organic matter." *Soil Biology and Biochemistry* 34 (2): 139–162.

Topic 5. Dissolved Organic matter *(9/20 & 9/22)* -

Reading 5.1. Kalbitz, K, S Solinger, JH Park, B Michalzik, and E Matzner. 2000. "Controls on the dynamics of dissolved organic matter in soils: a review." Soil Science 165 (4): 277.

Reading 5.2. Marschner, Bernd, and Karsten Kalbitz. "Controls of bioavailability and biodegradability of dissolved organic matter in soils." *Geoderma* 113.3 (2003): 211-235.

Reading 5.3.Marín-Spiotta, E., Gruley, K.E., Crawford, J., Atkinson, E.E., Miesel, J.R., Greene, S., Cardona-Correa, C. and Spencer, R.G.M., 2014. Paradigm shifts in soil organic matter research affect interpretations of aquatic carbon cycling: transcending disciplinary and ecosystem boundaries. *Biogeochemistry*, *117*(2-3), pp.279-297.

Suggested additional readings:

- Sanderman, J., K.A. Lohse, J.A. Baldock and R. Amundson. 2009. Linking soils and streams: Sources and chemistry of dissolved organic matter in a small coastal watershed. Water Resources Research 45, W03418, doi:10.1029/2008WR006977, 2009

- Jansen, B., Kalbitz, K. and McDowell, W.H., 2014. Dissolved organic matter: linking soils and aquatic systems. *Vadose Zone Journal*, *13*(7).
- Spencer, R. G. M., G. R. Aiken, K. D. Butler, M. M. Dornblaser, R. G. Striegl, and P. J. Hernes. 2009. Utilizing chromophotic dissolved organic matter measurements to derive export and reactivity of dissolved organic carbon exported to the Arctic Ocean: A case study of the Yukon River, Alaska, Geophys. Res. Lett., 36, L06401, doi:10.1029/ 2008GL036831.
- Kaiser, K. and Kalbitz, K., 2012. Cycling downwards–dissolved organic matter in soils. *Soil Biology and Biochemistry*, *52*, pp.29-32.
- Marin-Spiotta, E., Chadwick, O. A., & Kramer, M. (2011). Carbon delivery to deep mineral horizons in Hawaiian rain forest soils. Journal of Geophysical ….

- ***Term paper abstract, along with annotated bibliography of the 10 relevant papers due September 27, 2021***

Topic 6. Stability and Stabilization mechanisms of SOM *(9/27, 09/29, & 10/04)*

Reading 6.1. Torn et al (2009) Storage and Turnover of Soil organic matter. In Senesi, Xing and Huang (Eds). Biophysico-chemical processes involving natural nonliving organic matter in environmental systems. Wiley-intersciences.

Reading 6.2. Schmidt, M W I, M S Torn, Samuel Abiven, Thorsten Dittmar, G Guggenberger, I A Janssens, M Kleber, et al. 2011. "Persistence of Soil Organic Matter as an Ecosystem Property." *Nature* 478:49-56

Reading 6.3. Kleber, M., Bourg, I. C., Coward, E. K., Hansel, C. M., Myneni, S. C., & Nunan, N. (2021). Dynamic interactions at the mineral–organic matter interface. *Nature Reviews Earth & Environment, 2*(6), 402-421.

Suggested additional readings:

- Lehmann, J., Hansel, C. M., Kaiser, C., Kleber, M., Maher, K., Manzoni, S., . . . Torn, M. S. (2020). Persistence of soil organic carbon caused by functional complexity. *Nature Geoscience, 13*(8), 529-534.
- Kleber, M., & Lehmann, J. (2015). The contentious nature of soil organic matter. Nature, 1–9. http://doi.org/10.1038/nature16069
- Kleber, M., Eusterhues, K., Keiluweit, M., Mikutta, C., Mikutta, R., & Nico, P. S. (2014). Mineral-Organic Associations: Formation, Properties, and Relevance in Soil Environments. *Advances in Agronomy* (pp. 1–140).
- Keiluweit, M., Bougoure, J. J., Nico, P. S., Pett-Ridge, J., Weber, P. K., & Kleber, M. (2015). Mineral protection of soil carbon counteracted by root exudates. *Nature Climate Change*. http://doi.org/10.1038/nclimate2580
- Lützow, von, M., Kogel-Knabner, I., Ekschmitt, K., Flessa, H., Guggenberger, G., Matzner, E., & Marschner, B. (2007). SOM fractionation methods: Relevance to functional pools and to stabilization mechanisms. Soil Biology and Biochemistry, 39(9), 2183–2207.
- Oades, J. M. (1988). The retention of organic matter in soils. Biogeochemistry, 5(1), 35-70.

