Focus on Tar Creek

By Christi L. Patton

The University of Tulsa

Abstract

Tar Creek is #1 on the EPA cleanup list and it is located about 90 miles from the University of Tulsa campus. While the legislators and residents debate what should be done to clean up the area, freshman Chemical Engineering students research the history of Tar Creek and use this as a starting point for lectures and lively discussion on safety and ethics. Throughout the course students perform practice calculations that are based on the information gleaned through research. During the last weeks of the semester the students participate in a research project that takes them to Tar Creek to sample the water and test these samples in a series of experiments of their own design. This project gives the students a practical appreciation of safety and the environment and an opportunity to apply their skills to a real-life problem.

Background

Tar Creek has received national attention since it was established as a top priority by the EPA Superfund in 1983. As such, it is an appropriate topic for an introductory course in chemical engineering that emphasizes safety, ethics and the environment. The fact that it is located a ninety minute's drive from the University of Tulsa makes it an excellent way to blend an introduction to engineering with current events.

The Tar Creek Superfund site is named after a creek that runs through the area then into the Neosho River and on to Grand Lake. The environmental disaster is the result of abandoned lead and zinc mines in a 40 square mile area near Picher, OK. Tar Creek is only a small part of what was originally known as the Tri-State Mining District in Oklahoma, Kansas and Missouri where lead and zinc reserves were first discovered in 1891 and mined heavily until 1947. At the peak of activity, 23 million gallons of acidic water were pumped out of the mines each day and into the local creeks.

By the mid-1960s the mines were abandoned. The pumps were shut off which allowed the creeks to return to their natural state. Flora and fauna flourished once again. The area looked to be recovering. But hidden underneath the land a new disaster was

brewing. The miners had left more than 8000 shafts, 1400 of them open, and hundreds of thousands of bore holes. Mountains of spent ore, called chat piles, littered the countryside. Occasionally shafts collapsed, leaving large sinkholes. The mines slowly filled with water which reacted with the oxidized pyrite to create acid. By the mid-1970s this acidic water contaminated the Roubidoux aquifer below the mines and also overflowed the mines re-contaminating the creeks and streams.

In 1982, a consulting firm estimated that the cleanup would take 23 years and cost nearly $13 million [1]. Twenty-two years later, the land looks essentially the same and most of the money spent has been for additional studies rather than remediation. In June, 2004, Governor Brad Henry signed a bill authorizing the state of Oklahoma to spend $5 million to buy out homeowners in the area. This will be applied to homeowners with young children and is expected to be used to relocate one hundred families. Significant funds still have not been allocated for remediation.

Introduction to Chemical Engineering Course

The University of Tulsa course catalog describes the introductory class for freshmen studying Chemical Engineering as:

> Overview of the chemical engineering curriculum, professionalism, career opportunities, and issues of safety and the environment. Introduction to chemical engineering calculations; units, dimensions, and conversion factors.

Most students enrolling in the course are new to the university and have selected the major based on the fact that they liked chemistry and math in high school. They typically have no idea what a chemical engineer does. This course is intended to acclimate the student to the college environment, teach them the most basic skills required by engineering students and introduce them to chemical engineering as a career. Students meet with local representatives from industry and are encouraged to attend plant tours. New freshmen can also begin to "do" chemical engineering interpreted as the creative application of science. A successful approach to teaching students the difference between science and engineering has been to discuss technical challenges, conduct science experiments relating to the challenge then brainstorm solutions and discuss (or attempt) implementation. Searching current events for problems to tackle keeps the project interesting for everyone.

Introducing the Project

Early in the semester, students are taught basic college survival skills. The importance of avoiding plagiarism is one of the topics addressed. During the Fall 2003 semester, students were asked to read an article that was originally published in the LA Times outlining the history of Tar Creek [2]. Their assignment was to write an essay on the cause of the problems and then to venture an opinion on what might be done to remediate it.

This paper was due on the same day as the first lecture on engineering ethics. Rather than beginning with a traditional lecture on ethics, class began with a discussion of the Tar Creek problem. Since the students were familiar with the basic facts and had already formulated opinions on the situation, the discussion was underway before the instructor even entered the classroom. Questions raised during the discussion included:

Who is responsible for the problem?
What should be done for the residents now?
What should be done about the land and water?
Who should pay for the work they proposed?

Throughout the discussion, the instructor shared more recent news stories about the situation at Tar Creek [3] and introduced the story of dioxin contamination at Times Beach, Missouri [4]. Class ended with a quick examination of several engineering codes of ethics. That evening's assignment was to read the AIChE and NSPE codes and think about how use of these codes could help prevent future problems and how these codes effect decision-making for proposed solutions.

Once students have been introduced to engineering ethics, safety and the environment the course moves on to looking at basic problem solving tools such as significant figures, unit conversions and graphing. Although the Tar Creek problem does not directly relate to these topics, this provided a context for many problems. Using facts from the articles could also motivate the need to learn these skills. For instance, the LA Times article gives an estimate of 33,000 acre-feet of acidic water in the mines then relates that as being 10, 753,097,000 gallons [2]. This is an excellent example of the need to study significant figures!

