Advanced Water and Wastewater Treatment Design
(CHEE 676, 3 units)

Course Description

This course is a capstone (waste)water treatment processes course. It does not employ the conventional lecture/exam format, but attempts to simulate (as much as possible in a classroom, one semester setting) the thought, decision, and presentation process that would accompany the preliminary design of a remedial process for a major contaminated site. The Superfund project site considered is an actual contaminated site and the reports, data, and tools used are those that will or could be actually used for the development of a preliminary remedial plan.

Instructors

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Lecture time/venue

Date / Time / Location TBD

Office Hours

TBD

Examination

Final oral & written reports consisting of presentation of remedial plan. Due: Date / Time TBD

Homework

May be assigned periodically. They consist mainly of completion of steps in the design project.

Grading

60% final report, 20% final presentation, 10% homework and 10% group participation

University policy regarding grades and grading systems is available at
http://catalog.arizona.edu/policy/grades-and-grading-system

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Textbooks

Recommended:

Crittenden et al., *Water Treatment: Principles and Design*, 3rd Ed., John Wiley & Sons, 2012. ISBN-13: 978-0470405390

Supplementary:

American Water Works Association, *Water Quality and Treatment*, 6th ed., McGraw-Hill Inc., 2010. ISBN-13: 978-0071630115

Benjamin & Lawler, Water Quality Engineering: Physical/Chemical Treatment Processes, John Wiley & Sons, Inc., Hoboken, New Jersey, 2013. ISBN-13: 978-1118169650

Watts, Hazardous Wastes: Sources, Pathways, Receptors**.** John Wiley & Sons, Inc.; New York; January 1998, ISBN: 0-471-00238-0

Peters & Timmerhaus, *Plant Design and Economics for Chemical Engineers*, McGraw Hill, 5th ed., 2002. ISBN-13: 978-0072392661

Treybal, R.E., *Mass Transfer Operations*, 3rd ed., McGraw-Hill, 1980. ISBN-13: 978-0070651760

Perry, R.H. and D.W. Green, *Perry's Chemical Engineer's Handbook*, 8th ed., McGraw-Hill, 2007. ISBN-13: 978-0071422949

Park, C.S., *Contemporary Engineering Economics*, 5th edition, Addison-Wesley, 2015. ISBN-13: 978-9332550148

Project Description

The design project will be a team effort with 3-4 students per team. Each group will address the case of groundwater contamination in one section of the Park Euclid *Water Quality Assurance Revolving Fund (WQARF or State Superfund)* site in Tucson by developing a preliminary remedial Feasibility Study (FS). The remedial plan will be presented in both written and oral form to the management of the firm and representatives of interested parties.

The contamination of interest arose when chemicals used and stored at the site were intentionally and unintentionally released into the soil, air and groundwater. These have subsequently created soil

contamination and contaminant plumes in the groundwater underlying the site. Site characterization and remediation of the Park Euclid site is under the direction of the Arizona Department of Environmental Quality (ADEQ). Students will assume the role of members of an environmental consulting firm that has been hired by ADEQ to develop a site remedial FS.

The task includes the following:

1) Review of reports on the nature of the contamination,
2) Definition of the present and projected treatment tasks,
3) Evaluation of alternative treatment processes by preparation of preliminary process designs and comparison of the cost and effectiveness of the alternatives, and
4) Preparation of written and oral reports comparatively summarizing the alternatives and recommending a single treatment plan.

Information on the contaminated site can be obtained from **2004 Final Draft Park – Euclid Remedial Investigation Report prepared for the Park – Euclid Water Quality Assurance Revolving Fund Site** by Miller Brooks Environmental Inc. that is available on the course D2L site. All calculations, modeling, assumptions, and analysis should be based on the data in this report (and not previous or subsequent site characterization or treatment operational assessment reports). Additional literature may be assigned or recommended as appropriate for class and specific group needs.

At a minimum the design project must entail design and evaluation of <u>three</u> different treatment systems including granular activated carbon (GAC) adsorption, air stripping (AS), and/or advanced chemical oxidation (AOP) as treatment alternatives. Each treatment process must be considered in at least one of the treatment trains. The evaluation of oxidation processes will focus on alternatives involving ozone supplemented by ultraviolet radiation or hydrogen peroxide. The final plan must include an economic analysis of the various treatment schemes in order to identify the final recommended plan.