Debate # 1 - *(10/06)*

- should we keep employing the concepts of humic substances and recalcitrance or is it time to do away with these concepts? What does the latest science tell us?

1. Janzen, H. (2019). The future of humic substances research: Preface to a debate. Journal of Environmental Quality, 48(2), 205-206.
2. Kleber, M., & Lehmann, J. (2019). Humic substances extracted by alkali are invalid proxies for the dynamics and functions of organic matter in terrestrial and aquatic ecosystems. *Journal of Environmental Quality, 48*(2), 207-216.
3. Olk, D., Perdue, E., McKnight, D., Chen, Y., Farenhorst, A., Senesi, N., Chin, Y.-P., Schmitt-Kopplin, P., Hertkorn, N., and Harir, M. (2019). Environmental and agricultural relevance of humic fractions extracted by alkali from soils and natural waters. *48*(2), 217-232
4. Myneni, S. C. (2019). Chemistry of natural organic matter—The next step: Commentary on a humic substances debate. *Journal of Environmental Quality, 48*(2), 233-235.
5. Kleber, M. 2010. "What is recalcitrant soil organic matter?" Environmental Chemistry 7 (4): 320–332.
6. Lutzow, von, M., & Kogel-Knabner, I. (2010). Response to the Concept paper: "What is recalcitrant soil organic matter?" by Markus Kleber. *Environmental Chemistry*, *7*(4), 333–3.
7. Kleber, M. (2010). Response to the Opinion paper by Margit von Lützow and Ingrid Kögel-Knabner on "What is recalcitrant soil organic matter?" by Markus Kleber. *Environmental Chemistry*, *7*(4), 336–337.

Topic 7. Molecular Models of OM *(10/11 & 10/13)*

Reading 7.1. Wershaw, RL. 2004. "Evaluation of conceptual models of natural organic matter (humus) from a consideration of the chemical and biochemical processes of humification." *US Geological Survey Scientific Investigations Report* 5121 (1).

Reading 7.2. Kleber, M, P Sollins, and R Sutton. 2007. "A conceptual model of organo-mineral interactions in soils: self-assembly of organic molecular fragments into zonal structures on mineral surfaces." *Biogeochemistry*.

Suggested additional reading:

- Sutton, R., & Sposito, G. (2005). Molecular structure in soil humic substances: The new view. Environmental Science & Technology, 39(23), 9009–9015.

In class discussion of term paper ideas and progress you are making (10/18)

- Make sure to read additional 10 papers (in addition to the ones you read in September) related to your specific area of interest
- ***Detailed outline of your term paper outline and annotated bibliography for these additional papers due 10/22/21***

Topic 8. Fire and Black carbon biogeochemistry *(10/20 & 10/25)*

Reading 8.1. Bird, M. I., Wynn, J., Saiz, G., Wurster, C. M., & McBeth, A. (2015). *The Pyrogenic carbon cycle*. *Annual Reviews of Environmental Resources, 43*.

Reading 8.2. Major, Julie, Johannes Lehmann, Marco Rondon, and Christine Goodale. 2010. "Fate of soil-applied black carbon: downward migration, leaching and soil

respiration." Global Change Biology 16 (4): 1366–1379. doi:10.1111/j.1365-2486.2009.02044.x

Reading 8.3. Jaffé, R, Y Ding, J Niggemann, A V Vähätalo, and A Stubbins. 2013. "Global Charcoal Mobilization From Soils via Dissolution and Riverine Transport to the Oceans." *Science*

- Masiello, C A, and P Louchouarn. 2013. "Fire in the Ocean." *Science*.

Suggested additional readings:

- Lehmann, J. 2007. "Bio-energy in the black." Frontiers In Ecology And The Environment: 5.
- González-Pérez, J, F González-Vila, and G Almendros. 2004. "The effect of fire on soil organic matter—a review." Environment International

Topic 9. Role of Management *(10/27 & 11/1)*

Reading 9.1. Balesdent, J, C Chenu, and M Balabane. 2000. "Relationship of soil organic matter dynamics to physical protection and tillage." Soil and Tillage Research.

