New Jersey Water Resources Research Institute
Department of Environmental Sciences, School of Environmental and Biological Sciences

Annual Technical Report
2019

Products

For 2019NJ177B:

- Dillon, K.P., Krumins, V., Deshpande, A., Kerkhof, L.J., Mainelis, G., and Fennell, D.E. Using DNA stable isotope probing to study airborne methanotrophs. [*In preparation*]
- Dillon, K.P., Correa, F., Judon, C., Sancelme, M., Fennell, D.E., Delort, A.-M., Amato, P. 2021. Cyanobacteria and algae in clouds and rain in the area of puy de Dôme, Central France. *Applied & Environmental Microbiology*. 87(1): e01850-20. https://doi.org/10.1128/AEM.01850-20.
- Kevin P. Dillon, Diana Gentry, Noam Izenberg, David J. Smith. 2020. *Invited* Media Roundtable: Life in the clouds of Venus? Lessons from studying life in Earth's atmosphere. American Geophysical Union General Meeting. December 14. Virtual. [*oral presentation*]
- Kevin P. Dillon, Valdis Krumins, Aishwarya Deshpande, Lee J. Kerkhof, Gediminas Mainelis, and Donna E. Fennell. 2020. Application of DNA-stable isotope probing to study airborne methanotrophs. 38th Annual American Association for Aerosol Research Conference. October 9. Virtual. [*oral presentation*]
- Kevin P. Dillon, Valdis Krumins, Taewon Han, Gediminas Mainelis, Lee J. Kerkhof, and Donna E. Fennell. 2020. Determining the growth capability of airborne methanotrophs. American Chemical Society General Meeting. March 26. Philadelphia, PA, USA. *Cancelled due to COVID-19 pandemic [*Abstract accepted* for *oral presentation*]
- Kevin P. Dillon. A tale of two microbial guilds in the atmosphere. *Invited* seminar presentation. 2020. February 17. Monmouth University, West Long Branch, NJ, USA. [*oral presentation*]
- Donna Fennell, Kevin P. Dillon, Valdis Krumins, Lora R. McGuinness, Gediminas Mainelis, Lee J. Kerkhof, and Donna E. Fennell. 2019. Development of Stable Isotope Probing to Monitor Activity of Airborne Bacteria. American Geophysical Union General Meeting. December 9 – 13. San Francisco, CA, USA. [*oral presentation*]
- Kevin P. Dillon, Valdis Krumins, Agustin Bautista, Gediminas Mainelis, Lee J. Kerkhof, and Donna E. Fennell. 2020. Potential growth of airborne methanotrophs. Association of Environmental Engineering & Science Professors Meeting. March 4. Rutgers University. Piscataway, NJ, USA. [*poster presentation*]

For 2019NJ179B:

- Yeh, Heidi; David, Bushek, 2021. "Seasonal Oyster Microbiome Dynamics at Low and Moderate Salinity Sites in the Delaware Bay". Delaware Estuary Science and Environmental Summit, Mar 1-3, 2021. *[oral presentation]*
- Yeh, Heidi; David, Bushek, 2020 "Oyster Microbiome Dynamics Driven by Salinity and Seasonality in the Delaware Bay" in Mid-Atlantic Chapter Meeting of the American Fisheries Society, held virtually Nov 13, 2020. *[short oral presentation (virtual poster equivalent]*
- Yeh, Heidi; David, Bushek, 2019 *"*The Oyster Microbiome in Sickness and in Health*"* in Mid-Atlantic Chapter Meeting of the American Fisheries Society, Lewes, DE, Nov 21, 2019. [*poster presentation]*

For 2019NJ180B:

- Morales Medina, WR., Fahrenfeld, NL., Taylor, M., To, P., Nguyen, C. Microbiology of Biofilters: A Pilot Study for Disinfection by-Products Precursor and Manganese Bioremoval from Drinking Water. ACE20 Annual Conference, Orlando FL. June 2020. [*Abstract accepted for oral presentation*; *Conference canceled due to COVID-19*]

- Morales Medina, WR., Fahrenfeld, NL., Taylor, M., To, P., Nguyen, C. Comparing the Microbial Community and Water Quality Changes During Biofilters Acclimation Period 2019 Tri-Association Conference. Ocean City, MD. August 2019. [*oral presentation]*
- Morales Medina, WR., Fahrenfeld, NL., Taylor, M., To, P., Nguyen, C. Pilot Scale Biofiltration for Disinfection by-Product Precursor and Manganese Bio-removal from Drinking Water. AWWA New Jersey Annual Conference 2019, Atlantic City, NJ. March 2019. [*poster presentation]*
- Morales Medina, WR., Fahrenfeld, NL., Taylor, M., To, P., Nguyen, C. Pilot Scale Biofiltration for Disinfection by-Products Precursor and Manganese removal from Drinking Water. 2019 NJ AWWA Research Dinner., Piscataway, NJ. April 2019. *[invited oral presentation]*