Principles of GAC, AS and AOP treatment processes will be reviewed in lectures and discussions in the class and detailed design procedures will be studied. You may find that additional work is needed to identify, evaluate and design alternative treatment processes to meet the remediation requirements. Computer simulation programs for countercurrent AS, fixed-bed GAC adsorption, and oxidation processes involving ozone supplemented by ultraviolet radiation or hydrogen peroxide that have been tested and calibrated in the laboratory will be available to facilitate some design calculations. The basic principles of engineering economics and design costing will be covered in lectures and used to select the recommended treatment plan from competing treatment schemes to meet the environmental remediation

objectives. Much, but not all of the information needed to comparatively evaluate the different options will be made available to the teams. Additional required resources will need to be found and evaluated by the teams on a per case basis in consultation with the course instructor.

The instructor will act as the Chief Executive Officer (CEO) of the engineering firm and will serve as a resource person and mentor to the individual groups. However, because the CEO is primarily an administrative position, his role is not detailed management of the remedial plan development. The instructor will also act as "remedial design advisor" and will be available for consultation (a meeting time will be set on the first day of class).

You will present your recommendations in a final report and substantiate the recommendations by sample calculations, explanations, print outs, and references in appendices to the report. The final project report will be a document of about **30 pages** (double spaced, including tables and figures) supplemented by appendices comprised of example calculations, data, etc. There will also be an oral report presented to the entire class and any other interested parties, in which each student group will present an overview of their approach and conclusions.

The class will meet twice a week for lectures for the first half of the course and individual teams will meet as often as required to complete the project. Each group will meet the CEO at least once every week during the second portion of the class for progress reports and problem discussion.

Lecture topics

- → General introduction
- → Groundwater contamination
- → Environmental regulations & critical contaminants
- → Groundwater flow
- → Physico-chemical properties of environmental contaminants
- → Introduction to remediation site
- → Activated carbon adsorption
- → Air stripping
- → Advanced oxidation processes
- → Engineering economics

Specific Site Data

- *Miller Brooks Environmental Inc. 2004. Final Draft Park – Euclid Remedial Investigation Report.* Prepared for Park – Euclid Water Quality Assurance Revolving Fund Site, Tucson, Arizona.

This report summarizes the reports and investigations through 2004 undertaken to characterize the site's contamination. All calculations, modeling, assumptions, and analysis should be based on the data in this report (and not previous or subsequent site characterization reports).

References

Selected journal articles (made available for student use) are listed below. Additional literature may be distributed, recommended, or assigned as appropriate for class and specific group needs. Students are encouraged to use other information sources (e.g. UofA library resources such as the Web of Science database, other online resources, etc) as needed.

A. Love, O.T., Jr. and R.G. Eilers, "Treatment of Drinking Water Containing Trichloroethylene and related Industrial Solvents," 74(8), 413 (1982).

B. McKinnon, R.J., and J.E. Dyksen, "Removing Organics from Groundwater Through Aeration Plus GAC," J. Amer. Water Works Assoc., 76(5), 42 (1984).

C. Crittenden, J.C., et al. "Using GAC to Remove VOCs from Air Stripper Off-Gas," J. Amer. Water Works Assoc., 80(5), 73 (1988).

D. Hand, D.W., et al., "Design and Evaluation of an Air-Stripping Tower for Removing VOCs from Groundwater," J. Amer. Water Works Assoc., 78(9), 87 (1986).

E. Crittenden, J.C., and D.W. Hand, "Design Considerations for GAC Treatment of Organic Chemicals," J. Amer. Water Works Assoc., 79(1), 74 (1987).

F. Aieta, E.M., et al, "Advanced Oxidation Processes for Treating Groundwater Contaminated with TCE and PCE: Pilot Scale Evaluations," J. Amer. Water Works Assoc., 80(5), 64 (1988).

G. Glaze, W.H., and J. W. Kang, "Advanced Oxidation Processes for Treating Groundwater Contaminated with TCE and PCE: Laboratory Studies," J. Amer. Water Works Assoc., 80(5), 57 (1988).

H. Karimi, et al., "Evaluating an AOP for TCE and PCE Removal", J. Amer. Water Works Assoc., 89(8), 41 (1997).

I. Adams, J.Q. and R.M. Clark, "Cost Estimates for GAC Treatment Systems", J. Amer. Water Works Assoc., p.35, January 1989.