Reading 9.2. Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P., & Smith, P. (2016). Climate-smart soils. *Nature*, *532*(7597), 49–57. http://doi.org/10.1038/nature17174

Reading 9.3. Kaiser, M, R H Ellerbrock, M Wulf, S Dultz, C Hierath, and M Sommer. 2012. "The Influence of Mineral Characteristics on Organic Matter Content, Composition, and Stability of Topsoils Under Long-Term Arable and Forest Land Use." *Journal of Geophysical Research* 117 (G2) (June 1): G02018–. doi:10.1029/2011JG001712.

Suggested additional readings:

- Sanderman J, Hengl T, Fiske GJ. 2017. Soil carbon debt of 12,000 years of human land use. *Proceedings of the National Academy of Sciences* . Published August 21, 2017, doi:10.1073/pnas.1706103114
- Marin-Spiotta, W Silver, and C Swanston. 2009. "Soil organic matter dynamics during 80 years of reforestation of tropical pastures." Global Change Biology.
- Chivenge, P P, H K Murwira, K E Giller, P Mapfumo, and J Six. 2007. "Long-term impact of reduced tillage and residue management on soil carbon stabilization: Implications for conservation agriculture on contrasting soils." Soil and Tillage Research 94 (2): 328–337. doi:10.1016/j.still.2006.08.006.
- Stockmann, U., Adams, M. A., Crawford, J. W., Field, D. J., Henakaarchchi, N., Jenkins, M., et al. (2013). The knowns, known unknowns and unknowns of sequestration of soil organic carbon. *Agriculture Ecosystems & Environment*, *164*, 80–99. http://doi.org/10.1016/j.agee.2012.10.001

Debate # 2 - *(11/03)*

- Are soil carbon offsets a good thing or not? What does the latest science tell us about their potential as natural climate change solutions and the best time when these offsets must be considered?

1. Amelung, W., Bossio, D., de Vries, W., Kögel-Knabner, I., Lehmann, J., Amundson, R., Bol, R., Collins, C., Lal, R., and Leifeld, J. (2020). Towards a global-scale soil climate mitigation strategy. Nature communications 11, 1-10.
2. Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P., & Smith, P. (2016). Climate-smart soils. Nature, 532(7597), 49-57.
3. Zelikova, Z; G Amador;V Suarez, U Kosar, E Burns. Leading with Soil: Scaling Soil Carbon Storage in Agriculture. Carbon180, A report https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/5eaa30d12c3a767e64c3845b/1588211922979/LeadingWithSoil_Final+Text.pdf
4. Schlesinger, W. H., and Amundson, R. (2019). Managing for soil carbon sequestration: Let's get realistic. *Global change biology* **25**, 386-389.
5. Amundson, R., and Biardeau, L. (2018). Opinion: Soil carbon sequestration is an elusive climate mitigation tool. Proceedings of the National Academy of Sciences 115, 11652-11656.

Topic 10. Lateral fluxes of OM and Watershed processes *(11/8 & 11/10)*

Reading 10.1. Berhe, A. A., Barnes, R. T., Six, J., & Marín-Spiotta, E. (2018). Role of soil erosion in biogeochemical cycling of essential elements: Carbon, nitrogen, and phosphorus. *Annual Review of Earth and Planetary Sciences*, *46*, 521-548.

Reading 10.2. Berhe, Asmeret Asefaw, John Harte, Jennifer W Harden, and Margaret S Torn. 2007. "The significance of the erosion-induced terrestrial carbon sink." BioScience 57 (4): 337–346. doi:10.1641/B570408.

Reading 10.3. Aufdenkampe, Anthony K, Emilio Mayorga, Peter A Raymond, John M Melack, Scott C Doney, Simone R Alin, Rolf E Aalto, and Kyungsoo Yoo. 2011. "Riverine Coupling of Biogeochemical Cycles Between Land, Oceans, and Atmosphere." *Frontiers in Ecology and Environment* 9 (1): 53–60.

Suggested additional readings:

- Doetterl, S., Berhe, A.A., Nadeu, E., Wang, Z., Sommer, M. and Fiener, P., 2016. Erosion, deposition and soil carbon: A review of process-level controls, experimental tools and models to address C cycling in dynamic landscapes. *Earth-Science Reviews*, *154*, pp.102-122.
- Quinton, J, G Govers, K Van Oost, and R Bardgett. 2010. "The impact of agricultural soil erosion on biogeochemical cycling." Nature Geoscience.
- Berhe, Asmeret Asefaw, and Markus Kleber. 2013. "Erosion, Deposition, and the Persistence of Soil Organic Matter: Mechanistic Considerations and Problems with Terminology." *Earth Surface Processes and Landforms* 38: 908–912.
    - (Discussions in Berhe and Kleber 2013, were inspired by results from this paper → Berhe, Asmeret Asefaw, JW Harden, MS Torn, M Kleber, SD Burton, and J Harte. 2012. "Persistence of Soil Organic Matter in Eroding vs. Depositional Landform Positions." *Journal of Geophysical Research-Biogeosciences* 117, G02019.