For 2019NJ181B:

- One conference paper will be submitted to the 2021 IEEE *International Geoscience Remote Sensing Symposium* (*IGARSS* 2021)
- one journal publication is under preparation to be submitted to *Remote Sensing* journal (expected by April 2021)

For 2019NJ182B:

- Boran Wang, Miroslav Forgac, James White, Lucia Rodriguez-Freire (*under preparation*) Plant microbiome preserve plants from PFAS toxicity.
- Boran Wang, Lucia Rodriguez-Freire (*under preparation*) PFAS accumulation and effect of long-term exposure to *Arabidopsis thaliana.*
- Maedeh Soleimanifar, Boran Wang, Randy Nutakor, Aneesh Kakirde, Lucia Rodriguez-Freire (*under preparation*) Changes in microbial community in legacy-contaminanted sediments affected by a mixture of contaminants.
- Lucia Rodriguez-Freire, Boran Wang, James White, 2020, "PFAS distribution in contaminated soils and impact on rhizosphere and plant microbiota", American Geophysical Union Online Fall Meeting, December 1 – 17, 2020. [*oral presentation*]
- Lucia Rodriguez-Freire, 2020, "Plants and their microbes and their role on environmental fate of contaminants, ChEE Seminar, Clemson University, November 13. [*invited speaker*]
- Lucia Rodriguez-Freire, 2020, "Plants and their microbes and their role on environmental fate of contaminants, ChEE Seminar, University of Arizona, October 26. [*invited speaker*]
- Lucia Rodriguez-Freire, 2020 "Plant microbiome (rhizosphere and endosphere) and its role on environmental fate of contaminants", EWRE Seminar, Auburn University, September 3. [*invited speaker*]
- Lucia Rodriguez-Freire, 2020, "Harnessing natural processes to tackle environmental problems", Environmental Engineering Laboratory, Cal Poly Ponoma, July 22. [*invited lecturer*]
- Boran Wang, Lucia Rodriguez-Freire, 2020, "PFAS distribution in contaminated soils and impact on rhizosphere and plant microbiota". 258th American Chemical Society Meeting and Exhibition, Philadelphia, PA, March 22-26. [*oral presentation*]
- Lucia Rodriguez-Freire, Boran Wang, Maedeh Soleimanifar, Randy Nutaker, Aneesh Kakirde, 2019, "PFAS fate in complex mixtures in legacy contaminated sites", 16th International Symposium on Persistent Toxic Substances, Hoboken, NJ, October 25-29. [*oral presentation*]

For 2019NJ183B:

- Chen Wu, Qi Wang, Hao Chen, and Mengyan Li. Biotransformation and biodefluorination of 6:2 FTCA and 5:3 FTCA in municipal activated sludge. [*in preparation*]

For 2019NJ184B:

- Chunzhao Chen, Ling Chen et al., Organotin Release from Polyvinyl Chloride Microplastics and Concurrent Photodegradation in Water: Impacts from Salinity, Dissolved Organic Matter, and Light Exposure. Environmental Science & Technology (2019): 53, 10741-10752.
- Chunzhao Chen, Ling Chen et al., Impacts of Microplastics on Organotins' Photodegradation in Aquatic Environments, Environmental Pollution (2020): 267:115686.
- Chunzhao Chen, Wen Zhang, Organotin Pollution in Estuaries and Complex Interactions with Microplastics, NJAWWA, New Jersey, March 20st, 2019. [*poster presentation*]
- Chunzhao Chen, Wen Zhang. Organotin Release from PVC Microplastics and Subsequent Photodegradation Under Freshwater and Seawater Environment, Impacts of Microplastics in the Urban Environment Conference, New Brunswick, NJ, March 2019. [*poster presentation*]
- Chunzhao Chen, Ling Chen. Organotin Pollution in Estuaries and Complex Interactions with Microplastics. NJWEA 104th Annual Conference, Atlantic City, NJ, May 2019. [*poster presentation*]
- Chunzhao Chen, Wen Zhang. Bacterial-Microplastic Interactions: Implications on Microplastic Degradation and Bactericidal Effects. The 5th Stevens Conference on Bacteria-Material Interactions, Hoboken, NJ, June 2019. [*poster presentation*]
- Chunzhao Chen, Ling Chen. Trapping Effects and Mechanisms of Estuarine Turbidity Maxima for Organotin Contaminants, POPs Forum 2020, Shanghai, China, November 2020. [*oral presentation*]

