DESCRIPTION OF THE RESEARCH PROJECT FOR THE 2020 SUMMER RET SITE

Project 3: Physical and Chemical Treatment of Contaminated Sand Filter Backwash Water for Recycling and Reuse

Area Coordinator:
Dr. Soryong (Ryan) Chae
Assistant Professor, Environmental Engineering
Department of Chemical and Environmental Engineering
College of Engineering and Applied Science
University of Cincinnati
PO Box 210012
Cincinnati, OH 45221-0012
Office: 736 Engineering Research Center
Phone: (513) 556-4353
Fax: (513) 556-4162
E-Mail: chaesg@ucmail.uc.edu

Sub- Area Coordinator:
Dr. Margaret J. Kupferle
Associate Professor & Chair, Environmental Engineering
Department of Chemical and Environmental Engineering
College of Engineering and Applied Science
University of Cincinnati
PO Box 210012
Cincinnati, OH 45221-0012
Office: 770 Engineering Research Center
Phone: (513) 556-3329
E-Mail: Margaret.Kupferle@uc.edu

Graduate Research Assistant:
Mr. Hyunsik Kim
M.S. student in Chemical and Environmental Engineering
Office: 737 Engineering Research Center
Phone: 513-926-5809
E-Mail: kim4hk@mail.uc.edu

Project Summary

This research topic is inspired by the **National Academy of Engineers (NAE) Grand Challenge**, "Provide access to clean water" linked to the ***big idea*** that public water treatment systems play a critical role in protecting public health. In particular, there are significant ***challenges*** faced by small utilities regarding recycle and reuse of sand filter backwash water (SFBW) that is contaminated by paritcles, nutrients, and microorganisms such as *Cryptosporidium parvum* and *Giardia lamblia*.

This research answers the ***guiding question****: How can we improve recycling and reuse potential of contaminated SFBW?*

Background: During the late nineteenth and early twentieth centuries, concerns regarding drinking water quality continued to focus mostly on disease-causing microbes (pathogens) in public water supplies. Scientists discovered that turbidity was not only an aesthetic problem, but particles in source water, such as fecal matter, could harbor pathogens. As a result, the design of most drinking water treatment systems built in the U.S. during the early 1900s was driven by the need to reduce turbidity, thereby removing microbial contaminants that were causing typhoid, dysentery, and cholera epidemics. To reduce turbidity, some water systems in U.S. cities (such as Philadelphia) began to use **sand filtration**.

The Richard Miller treatment plant (RMTP) provides approximately 85% of drinking water (~ 140 MGD) to the city of Cincinnati (Figure 1-1). Sand filtration has been successfully operated to remove particles and microorganisms before granular activated carbon (GAC) over the past 120 years. However, SFBW (~10% of the daily drinking water production) has been recognized as a potential environmental pollution source in the RMTP. In our on-going study in collaboration with the RMTP, we observed that SFBW from the RMTP contains high contents of turbidity, nutrients (such as nitrogen and phosphorus), and cells.

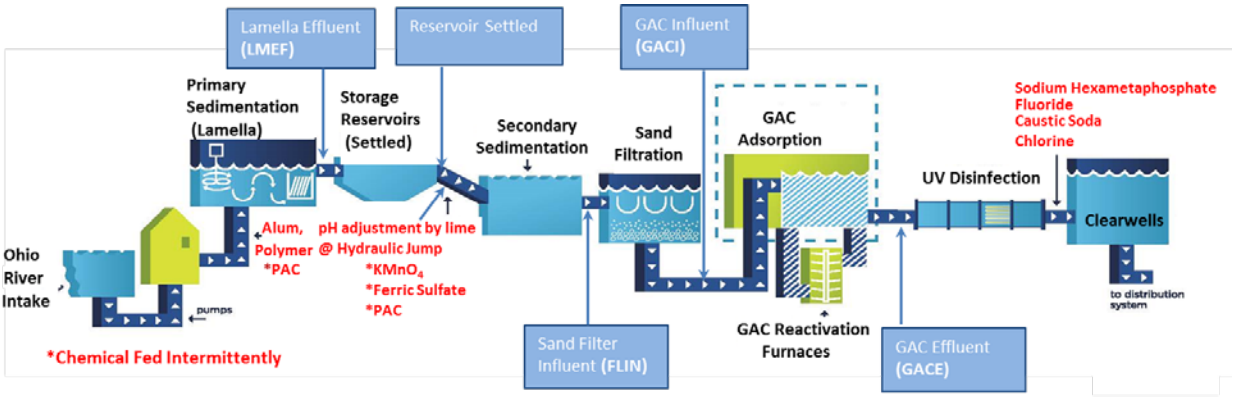

Figure 1-1. Process train of the Richard Miller treatment plant (RMTP) in Cincinnati, Ohio.

To meet the challenges of the stringiest drinking water regulations established to improve control of **environmental pollutants in SFBW**, additional treatment is required. Therefore, in this study, we aim to develop a multi-barrier advanced drinking water treatment process for simultaneous removal of particles, nutrients, and pathogenic microorganisms from SFBW. In this study, we aim to optimize a multi-barrier treatment system, including coagulation/flocculation/sedimentation (C/F/S) and and ultrafiltration (UF) membrane filtration, to remove particles, nutrients, and pathogenic microorganisms from SFBW.

Training

Training on documentation and interpretation of the results will be provided during Weeks 2-3 to familiarize participants with the experimental setup to be used, required physical and chemical analyses to be performed, calibration and operation of analytical instrumentation, and use of Excel in plotting/interpreting results. In particular the participants will be trained in:

- The operation of a bench-scale coagulation/flocculation device.
- The operation of a membrane filtration device.
- Characterization of waste quality using UV/Vis spectroscopy (DR6000, HACH).

A field trip is also planned to the RMTP (5651 Kellogg Ave, Cincinnati, OH 45230) to showcase to the RET participants the application of the research they were doing to a real world setting.

Industrial Advisor

In addition to coordinating the field trip, an industrial advisor, **Dr. Ying Hong** at the Greater Cincinnati Water Works will serve as the Industrial Advisor for this project. She will participate in an *Industrial Advisors Panel Session* to plan and schedule activities for teachers' students during the school year.

Ideals for Classroom Implementation

Through this project, a participant will be able to introduce a scientific concept of physical, chemical and biological principles for water treatment recycling/reuse to students. Also, a participant will gain knowledge and computational skill for mathematical interpretation of kinetic studies related to removal of various contaminants in SFBW using phyicial and chemical treatment methods.

School teachers from different grade bands will be able to teach the following things in the classroom.

- **Intermediate and/or Middle School (5^{th} - 8^{th} grades):** Science: What are the environmental contaminants in natural waster resources? What happens during the drining water treatmentant?

- **Junior high school and high school (9^{th} – 12^{th} grades):** Science: What physical (gravity, density, adsorption, fitration), chemical (coagulation, flocculation, disinfection) and biological (slow sand filtration) processes should be used to remove environmental contaminants in natural water resources? Is order of the processes important? Math: Rate data analysis and visualization, linearization and/or non-linear curve fitting.

- **College (13^{th} – 14^{th} grade):** Advanced knowledge of 1) underlying mechanisms of coagulation, flocculatioin, and sedimentation, and 2) physical separation of environmental contaminatns using membrane filtration. Math: mathematical modeling, linearization and/or non-linear curve fitting.