CIV ENV 365: Environmental Laboratory (Winter 2025)

Syllabus
November 14, 2024

Thursday between 1:00 and 4:50 pm in Tech Room A147/A151

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Abstract: The focus of this course is to introduce analytical methods for determining the concentration of chemical element/species present in environmental samples. These methods will be applied to water samples that result from a treatment process, and solid/residues of water treatment. The purpose is to follow the chemical evolution of the samples and document how it can be verified/predicted through concepts presented in the course on chemical processes in aquatic systems - CIV ENV 367. It provides hands-on experiments focused on making measurements using state of the art and conventional instrumentation.

1 Course Objectives

This year, this course has been designed to offer students a limited amount of time for performing basic analytical tasks in the laboratory. A problem-based approach has been adopted where students design - given the suite of analytical methods that can be used in relation to most of the instruments that are available in the teaching laboratory - experiments, predict the outcomes of the experiments and verified that indeed these predictions can be validated or refuted by measurements. Students will work in groups of 2 in the laboratory at one experimental station.

Specific objectives are:

1. to be able to plan and conduct experiments to improve water quality, measure the concentrations of contaminants, and design treatment options to remove contaminants
2. to learn basic chemistry laboratory skills used by environmental engineers for assessing the chemical composition of environmental samples
3. to learn how to determine concentrations of key chemical species
4. to be able to effectively report, analyze and interpret laboratory results

2 Textbooks & Online Resources

- **Reading: Analytical Chemistry 3.0** by David Harvey (2020)
  It is an e-book, that is made available by the author after being printed for a few years by a publisher. It is a great resource, please download your copy from Canvas, you will find it in the first module. For each of the experiments, reference will be made to various chapters of this book.
- **Additional Recommended Readings:** This is a list of additional reading material that you can access online, and books located in the teaching lab. The textbooks listed below are excellent references for more detailed coverage of the subject matter and are reported for your perusal.

  1. Visit https://chem.libretexts.org/Bookshelves/Analytical Chemistry - a repository for various analytical methods and details about some core principles upon which chemical instrumentation is based.
  2. Analytical Chemistry (2004) - A Modern Approach to Analytical Science - edited by: R. Kellner, J.M. Mermet, M. Otto, M. Valcrcel, and H. M. Widmer, publisher Wiley-VCH. (Note: a very complete treatment of analytical methods, a must have if you go in this field).
  3. Principles of Instrumental Analysis (1998 - Fifth Edition) by D.A. Skoog, F.J. Holler, and T.A. Nieman, publisher Saunders College Publishing. (Note: a more advanced text that builds upon the foundation of

the text above, provides detailed information about electronic components entering the design of instrumentation).

3 Prerequisites

- Chemical Processes in Aquatic Systems: CIV ENV 367
- Computer Programming/Use: Understanding how to use ChemEql, basic knowledge of Python and the Jupyter notebook to write reports.

4 Grading

Final Grade = Laboratory reports (72%) + Final report (28%)

5 Additional Information

- **Computer Use:** Most of the calculations for preparing reports as Jupyter Notebook need to be performed in Python. Examples will be provided on CANVAs and are also present in the textbook using either Excel or R.
- **Class Participation:** The expectation is that you will - except for the students that have doctors' note - be able to perform all lab work on the bench to prepare calibration standards and make measurements. Laboratory coats, gloves, and other safety equipment will be provided.

6 Weekly Schedule & List of Experiments

The schedule and the list of experiments will be performed during the course. The list of instruments and analytical methods in the laboratory is:

1. **"pH-meter":** a high entry impedance voltmeter to measure the difference of potential produced by a combination pH electrode. NIST buffer solutions for calibration will be provided and measurements will be made on the milli-volt scale.
2. **Turbidity-meter/Nephelometer:** to measure the concentration of suspended particles in solution
3. **Conductivity-meter:** to measure the overall ability of the solution to conduct an electric current. This measurement provides a proxy for the ionic strength of the solution.
4. **Titration Alkalinity:** this will be determined by means of a computerized titration system.
5. **TOTCa & TOTMg:** the concentration of these cations - as also other elements in solution - will be determined by Flame Atomic Absorption Spectroscopy (FAAS).
6. **TOTNa, TOTK, and TOTLi :** the concentration of these akali metals - i.e., elements in the first left column of the periodic table - are best measured by Flame Atomic Emission Spectroscopy (FAES)
7. **Major and Minor Anions:** are measured by Ion Chromatography (IC)
8. **Dissolved Organic Carbon:** Measurement of DOC is performed by high temperature catalytic oxidation followed by infra-red detection of the CO_2 evolved in the process
9. **Trace metal analysis:** Analyses of dissolved metals - such as transition metals Cu as well as "heavy metals" such as Pb - are analyzed by Graphite Furnace Atomic Absorption Spectroscopy (GFAAS).
10. **Major/minor metal analysis**: Analysis of elements in solid samples, some major elements – such as Al, Si as well as some minor elements – such as Fe, are analyzed by X-ray Fluorescence (XRF).
11. **Nutrients:** $TOTPO_4$ and $TOTNH_4$: are analyzed by spectrophotometry after forming colored complexes and measuring their molecular absorption. Colorimetric methods also work well for some metals, such as for dissolved Fe and can be specific of a given oxidation state.
12. **Caffeine:** The concentration of this is analyzed by High-performance liquid chromatography (HPLC).