Land Use and Water Quality (WR418)

Contents

I Syllabus **1**

1 Land Use and Water Quality (WR418) **1**
1.1 Course Goals . . . 2

2 Approach **2**
2.1 Class policies . . . 2
2.2 Academic integrity . . . 3
2.3 Attendance . . . 3
2.4 Notes . . . 3
2.5 Grading . . . 3
2.6 Schedule . . . 3

II Courses **5**

3 Introduction (Week 1) **6**
3.1 Land-Use change . . . 6
3.2 Types of Water Quality Change . . . 6
3.3 My work on land-use change - Mining in West Virginia . . . 6
3.4 Types of Water Quality Change . . . 6
3.5 Examples of water quality impacts . . . 7
3.6 Treatment . . . 7
3.7 Summary . . . 7

4 Thermodynamics **8**
4.1 To Watch Before Jan 25th . . . 8
4.2 To Watch Before Jan 27th . . . 8

Part I

Syllabus

1 Land Use and Water Quality (WR418)

This working webpage hosts all lecture material, code, assignments, and the syllabus for Land Use and Water Quality (WR418) taught at Colorado State University. This class is undergoing rapid change and

The long-term vision for this project is to work towards an open access book similar to R for Data Science, which can be used to teach college students about the interaction of human land-use and downstream water quality change.

1.1 Course Goals

The broadest goals of the course are for students to develop both an intuitive and quantitative understanding of:

- Understanding basic aqueous chemistry to better understand dominant chemical controls on water quality
- The chemical reactions and processes that govern the connection between land-use and downstream water quality, over short and long time-scales.
- The status of water quality in lakes and rivers across the globe and how it relates to legislation, developoment, and environmental change broadly.

2 Approach

To reach these goals, we will have a flipped classroom. All content will be delivered before class begins in the form of previously recorded YouTube videos from me or our partner content creators Richard Marinos (at the University of Buffalo) and Anna Bergstrom (at Boise State University). Our philosophy is to share in content generation so that we can bring you the highest quality lectures before class and save class time for paper discussions, homework time, and group projects.

With this approach it is critical that you watch all lectures and read all materials before class. This is your homework for the most part, with plenty of in-class time dedicated to other tasks that are traditionally done at home (like assignments). This is even more important because we will be using the R programming language for all of our assignments. I know most of you have never used R before, so we have ample class time to help you integrate this vital tool into your understanding of water quality.

Finally, this is the first time we are doing the course this way, so there will be constant changes to this site, based on new content. I will work to have this content updated at least a week before you need to work on the material, but please let me know if you are getting lost in the syllabus.

2.1 Class policies

2.1.1 Inclusive classroom

We will have an inclusive classroom: respecting and valuing the diverse backgrounds, perspectives, and identities of individuals in the class. Students are expected to have an awareness of and sensitivity to language or actions that may be exclusionary or alienating. I am committed to fostering a collaborative and inclusive class and appreciate any feedback on how to improve my own practice.

This is particularly important in a class that will have group work, peer grading, and generally serve individuals with a large range in background with watershed, chemistry, statistics, and other skills we will use in class. We all get better if we work together. A final note on treatment of others: one of the most important things when interacting with others who have more or less research experience than you is to learn how to ask effective questions that show you understand and value other people's time. "What work can I do to prepare my question in a way that makes it easiest for someone to help me?" I want you to ask questions and work collaboratively and do so in a way that helps you and everyone else.

2.1.2 Assignments

All assignments will be distributed through Canvas.

2.1.3 Asking for help and code on the internet:

One of the most common ways people learn to code is to use the age-old (okay, maybe 10 years) technique of asking the internet for help. This is a great idea! But! When you do you should ask for help in specific ways that enable people to answer your question more easily and clearly. Great instructions are here:

https://blog.revolutionanalytics.com/2014/01/how-to-ask-for-r-help.html and a more general guide to help in R is here: https://www.r-project.org/help.html.

2.1.4 Using other people's code

Inevitably, you will want to perform a task in R that someone else has already done. This is useful and part of why the R community is so great. But! If you use other people's code, you should:

a) explitly cite where you got the code or the inspiration for it

b) work hard to understand the code and what it does, break it down into pieces, and try to rebuild it

Code that you did not write and is not cited will be treated as academic plagiarism. Assignments will vary in how much code is allowed to be shared between students, but the general rule is that you should be submitting your own code or code from your own team. As an example of best practices, a lot of the inspiration for this page (and the class in general) comes from Mine Cetikaya-Rundel and her amazing STA 199 course at Duke

2.2 Academic integrity

Academic integrity: You are responsible for adhering to all university policies on academic integrity and student conduct https://tilt.colostate.edu/integrity/knowTheCode/. TILT has a number of resources for students related to writing and study skills: https://tilt.colostate.edu/integrity/resourcesStudents/.

2.3 Attendance

This class will heavily depend on you being present. There will be a participation grade that will reflect a combination of your consistent presence, focus in class, and participation in group work. We will also occasionally have quizzes to check in on your understanding of material but also to make sure you are present.

2.4 Notes

If you learn by taking notes, I encourage you to take notes in class when there are lectures. However, all lectures will be posted online on my GitHub account. Additionally, a more verbose version of the notes will be on this site (look to your left).

2.5 Grading

Assignments

Quizzes

Final

Participation

40%

30%

20%

10%

2.6 Schedule

This schedule will likely change considerably as we move through the course, but I will keep it updated. Every Thursday there will be an assignment due the next Thursday, unless otherwise stated.