The Project

During the last few weeks of the semester the students are assigned a small research project. The purpose of this project is to get the students to work in a group to solve a problem and then to report on this work through an oral presentation. The project typically uses the basic science skills they have learned in Chemistry 1 and high school to do independent problem solving.

For the Tar Creek project, students were taken to Picher, OK to see the damage first-hand and to take water samples. Water was also collected from the Arkansas River (which runs through the city of Tulsa) and Lake Eufala (the source of Tulsa's drinking water) and the instructor's home aquarium. They then were given $1000 of Chem-E Cash and a price list of tests that could be performed on the water samples. The tests ranged in price from $50 to $150 and included ion chromatograph (to test for common anions or cations), atomic absorption (to test for a variety of metals), gas chromatograph (to test for organics), dissolved oxygen, conductivity and pH studies. The groups were instructed to design a series of tests on these samples that would tell a story. For instance, one group did a comparison on the "livability" of Tar Creek, the Arkansas River

and the aquarium. Another did a complete analysis o the Tar Creek samples and compared them to the U.S. Geological Survey's published values [5] and the EPA guidelines for drinking water [6].

The groups of students then were assigned to work with volunteer graduate students and faculty to learn to use the instruments needed to complete these tests. Each group became the class expert for one instrument and shared the results with other groups that had purchased the information. Since none of these experiments were performed in advance, the results were occasionally surprising but that, too, was part of the lesson. Once all experiments were completed the groups met again to summarize their data and interpret the results. They were asked to brainstorm ways of correcting any problems they found (in either the testing procedure or the environmental site). The final deliverable was a written memorandum with a summary of their data and an oral presentation on their results.

Conclusion

The response of the students was quite positive throughout the semester. It was gratifying to walk into the classroom planning to facilitate a discussion and find that the students were already discussing it on their own! The students continued through the next semester to come to my office to share news stories about Tar Creek and discuss the ramifications.

The students' awareness of the environmental impact of their actions was also tremendously increased. An incident that occurred during the course exemplifies this. During the semester, the class made ice cream in a bag as one of their activities unrelated to Tar Creek. The leftover salt-and-ice mixture was left in an office overnight to be cleaned out the next day. Unfortunately, the brine was accidentally dumped on the lawn by someone thinking it was just water. The class was aware of the potential problems this could cause and followed up by testing the contaminated soil and researching remediation methods in case there was a problem. Although the problem was minimal, the class was prepared to take the necessary steps to repair any damage they may have inadvertently caused. Once the students are out in the workforce, perhaps the lessons learned will truly help to make a difference.

The most significant impact was on retention. A remarkable 100% of the students enrolled in the next Chemical Engineering course in the sequence for the Spring semester. Some even invited friends to join them in their new major. Teacher evaluations for that course were significantly higher than in previous semesters giving additional evidence that this project was a success. Variations of this project with new guest speakers and new water quality tests will be used in future semesters. Eventually the Tar Creek area will fade from front page news, but in the meantime it can be used to increase the number of socially-aware chemical engineers.

Bibliography

[1] *Cleanup figured to take 23 years*, Oklahoma City Times, (1/8/82). Accessed on 5/31/04 at <http://www.nelpi.org/tarcreek/articles/paper.asp?id=10>

[2] Meyer, Richard E., *The Tar Creek Time Bomb*. LA Times. Accessed on 5/31/04 at <http://www.science.uwaterloo.ca/earth/waton/s902.html>

[3] *Tar Creek*, NELPI (2002). Accessed on 5/31/04 at <www.nelpi.org/tarcreek/>

[4] *Times Beach, Missouri*, Wikipedia (2/11/03). Accessed on 5/31/04 at <http://en.wikipedia.org/wiki/Times_Beach,_Missouri>

[5] *Summary of Surface-Water-Quality Data Collected Near the Tar Creek Superfund Site in Ottawa County, Oklahoma, in 2000*, U. S. Geological Survey, in Cooperation with the Quapaw Tribe of Oklahoma, (2000). Accessed on 5/31/04 at <http://ok.water.usgs.gov/quapaw>.

[6] *Drinking Water Standards*, U. S. Environmental Protection Agency, (5/30/04). Accessed on 5/31/04 at <http://www.epa.gov/safewater/standards.html>

Additional Resources

For additional articles on Tar Creek see this webpage set up by Miami (OK) High School students: <www.tarcreek.org>. One may view the reports from the Oklahoma Governor Frank Keating's Tar Creek Superfund Task Force (2001) at <www.deq.state.ok.us/LPDnew/Tarcreek>.

Biographical Information

CHRISTI L. PATTON is Applied Assistant Professor of Chemical Engineering at The University of Tulsa. She received her B.S. in Chemical Engineering from Texas A&M University and her M.S. in Applied Mathematics and her Ph.D. in Chemical Engineering from The University of Tulsa. She is teaching the freshman introduction to Chemical Engineering for the fourth year.