Research in our laboratory centers on fluid flow and solute/particle transport in porous media. Applications of this work include the design and testing of ceramic porous media embedded with metallic nanoparticles and nanopatches for point of use water purification in the developing world, fate and transport of groundwater pollutants and microorganisms in porous media, nanoparticle transport, and design of earthen landfill liners and reactive slurry walls. Our work includes creation of innovative designs and systems for low-impact development of linear transportation systems.

Our work is both experimental (laboratory and field) and computational. Equipment in our Water Quality Laboratory includes a graphite furnace atomic absorption spectrophotometer, two gas chromatographs, a mercury porosimeter, a specific surface area analyzer, a scintillation counter, and a dynamic light scattering system for particle size distribution determination of nanoparticles. Field research sites have included Picatinny Arsenal in Morris County, New Jersey, San Mateo Ixtatan in the Guatemalan Highlands, and the Venda region of Limpopo Province, South Africa.

Water Treatment Technologies Research Group

James A. Smith

Henry L. Kinnier Professor of Environmental Engineering
jsmith@virginia.edu
www.cee.virginia.edu/faculty/smithja.html

Dept. of Civil & Environmental Engineering
University of Virginia
Charlottesville, VA
434.924.7991

"Working at the intersection of water, societal, and human health disciplines."

UNIVERSITY of VIRGINIA
SCHOOL of ENGINEERING & APPLIED SCIENCE

Sustainable point-of-use water treatment technologies for developing global communities

We study the social, economic, and environmental sustainability of ceramic filters impregnated with silver nanoparticles for point-of-use (POU) drinking water treatment in developing countries. Results indicate that the ceramic filters are 3-6 times more cost-effective than the centralized water system for reduction of waterborne diarrheal illness among the general population and children under five. The ceramic filters also exhibit better environmental performance for four of five evaluated life cycle impacts: energy use, water use, global warming potential, and particulate matter emissions.

Disinfection properties of zero-valent nano-silver particles

Ceramic filters coated with silver nanoparticles have proven to be an effective POU water purification system. We are investigating the retention and transport of silver nanoparticles (Ag-NPs) through ceramic porous medium to determine the best method of application allowing for maximum water purification. We are quantifying the effects of solution ionic strength, nanoparticle size, and nanoparticle capping agent on transport of the nanoparticles through ceramic media. We are also quantifying the release of Ag-NPs into effluent water from ceramic media that has previously been impregnated with Ag-NPs using the fire-in method and compare these results to Ag-NP release from ceramic media fabricate using conventional methods such as paint-on and dipping.

Ceramic tablets for point-of-use drinking water purification

We are developing a new point-of-use water treatment technology that consists of a porous ceramic tablet infused with silver and/or copper. When dropped into a household water storage container, it gradually releases silver and copper ions to disinfect the water. The tablet is designed so that the silver and copper ion levels are sufficient to disinfect the water while remaining well below the drinking water standards for these metals. The tablets are a potentially disruptive technology given their technological effectiveness, ease of use, low cost, and social acceptability.

Low-impact development technologies for stormwater runoff

We are investigating the long-term performance of low-impact development (LID) strategies for mitigating the effects of pollution on stormwater runoff from linear transportation systems. In the field, we are investigating these technologies as part of the Lorton Road Widening Project in northern Virginia. We have also developed new management strategies for the reduction of salt runoff from road-salt storage facilities.

Engineering properties of organoclays

Clays are commonly used as low-permeability barriers at waste-disposal facilities and ground-water remediation sites. We have studied modification of the surface properties of natural clay minerals by the exchange of quaternary ammonium cations onto the clay surface. The resulting "organoclay" exhibits strong sorption of organic pollutants and therefore can improve the performance of the earthen liner or slurry wall.

RECENT RESEARCH DEVELOPMENTS

- Silver-ceramic tablet for point-of-use water treatment provides 6- log reduction of *E. coli*
- Silver nanoparticles found to be relatively mobile in porous ceramic water filters
- Silver ions can reduce the infectivity of *Cryptosporidium* oocysts in water
- Elected to Fellow grade of the American Society of Civil Engineers
- Elected to Diplomate of the American Academy of Water Resources

RECENT GRANTS

- NSF – Formation of Silver and Copper "Nanopatches" in Ceramic Porous Media and Application for Point-of-Use Water Treatment
- Virginia Center for Transportation Innovation & Research – Assessment of Low Impact Development Strategies Used for the Lorton Road Widening Project, Fairfax County, VA
- NSF – REU SITE: Water, Society, and Health

SEAS Research Information
Pamela M. Norris,
Executive Associate Dean for Research
University of Virginia
Box 400242
Charlottesville, VA 22903
pamela@virginia.edu
434.243.7683

UNIVERSITY of VIRGINIA | SCHOOL of ENGINEERING & APPLIED SCIENCE