Week Starting

Videos Posted on Site

Content

Video producer

2021-01-18

NA

Intro Basic Chem Review

Matt

2021-01-25

2020-01-18

Thermodynamics and activity

Richard Marinos

2021-02-01

2020-01-25

Acid Base Chemistry

Matt

2021-02-08

2020-02-01

Carbonate chem and Alk

Anna Bergstrom

2021-02-15

2020-02-08

Dissolved Gasses

Matt

2021-02-22

2020-02-15

Kinetics

Richard + Matt

2021-03-01

2020-02-22

Weathering/Solubility

Anna Bergstrom

2021-03-08

2020-02-29

Complexation/Ion Exchange

Richard

2021-03-15

2020-03-07

Redox

Matt

2021-03-22

2020-03-14

Nutrient Cycling

Anna Bergstrom

2021-03-29

2020-03-21

Organic Contaminants

All

2021-04-05

2020-03-28

Contaminant Grab Bag (Metals/etc. . .)

All

2021-04-12

2020-04-04

Mapping Aqueous to Land Use

MR

2021-04-19

2020-04-11

Clean Water Act/NPDES/Etc. . .

MR

2021-04-26

2020-04-18

Final work time

MR

2021-05-03

2020-04-25

Final work time

MR

2021-05-10

2020-05-02

Final Presentations/YouTube Viewing

MR

Part II

Courses

3 Introduction (Week 1)

The goal of our first class is twofold. First to pique your interest in the content of the course through open discussion and sharing some videos and images. Second, to get to know each other both in terms of your academic background and your interest in Water Quality.

3.1 Land-Use change

A core component of this class will be understanding how people change the landscape and how these changes propagate downstream. There are many ways people can impact the land and satellites have been recording these changeas since the 1970s, and with high resolution since 1984, with the launch of Landsat 5.

- What kind of land-use change can you see in the video below?
- What human impacts are not captured by this video or by satellite observation in general?
- Which land-use changes are most likely to impact inland waters?

If you enjoy looking at these timelapses, I encourage you to play around with this website from Google and Carnegie Melon which shows the entire globe changing over the past 30 years.

3.2 Types of Water Quality Change

The ways people can alter water quality are almost limitless as we continue to invent new chemicals, create novel cocktails of elements, and a myriad other impacts. Understanding which of these impacts are most harmful to people and the environment will be part of this course, but we will also cover which problems are avoidable, which are inherent to modern life, and which ones can be treated.

- What water quality problem do you think is most pressing right now in Colorado? in the United States? the Globe?
- What causes the water quality problem you identifed from above? Was it land-use change or something else?

3.3 My work on land-use change - Mining in West Virginia

For my PhD I worked on understanding the impacts of a particularly destructive form of coal mining called Mounataintop Mining. Mountaintop mining covers almost 6,000 square kilometers of land in Central Appalachia. This map shows the expansion of Mountaintop Mining in West Virginia and Kentucky. You can see more here

Unlike most land-use change impacts, mounataintop mining does not only change the land in two-dimensions, but direclty alters the topography of the landscape as shown here.

Whether agricutlure, mining, or industry, almost all human activities on land end up impacting water quality downstream.

3.4 Types of Water Quality Change

- What water quality problem do you think is most pressing right now in Colorado? in the United States? the Globe?
- What causes the water quality problem you identifed from above? Was it land-use change or something else?

3.5 Examples of water quality impacts

For each image answer the following questions

- what is the water quality impact you see?
- What may have caused this impact?
- Is it natural or human-caused?

3.5.1 Lake Erie

Lake Erie algae bloom caused by excess nutrients from agriculture and increasing temperatures from climate change

3.5.2 Animas

Animas river had ~ 3 million gallons of mine waste accidentally released into it from the abandoned Gold King Mine. The spill contained a variety of elemental contaminants including: arsenic, cadmium, lead, aluminum, and copper, with the orange color coming from iron. The long-term impacts from the spill are still unknown

3.5.3 West Virginia

This is a case where the murky brown water you see in this flood are completely natural. This was a major flooding event in a reference watershed for some of our work on the impacts of mining (more here). This was just a very large flood that mobilized a lot of sediment in the river. I'm standing on a bridge that is about 4 feet above the river bottom.

3.5.4 West Virginia 2

In this image we have Laurel Branch flowing into the Mud River. Although the Mud River water looks clear here, both streams are heavily impacted by mining and have high ion concentrations in the water leading to elevated salinity and declines in biodiversity. Not all pollutants are visible.

3.5.5 Fort Collins

Video documenting a fish kill that happened in Fort Collins in October of 2018. The cause of the fish kill is still unkown, but something the city is still investigating. These kinds of events often cause lots of public attention but understanding exactly why fish-kills occur can be difficult.

3.5.6 Boulder

Starting in 2004, David Norris noticed that the fish in Boulder Creek were changing sex. Eventually he discovered that this was due to a suite of chemicals that imitate estrogen being released into the river. Modern organic contaminants are one of the least well-understood impacts to water quality.

3.6 Treatment

- As we will learn in this class most water quality problems are pernicious and wicked
- Difficult to treat once they start and hard to disentangle from the land-use change that causes them

3.7 Summary

- The goal of this course is for you to intuitively and quantitatively understand the linkages between human's actions on land and our downstream water quality impacts.
- Before Friday's class please complete Canvas Quiz on your background and previous experience with related topics (remote sensing, water quality, etc. . .)

4 Thermodynamics

4.1 To Watch Before Jan 25th

4.1.1 Introduction

4.1.2 Systems

4.1.3 Laws of Thermodynamics

4.2 To Watch Before Jan 27th

4.2.1 Enthalpy

4.2.2 Gibbs Free Energy