J. Adams, J.Q., R.M. Clark and R.J. Miltner, “Controlling Organics with GAC: A Cost and Performance Analysis”, J. Amer. Water Works Assoc., p.132, April 1989.

K. Weir, B.A., C.R. McLane and R.J. Leger, “Design of a UV Oxidation System for Treatment of TCE-Contaminated Groundwater”, Environmental Progress, 15(3), 179 (1996).

L. Topudurti, K., “A UV/Oxidation Technology Demonstration to Treat Groundwater Contaminated with VOCs”, Water Science and Technology, 25(11), 347 (1992).

M. Johnson, P.C., C.C. Stanley, M.W. Kemblowski, D.L. Byers, J.D. Colthart, "A Practical Approach to the Design, Operation, and Monitoring of In Situ Soil-Venting Systems, GWMR, 159 (Spring 1990).

N. Staudinger, J., P.V. Roberts, J.D. Hartley, "A Simplified Approach for Preliminary Design and Process Performance Modeling of Soil Vapor Extraction Systems", Environ. Progress, 16(3), 215 (1997).

O. Mitchell, J.K. and R.R. Rumer, “Waste Containment Barriers: Evaluation of the Technology”, in In-situ Remediation of Geoenvironment, publication #71, ASCE, October, 1997.

P. Roustan, M, R.Y. Wang, O. Wable, J.P. Duguet and J. Mallevialle, “Mathematical Model for the Design of Ozone Bubble Diffuser Contactors”, in Ozone in Water and Wastewater Treatment, vol. 2, Proc. 11th Ozone World Congress, San Francisco, CA, International Ozone Association, 1993.

Additional Policies, Warranties and Disclaimers:

Attendance: The UA’s policy concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy.
Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: https://deanofstudents.arizona.edu/absences.

If you will be missing class for one of these reasons, you must notify your instructor at least one week in advance of the absence to arrange for appropriate accommodations.

Withdrawals/Drops: Please consult the Schedule of Classes for dates and deadlines (http://registrar.arizona.edu/dates-and-deadlines/view-dates?field_display_term_value=164). Students must execute withdrawal procedures according to the University of Arizona General Catalog (http://registrar.arizona.edu/grades/withdrawal-grades).

Electronic Devices: Students should turn off all electronic devices during class unless the device is deemed necessary for the class by the instructor. This includes, but is not limited to cell phones, mp3 players, PDAs, and computers. It is extremely inappropriate to text during class and especially during a presentation. If an emergency arises, please leave the classroom to call/text in the hall.

Academic Integrity: Integrity is expected of every student in all academic work. Scholastic dishonesty will not be tolerated. Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.Please refer to the UA Code of Academic Integrity for information about procedures and about what constitutes scholastic dishonesty

University Libraries have some excellent tips for avoiding plagiarism, available at http://new.library.arizona.edu/research/citing/plagiarism.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Classroom Conduct Policies: While in class you are expected to conduct yourself in a manner conducive to learning and one that does not interfere with other students' concentration or attention. Threatening behavior (http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students) by any student will not be tolerated.

Threatening Behavior Policy: The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Accessibility and Accommodations: Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit http://drc.arizona.edu.

UA Nondiscrimination and Anti-harassment Policy: The University is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy.

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Personal Privacy: We strive to maintain the anonymity of individual students taking this course relative to grades given on assignments or exams, or final grades at the completion of the course. For a detailed description of University of Arizona guidelines on disclosure of personal information please go here: http://www.registrar.arizona.edu/ferpa/default.htm.

Statement of Copyrighted Materials: Students are advised that all lecture notes, lectures, study guides and other course materials disseminated by the instructor to the students, whether in class or online, are original materials and as such reflect intellectual property of the instructor or author of those works. All readings, study guides, lecture notes and handouts are intended for individual use by the student. Students may not distribute or reproduce these materials for commercial purposes without the express written consent of the instructor. Students who sell or distribute these materials for any use other than their own are in violation of the University's Intellectual Property Policy (http://policy.arizona.edu/research/intellectual-property-policy). Violations of the instructor's copyright may result in course sanctions and violate the Code of Academic Integrity.

Subject to Change Statement: Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice to the students, as deemed appropriate by the instructor.