Water Resources Research Center
University of Massachusetts

Annual Technical Report
2019

Products

1. Microbial Community Characterization And Pharmaceuticals Analysis Of Agricultural Soils Irrigated With Calcium Hydroxide (lime)-treated Urine From The Grow Food Northampton Community Garden In Florence, Massachusetts: manuscript to be submitted to a peer-reviewed journal, in prep

2. Nabi MM, Wang J, Meyer M, Croteau MN, Ismail N, Baalousha M. Concentrations and size distribution of TiO2 and Ag engineered particles in five wastewater treatment plants in the United States. Science of The Total Environment. 2021 Jan 20; 753:142017

3. Lesser E, Sheikh FN, Sikder M, Croteau MN, Franklin N, Baalousha M, Ismail NS. Bioaccumulation of citrate coated silver nanoparticles after environmentally realistic aqueous and dietary exposures (in preparation, planned submission to Environmental Toxicology and Chemistry May 2021)

4. Khan. ST et al. "Dynamic stormwater management to mitigate phosphorous export." Science of the Total Environment. (In revision; resubmission due late March)

5. Cordero, S., M. Harlan, X. Mai, 2019**.** Research Highlights from the North East Graduate Student Water Symposium, https://wrrc.umass.edu/sites/wrrc.umass.edu/files/pdf-doc-ppt/NEGSWS_USGS_Report.pdf

Information Transfer Program

2018MA104G: Results from the wastewater treatment testing (at 5 facilities across the US (MA, SC, CA) have been published in Science of the Total Environment. The results from microcosm experiments testing the bioaccumulation and fate of silver nanoparticles on *Daphnia magna* are will be published in 2021 (planned May 2021). The PI and postdoctoral research fellow (Smith College) presented results from experiments at the SETAC national conference in October 2020, undergraduate students presented results at the annual Celebrating Collaborations symposium at Smith College.

Results from the wastewater sampling were shared with WWTP personnel. In addition, personnel informally learned about the project while helping the PI and her students collect sampling in MA and CA.

Undergraduate students were also exposed to nanoparticles and metals in the environment through the PI's course-based research seminar "Contaminants in Aquatic Systems" taught in Spring 2020. Students had begun to conduct experiments (prior to shift to remote learning) involving uptake of metals in wetland microcosms containing different plant species.

2019 North East Student Water Symposium: A conference was held on the campus of UMass Amherst September 6-8, 2019 on the theme of research advances in water engineering, resources, science, and policy. Created to provide an affordable conference opportunity in the greater North East region for graduate students in water-rated disciplines, the 2019 symposium was attended by 107 pre-registered students, faculty, sponsors, community members, and post-

docs representing 19 colleges and universitiesin 7 states and one Canadian province, 3 companies, two non-profit organizations, and one state agency. The number of attendees who registered during the conference was unfortunately not tallied, but is estimated at 30. 43 oral presentations and 38 poster presentations were delivered by students representing. A report was written by three UMass Amherst graduate students assisted by a committee of 25 graduate students representing 18 other universities.

Student Support

Undergraduate: 10
Graduate: 5
Post Doc: 2

Notable Achievements and Awards

2019MA133B Real-time Responsive Nutrient Loading Management In Urban Catchments Through Sewer-embedded Sensing And Controls directly led to recommended design for a high resolution stormwater monitoring station within the City of Boston (work funded through the Boston Water and Sewer Commission). This new system will go online in Q2 of 2021, collecting data online for a range of parameters, including both bulk characterization of water and nutrients. These data will contribute to improvement/validation of the City model for nutrient (primarily phosphorous) and other pollutant (nitrogen, TSS, zinc, copper) loading to the Charles River.
Preliminary results from this work resulted in award of a contract (<$250k) with the Boston Water and Sewer Commission (subaward via Kleinfelder as part of a larger project) for a high resolution study of Boston stormwaters during 2020-22

2019MA132B Wireless Network Of Smart Graphene Sensors For Large-scale Monitoring Of Water Heavy Metals A patent disclosure based on the research outcomes is in preparation.

Wireless Network Of Smart Graphene Sensors For Large-scale Monitoring Of
Water Heavy Metals

Project Type: Annual Base Grant
Project ID: 2019MA132B

Project Impact:
The ultimate goal of this program is to develop a wireless network of ultra-high-sensitivity smart sensors based on graphene-aptamer hybrids for chronic large-scale real-time monitoring of heavy metals in water bodies. The development and implementation of the sensor network can offer the prospect of enormous societal benefits through its potential impact on environmental protection, water safety, public health, advancement of scientific understanding on health outcomes of chronic exposure to low-level environmental heavy-metal toxins, and development of water heavy-metal guidance values. In the first-year (2019) research, we have combined two enabling technologies: a microfluidic heavy-metal isolation device and an aptasensor array based on graphene. The microfluidic device is capable of separating microions, including Hg2+, and small organic molecules from complex solution such as lake water. The aptasensor array demonstrates excellent capability of detecting the Hg2+ coexisting with organic molecules in solution on the sensing array at high sensitivity.