Information Transfer Program

The New Jersey Water Resources Research Institute (NJWRRI) supports a diverse program of research projects. With oversight from the Advisory Council, which sets the Institute's Research Priorities, the available funds are divided between supporting faculty with 'seed' projects or new research initiatives and funding graduate students to develop their thesis research. The funding is intended to initiate novel and important research efforts by both faculty and students, thus emphasizing new research ideas that do not have other sources of funding. We hope to support the acquisition of data that will enable further grant submission efforts and in the case of students, lead to research careers focused on cutting-edge research topics in water sciences.

For the FY2019 annual program reporting period of June 18, 2019 through December 31, 2020, program management activities included administration of the junior faculty and graduate student grants, maintenance of contact with Advisory Council members, attendance at meetings of the Water Quality Monitoring Council, attendance at other water-related meetings and conferences to maintain contact with and information flow from water-related organizations in the state and across the Northeast, and having Water Resources Program undergraduate student interns conduct research on the planning, design, and efficiency of climate resilient green infrastructure practices for stormwater management. The NJWRRI continued to emphasize the redevelopment and upkeep

of the website and e-based communications with stakeholder groups and continued its partnership with the New Jersey Department of Health (NJDOH) through its *Fostering the Growth of Private Well Researchers at New Jersey's Universities* program.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	15	0	0	0	15
Masters	1	0	0	0	1
Ph.D.	7	0	0	0	7
Post-doc.	0	0	0	0	0
Total	23	0	0	0	23

Notable Achievements and Awards

For 2019NJ179B:

- Best Student Poster, 2020 Meeting of the Mid-Atlantic Chapter of the American Fisheries Society (11/13/2020)
- Awarded a $19,000 Hudson River Foundation Mark B. Bain Graduate Fellowship to support additional research by Ms. Yeh: "Phylogeography and Nutrient Dynamics of the Oyster Microbiome in NYC Harbor".

For 2019NJ180B:

- 2nd Place, Graduate Student Poster, 2019 AWWA New Jersey Annual Conference

For 2019NJ182B:

- *Proposals awarded*: EPA – P2 — Remediation of PFAS contaminated soil and sediment. Rodriguez-Freire role: Co-PI
- *Proposals pending*: NIEHS — Building food sovereignty, sustainability and better health in environmentally-impacted Native Americans. Rodriguez-Freire, role Co-PI; EPA — Occurrence, attenuation, and mitigation of PFAS in biosolid treatment and management processes. Rodriguez-Freire, role Co-PI

Potential Impact Of Aeromicrobes On Surface Water

Project Type: Annual Base Grant
Project ID: 2019NJ177B

Project Impact:

Information regarding the diversity and abundance of oxygenic photoautotrophs in the atmosphere is limited. More information from diverse locations is needed. These airborne organisms could have important impacts upon atmospheric processes and on the ecosystems they enter after deposition. Oxygenic photoautotrophic microbes, cyanobacteria and algae, are integral to ecosystem functioning and some have the potential to affect human health. A better understanding of the diversity and the movements of these aeolian dispersed organisms is needed to understand their ecology, as well as how they could affect ecosystems and human health. This work identified phylotypes of cyanobacteria that are associated with toxin-production present in rain and clouds. Additionally, since algae could be cultivated from rain and clouds, these organisms could have a direct impact upon the ecosystems they enter. We also provide preliminary data on algal aerosol characteristics, but that work was stopped due to the COVID-19 pandemic. Overall, our work is important in demonstrating that aerially dispersed microorganisms could have an impact upon ecosystems they enter.

Bugs On Drugs: The Influence Of Environmental Conditions On The Microbial Degradation Of Pharmaceuticals And Bacterial Community Structure In The Raritan River

Project Type: Annual Base Grant
Project ID: 2019NJ178B

Project Impact:

