Project 1: Availability of Safe Drinking Water

Faculty Mentor:
Dr. George A. Sorial
Chair and Professor of Environmental Engineering Program
School of Energy, Environmental, Biological and Medical Engineering
University of Cincinnati
Cincinnati, OH 45221-0012
Office: 701 D Engineering Research Center (ERC)
E-Mail: George.Sorial@uc.edu
Phone: (513)-556-2987

Graduate Student Mentor:
Mr. Hafiz Salih
Ph.D. Student in Environmental Engineering
Office: 709 Rhodes Hall
E-Mail: salihhh@email.uc.edu
Phone: 513-382-5480 (C)

Project Summary

Mass production and development of commercially available nanomaterials (NM) has the potential to adversely impact the removal of organic contaminants using activated carbon. The American Society for Testing Materials defined NM as a material with one dimension less than 100 nm. Nanoparticle (NP) is a subgroup of NM with at least two dimensions less than 100nm. In recent years, the manufacturing of synthetic NM has grown spectacularly. This includes many different compounds such as metal oxides; semiconductor materials, including quantum dots; zero-valent metals such as iron and silver. The high production and use of the NM is manifested by high release of NP into the environment and consequently to natural water. Nano silica is one of the most common NP that could find their way into the water system because of their use in water and soil treatment. Other NP of concern could also be nano TiO2 or zero valent iron. More studies are needed to understand the fate and transport of NP in water and their impact on the conventional water treatment methods.

Trichloroethylene (TCE) is a volatile organic carbon (VOC) that is commonly used as a cleaner in industry. This solvent is also used in metal finishing, electrical component, paint and ink formulation, and rubber processing wastewaters. Due to its negative impact on the ecosystem and human's health, which can be as severe as increased risk for cancer, TCE is regulated by the USEPA to a low level of (MCL= 5µg/l). Due to TCE's extensive commercial use and inappropriate waste disposal, TCE has become a main environmental pollutant.

Activated carbon (AC) has been regarded by USEPA as the best available technology for removing VOCs. However, the presence of background materials in natural water can highly impact this process. Natural organic matter (NOM) is the product of the breakdown of dead plants and animals. NOM is present in the environment in high concentrations and molecular weights. NOM can affect the AC adsorption through one of the following two avenues. The low molecular weights NOM can reduce VOCs adsorption by competing with the VOCs for adsorption sites. On the other hand, the larger molecular weigh NOM usually decreases VOC adsorption through AC pore blockage that can lead to AC fouling. NPs may have an effect similar to that of NOM on TCE adsorption. It is known that NPs aggregate in water and form larger particles. According to their electrical charge and the water pH and ionic strength, these larger particles can get attached to the carbon and damage or block the adsorption pores and subsequently reduce the surface area and the amount of TCE adsorbed. Another scenario could be the behavior of these NPs as adsorption sites; this could be the most likely situation for the Zero -valent iron.

The fate of NPs in the environment is yet to be fully understood. Like VOCs, the production of NMs is estimated to be in millions of tons per year. The effects of these substances when released into aquatic systems are not clear. Moreover, little is known regarding the interaction of NMs and VOCs, and the impact of this interaction on the removal of VOCs from water. This study will increase the understanding of NM behavior in regards to VOCs removal by AC. This knowledge is vital due to the severe health risks imposed by VOCs. On the other hand, NPs take a very long time to settle, thus they are likely to be carried by water, along with other hazardous adsorbates, to the consumer.

In the state-of-the art Environmental Chemistry Laboratory, participating teachers will conduct batch adsorption experiments in the presence of nano silica with or without background NOM by employing vials with Teflon caps. The main objective of this study is to evaluate the impact of nano silica on the effectiveness of AC adsorption of the TCE. In the previous summer periods the teachers conducted experiments with different nanomaterial. Returning teachers will be able to demonstrate the difference in performance for different nanomaterials and at the same time will have the chance in training the new teachers. The objective of this project is to determine the implication of different nanomaterials on the removal of TCE. Teachers will be provided with the necessary documentation for experimental procedures and interpretation of the results and will be trained prior to conducting any experiments.

Possible Ideas for Classroom Implementation

This project is expected to open the realm of the multidisciplinary field of environmental engineering, and surface chemistry to the teachers. It will empower them to show in a meaningful manner how such integrated knowledge is used to solve a pressing community problem. It will be attractive to women and minorities, who tend to choose pathways leading to careers that improve quality of life. The teachers will be assisted in enhancing lab infrastructure at their schools by simplifying the approaches they used in this research to suit the resources available to them. This activity, when integrated into math, science and social studies classes, exposes students to issues faced by environmental engineers as they design and build a functioning water filter using local materials to improve water quality and protect the public health.

Figure 1. Batch and Column Experimental Setup

Figure 2. Gas Chromatograph for determining pollutant concentration

Figure 3. Sample Preparation