Real-time Responsive Nutrient Loading Management In Urban Catchments Through Sewer-embedded Sensing And Controls

Project Type: Annual Base Grant
Project ID: 2019MA133B

Project Impact:
The primary achievements of this project were the evaluation of a range of physical parameters and sensors signals for accurate and/or real-time quantification of phosphorous fluxes in separated stormwater sewers in highly urbanized areas. Six wet weather events were studied in 2019-20 at 6 different sites in two cities. A range of parameters were measured in real-time by sensors (e.g., flow, level, conductivity, pH) while others were measured through lab analysis on collected samples (TSS, orthophosphate, total phosphorous, and total phosphorous in sub-samples filtered to four different size fractions). The main findings of this work are, contrary to the conclusions of prior studies which focused primarily on non-urban waters:
(1) the fraction of P in dissolved versus particulate form is highly variable, with dissolved fraction representing 0-40% of P flux, meaning online measurements need to characterize both orthophosphate and particles to be useful for the stated purpose, and (2) the size of particles with which phosphorous is associated varies not only by site but also by wet weather event, i.e., particle loading and/or water velocity are not accurate proxies for phosphorous flux. These insights directly informed the design of next -generation of online instrumentation for this study (constructed Fall 2020, being deployed 4/2021) including characterizing the dissolved phase constituents (7 ion selective electrodes for nutrients, as fluxes may be correlated with P fluxes, and metals, which may account for some non-P related particulate loading) as well as bulk properties related to dissolved and particulate phases (conductivity, DO, pH, turbidity).

Microbial Community Characterization And Pharmaceuticals Analysis Of Agricultural Soils Irrigated With Calcium Hydroxide (lime)-treated Urine From The Grow Food Northampton Community Garden In Florence, Massachusetts

Project Type: Annual Base Grant
Project ID: 2019MA134B

Project Impact:
This project explored the potential benefits and effects of using urine treated with calcium hydroxide (lime) as a fertilizer for non-food crops. Urine was treated and collected from the Grow Food Northampton (GFN) community garden in Florence, Massachusetts. The objective of this work was to provide an assessment to the garden management team and the broader community of the effects of fertilizer applications of lime-treated urine on plant growth and the soil microbial community. Two 7-week agricultural experiments took place at the University of Massachusetts Amherst between Fall 2019 and Fall 2020 using sunflowers as a model species. In both experiments, applications of lime-treated urine diluted 1:10 were found to increase plant growth, including the number of leaves per plant, leaf area, and overall plant biomass. However, in the second experiment, the nutrient “match” increased the number of leaves per plant and leaf area significantly more than the lime-treated urine. We also found that plants treated with the nutrient “match” retained significantly more water in their leaves and had more total chlorophyll compared to plants treated with the lime-treated urine or water alone. However, no differences in photosynthetic efficiency or soil microbial diversity were observed between the exposure groups. The results of this project imply that fertilizer applications of diluted lime-treated urine on non-food crops could increase plant growth without altering the soil microbial community.

Fate and Impacts of Silver Nanoparticles in Treatment Wetlands

Project Type: National Competitive Grant
Project ID: 2018MA104G

Project Impact:
Bicoastal wastewater sampling efforts have been completed. Influent, activated sludge and effluent samples were tested from 3 states (5 plants) over a period of 1 year. Samples were tested for a range of metal based engineered nanoparticles (NP) and Ag and TiO_2 were both identified in samples. Results showed that Ag-NP removal was in the range of 82-95% while TiO_2-NP were in the range of 90-96%. Analysis also showed that almost all of the particles discharged to the environment in effluent were in the nano-sized range. The studies show that WWTP removal of NP is not 100% efficient and can be a source of metal-based NP in the environment especially as the use of NPs continues to increase.
Laboratory based experiments have been completed using isotopically labeled citrate coated AgNPs (Ag-109) to characterize Ag uptake and elimination in *Daphnia magna*, a model zooplankton species that is important in treatment wetlands. Studies compared uptake from AgNP and $AgNO_3$ to understand the influence of Ag form on bioaccumulation from aqueous and dietary sources. Completed studies show that dietary exposure is the dominant pathway and low efflux rates can result in high bioaccumulation of Ag from AgNP. AgNPs have a higher retention potential than $AgNO_3$. These results show the potential of AgNP to impact health of *D. magna* populations in natural treatment systems and can also result in trophic transfer of Ag since *D. magna* is a critical primary consumer and prey item n aquatic food chains.