- Tranvik, L.J., Downing, J.A., Cotner, J.B., Loiselle, S.A., Striegl, R.G., Ballatore, T.J., Dillon, P., Finlay, K., Fortino, K., Knoll, L.B. and Kortelainen, P.L., 2009. Lakes and reservoirs as regulators of carbon cycling and climate. *Limnology and Oceanography*, *54*(6part2), pp.2298-2314.
- Regnier, Pierre, Pierre Friedlingstein, Philippe Ciais, Fred T Mackenzie, Nicolas Gruber, Ivan A Janssens, Goulven G Laruelle, Ronny Lauerwald, Sebastiaan Luyssaert, and Andreas J Andersson. 2013. "Anthropogenic Perturbation of the Carbon Fluxes From Land to Ocean." *Nature Geoscience*. **6**, 597–607 (2013) doi:10.1038/ngeo1830
- Keller, C. K. (2019). Carbon Exports from Terrestrial Ecosystems: A Critical-Zone Framework. *Ecosystems*, 1–15. http://doi.org/10.1007/s10021-019-00375-9

Topic 11. Global change *(11/15 & 11/17)*

Reading 11.1. Davidson, E, and I Janssens. 2006. "Temperature sensitivity of soil carbon decomposition and feedbacks to climate change." Nature.

Reading 11.2. Conant, Richard T, Rhae A Drijber, Michelle L Haddix, William J Parton, Eldor A Paul, Alain F Plante, Johan Six, and J Megan Steinweg. 2008. "Sensitivity of organic matter decomposition to warming varies with its quality." Global Change Biology 14 (4). Temperature sensitivity of organic matter decomposition (January 8): 868–877. doi:10.1111/j.1365-2486.2008.01541.x.

Reading 11.3. Cusack, DF, WL Silver, MS Torn, and WH McDowell. 2010. "Effects of nitrogen additions on above-and belowground carbon dynamics in two tropical forests." Biogeochemistry: 1–23.

Reading 11.4. Chou, W, W Silver, RD Jackson, A Thompson, and B Allen-Diaz. 2008. "The sensitivity of annual grassland carbon cycling to the quantity and timing of rainfall." Global Change Biology 14 (6): 1382–1394.

First draft of term paper due November 19, 2021 (peer review of papers starts)

Topic 12. Regional perspectives and Contemporary issues (*11/22 & 11/29*)

Reading 12.1. Six, J, RT Conant, EA Paul, and K Paustian. 2002. "Stabilization mechanisms of SOM: implications for C-saturation of soils." *Plant and Soil* 241 (2): 155–176.

Reading 12.2. Thevenot, Mathieu, Marie-France Dignac, and Cornelia Rumpel. 2010. "Fate of lignins in soils: A review." *Soil Biology and Biochemistry* (April 9).

Reading 12.3. Rumpel, Cornelia, and Ingrid Kögel-Knabner. 2011. "Deep Soil Organic Matter—a Key but Poorly Understood Component of Terrestrial C Cycle." *Plant and Soil* 338 (1-2) (January 15): 143–158. doi:10.1007/s11104-010-0391-5.

See also: Depth matters for soil carbon accounting. By Eric Slessarev, Jane Zelikova, Joe Hamman, Danny Cullenward, Jeremy Freeman https://carbonplan.org/research/soil-depth-sampling

Reading 12.4. Ward, C.P. and Cory, R.M., 2016. Complete and partial photo-oxidation of dissolved organic matter draining permafrost soils. *Environmental science & technology*, *50*(7), pp.3545-3553.

- See also: Lin, Y. and King, J.Y., 2014. Effects of UV exposure and litter position on decomposition in a California grassland. *Ecosystems*, *17*(1), pp.158-168.

Peer review reports of term paper due December 1, 2021

(1-1 discussions of peer review reports of papers between reviewer and author in class)
(If you have never conducted peer-review of a manuscript (or would like a guide on how to do it best), you want to read this guide for conducting peer review by Josh Schimel … As Dr. Schimel (season editor) states, "Peer review isn't just criticism—it's triage." Aim to give constructive feedback in your review of your peer's work.
https://schimelwritingscience.wordpress.com/2018/04/13/how-to-write-a-useful-manuscript-review/)

Topic 13. Student Presentations of Term-paper findings *(12/6 & 12/8)*

December 14, 2021 ***Final paper due***

*Additional and/or substitute readings may be selected based on consultation with the student, to maximize the benefit of this class to the student's research needs.

Some additional references, Books

1. F. J. Stevenson. Humus Chemistry: Genesis, Composition, Reactions. 1994
2. Kyoichi Kumada (Ed). Chemistry of Soil Organic Matter. 1987. Developments in Soil Science. Volume 17, Pages iii-viii, 1-241
3. Qiaoyun Huang, Pan Ming Huang, Andrea Violante (Eds). Soil Mineral -- Microbe-Organic Interactions: Theories and Applications. 2010. Springer
4. Balwant Singh and Markus Gräfe (Eds). Synchrotron-Based Techniques in Soils and Sediments. Developments in Soil Science. Volume 34, Pages 1-480
5. Schlesinger, W. 1997 or 2013 – Biogeochemistry
6. Schlesinger, W (Ed). 2005 – Treatise on Geochemistry – volume 8, Biogeochemistry
   - Second edition published in 2014
7. Handbook of Clay Science (2006) F. Bergaya, B. K. G. Theng, G. Lagaly(Eds)
8. Huang, Pan Ming, Yuncong Li, and Malcolm E. Sumner, eds. *Handbook of soil sciences: resource management and environmental impacts*. CRC Press, 2011.

Additional Resources

Glossary of Soil Science: online at http://www.soils.org/sssagloss/
Biogeochemistry Journal: online at http://www.springer.com/earth+sciences/journal/10533
Journal of Geophysical Research – Biogeosciences: online at http://www.agu.org/journals/jg/
Global Biogeochemical Cycles: online at http://www.agu.org/journals/gb/
Biogeosciences Journal: online at http://www.biogeosciences.net
Soil Biology and Biochemistry: online at http://www.journals.elsevier.com/soil-biology-and-biochemistry/
Spectroscopy tutorial and reference: http://orgchem.colorado.edu/Spectroscopy/Spectroscopy.html
Spectroscopy and Spectrometry quick guide:
http://www.cea.fr/var/cea/storage/static/gb/library/Clefs54/pdf-gb/EncadreD_54gb.pdf
NMR guide: http://www.chem.queensu.ca/facilities/nmr/nmr/webcourse/

Helpful information for seminar
(Modified from Michael Reed, Tufts)

Expectation for in-class discussion

Expectations for Discussion Leaders
Introduce the readings (5-10 min - NO MORE!). Your introduction should draw on the readings, but should not simply re-state what we have all read. Simply reiterating what the readings say is boring and doesn't accomplish much. Instead, your job as leader is to get a discussion going. This is far more interesting for everyone involved.

Here are some tips:

1. **Have enough to say:** Make sure that you have enough to say to keep things moving, but do not feel that you have to say everything that you have thought of or cover every idea in the readings. If the conversation is going well, let it. The worst thing that can happen is that no one says anything. The next worst thing is that the leader completely dominates the conversation

2. **Major points:** In your introduction, try to synthesize the material and draw out the major points. What are the 5 things you'd tell your parents if you were going to explain this to them over dinner? The chances are good that these are the same things we should be focused on. Also, feel free to supplement the reading material with other information on the topic to broaden the discussion.

- **Questions to ask:** Come with a list of questions to ask (more than you think you'll need). The more specific the questions are the better, as this makes them easier for people to respond to. Preferably, post some questions on UCMCROPS. Some topics might include:
    - questions about methods, interpretation of results, further depth on discussion points, implications not discussed in the reading
    - be able to interpret the figures & tables
    - think about possible follow up experiment/question from the study
    - implications for different ecological and/or pedogenic properties, processes.

- **Where there surprises?** Ask the class what surprised them, and why. If you're not leading, think how you'd answer this question. If people complain about the readings, ask them how things could have been done better, or what needs to be done next.

- **Relation to past topics:** Where possible, try to relate your topic to those we have discussed in previous weeks so that the ideas covered by the class build over the course of the semester.

- **Play the devil's advocate:** Being purposefully provocative (even if you don't believe what you're saying) can often help to get people talking. If the material is appropriate, set the discussion up as a debate - tell half the class that they have to argue one side and the other half that they have to argue the opposite. This approach can force people to really think

about the ideas and about their preconceptions. If you are going to do this, it is best to warn people ahead of time (though don't tell them which side they will be on).

- **Give'em time:** When you ask a question, give people lots of time to respond. A good rule is to (slowly) count to 10 in your head before moving on. This is because (a) it often takes people this long to formulate something to say and (b) the uncomfortable silence (and it can be excruciating) is often what it takes to get people talking. This sounds (and can feel) horrible, but it really works, and the discussions that result are much richer.
- If no one answers a question, and there is a simple yes/no, do you agree/disagree, type answer, then ask for a show of hands - then you can focus in on individuals and ask them to explain their response.

- **Putting them on the spot:** Don't pick on individuals and make them comment unless you have to. But if no one says anything, then it is OK to do this. Everyone else is responsible for reading and thinking about the material too, so it should not be a surprise to them. Even though you are in charge of running things, the responsibility for maintaining a discussion lies with everyone in the room.

The hardest part is getting the conversation started. Once it's going, it will often run itself - and if it is doing this you should let it. I've been running seminars for a few years now, and I'm only just getting to where I realize that my job is to say as little as possible. If I talk the whole time, then I'm essentially lecturing ... and this is not a lecture format ... *the goals are very different, they are to get people thinking on their feet and discussing ideas to help them learn the stuff for themselves*. But, it is your job to make sure that we are not just subjected to silence.

Audio-visual equipment: Prepare PowerPoint slides that summarize major topics/findings, and show important figures/tables. Send ppt file to me at least two hours before the start of class.

Expectations for the rest of the class
In classes that you are not leading, make sure that you have thought about the material enough that you can help the leader out. Come with at least 2 or 3 ideas to talk about if things get too quiet. If the leader has sent out questions, actually think about them before class. And be responsible about doing the reading. If you do all this stuff, others will do the same when it's your turn to lead.

Read the material for class before you get there. Review the expectations for Presenters - it's your job to make the discussion flow, and you'll be grateful when you are a presenter and the other students help you.

Term paper Guidelines

Due dates to watch out for (make sure to check exact times on catcourses):

- ***Paper topic due September 10, 2021***
- ***First draft of paper outline due September 27, 2021***
- ***Detailed outline of paper due October 22, 2021***
- ***First draft of paper due November 19, 2021***
- ***Peer-review discussion in class December 1, 2021***
- ***Presentation of term paper results, December 6 or 8, 2021***
- ***Final paper due December 14, 2021***

Objective: The goal of this assignment is to enable you to think critically and summarize research findings concisely in paper of scientific quality, for a like-minded audience of fellow soil scientists. You are expected to put together more than a narrative review of the assigned topics. It will be evaluated based on how well you are able to communicate an understanding of the topic/issue.

Topic: Choose a topic related to Soil Organic Matter that interests you (It can be related to your dissertation/thesis research and/or serve as an introductory chapter to your thesis).

Word limit, formatting: Try to limit your paper to less than 5000 words– excluding abstract and references. Papers must be neatly typed, using 11 or 12pt font, be single spaced with 1-inch margins. Include page numbers. Note that the draft could be considerably shorter, but it should have a complete outline, all the major components your paper should be there. Figures and tables can be placed within the text pages or at the end of the document. All figures and tables should be relevant to the discussion and must have a descriptive caption. Make sure to use appropriate headings and subheadings, and make the best use of maps, figures or tables. You should/could redraw figures and/or recalculate data in published works if it gives interesting information.

References for all cited works should be given (both as in-text citations and bibliography list at the end of the document) in accordance with one of the widely accepted styles, ex. Chicago or APA. Choose one reference style at the beginning and be consistent with its use. Using lecture notes, webpages, Wikipedia, or similar materials as references is not acceptable – unless the webpage is available for providing scientific information that you can't find anywhere else, ex. site descriptions. If you do use webpages as references then provide complete URLs and date you accessed them. Please make sure to review the University of California, Merced's academic honesty policy.

Grades: The final grade for your assignment will be derived from grades for outline (5%, depending on whether you submitted one or not), the first draft (25% for organization of ideas and content), and 70% for the content, organization, understanding of the topic, and completeness of your final product.

Papers submitted after the due date will lose 20 points per day (no credit for papers submitted 5 or more days). If you have a very good reason you can't submit on time (ex. illness or other similar issues) it is your responsibility to let me know ahead of time and make arrangements for submission.