Pharmaceuticals and personal care products (PPCPs) are emerging contaminants in aquatic ecosystems throughout the world. The major goal of this study was to determine how environmental conditions impact the biodegradability of select PPCP compounds and the bacterial communities responsible for their degradation in anoxic estuarine sediments. It was hypothesized that both the extent of biodegradation and the microorganisms responsible would be dependent on the site conditions and pharmaceutical compound. Anaerobic cultures to determine rates and extent of degradation were established using site water and sediment collected from five sites within the Raritan River. Four sites with known PPCP contamination between the Raritan Bay and Highland Park, New Jersey (NJ) were sampled, as well as a site with no direct PPCP input in High Bridge, NJ. Cultures were spiked with four analgesic/antipyretic compounds (acetaminophen, aspirin, diclofenac, and ibuprofen) as model PPCPs and sampled periodically. Degradation and transformation of these compounds was monitored by high performance liquid chromatography. The results indicate that the extent of biodegradation was dependent on both the site conditions and PPCP, with aspirin being the most readily degradable and ibuprofen the most recalcitrant compound. Potential transformation products were observed for both acetaminophen and diclofenac. Actively degrading cultures continue to be enriched and ribosomal operon analysis via the Oxford Nanopore MinION system will be used to characterize and quantify bacterial community members in actively degrading cultures. Highly enriched cultures will also be used to isolate and characterize strains of anaerobic bacteria responsible for the degradation of the individual PPCPs.

Disease Impact On Denitrifying Potential Of Oysters In Delaware Bay

Project Type: Annual Base Grant
Project ID: 2019NJ179B

Project Impact:

This project to-date has provided several interesting findings indicating how oyster microbiome dynamics are driven in part by salinity and season. The digestive gland microbiome of oysters found at lower salinities had a higher diversity of bacteria present. Regardless of salinity, alpha diversity increased with the progression of time through the sampling months indicating a seasonal influence on the bacterial community composition. Conclusions regarding the central question of oyster microbiota participation in the nitrogen cycle will have to await the completion of forthcoming qPCR analyses. The experience gained performing these methods and generating ideas to improve upon them for future experiments has been beneficial to Ms. Yeh’s graduate training. She will build upon these results and experience to continue studying the oyster microbiome in the Delaware Bay and the NYC harbor and, using the results and knowledge gained, has been awarded a prestigious Hudson River Foundation Baine Fellowship.

Resolving Aesthetic Issues And Disinfection Byproducts In Drinking Water Through Biofiltration

Project Type: Annual Base Grant
Project ID: 2019NJ180B

Project Impact:

There have been multiple violations for carcinogenic disinfection byproducts (DBPs) in drinking water over the last 6 years in New Jersey. Biofiltration is an alternative treatment method with the potential to reduce the formation of these compounds and efficiently remove other water contaminants. However, achieving optimal contaminant removal in biofilters requires a period of bacterial acclimation that is not fully understood. This funding allowed for biomolecular analyses of samples preserved from a full-scale biofiltration demonstration. Results showed that under our operating conditions, the acclimation of the biofilter for Manganese (Mn) took 9 months to achieve a similar removal to the chlorinated filters. However, the removal of total organic carbon (TOC) was better in the biofilter then in the chlorinated throughout the experiment. Biomass increased during the first 6 months before achieving a steady state of 1010 16S rRNA gene copies per gram of media. Bacterial family taxa containing species involved in Mn oxidation and nitrogen cycling were highly abundant in the microbiome of the biofilters. Seasonal changes appear to have impacted the microbial community structure and prokaryotic diversity, the latter of which decreased when the water temperature dropped. After 30 hours of biofilter operation, a higher cell density was detected in the upper layer of the biofilters. However, after a backwash event the bacterial cells appear to be homogenized throughout the filter core. In sum, the results presented in this research provide an insight of the changes in the microbial community during the acclimation period of full-scale sand-anthracite biofilter and could be used to accelerate biofilter acclimation and contaminant removal.

Monitoring Chlorophyll-a Concentration In New Jersey Lakes Using Remote Sensing And Ground Observations

Project Type: Annual Base Grant
Project ID: 2019NJ181B

Project Impact:

The presence of Harmful Algal Blooms (HABs) occurs when colonies of cyanobacteria grow out of control and produce toxic or harmful effects on humans, fish and livestock. They are among the most important factors that threaten water quality of lakes. Since 2005 NJDEP created a network design to monitor the 800+ lakes in New Jersey. Due to the amount of testing it is nearly impossible to be able to monitor and test and control each lake in NJ. With climate and temperature change, the concern of harmful algae blooms affecting public health has increased and affected everyday lives as it did in Lake Hopatcong in 2019. The NJDEP's monitoring system, while effective, can be costly and time consuming. A possible alternative manner of monitoring the water's algae levels would be remote sensing, using satellite images, from Landsat-8 and Sentinel, both available to the public. In this project, we utilized these remote sensing observations and in situ data to examine the effectiveness of existing algorithms to find a regionally robust method that is applicable for NJ lakes. The methods consist of experimental equations that use several visible and near-infrared remote sensing data. Two methods with higher capabilities to predict Chla concentration at the regional scale were then selected and used to study their effectiveness for NJ lakes (Pahlevan et al 2018 and Kabbara et al 2008 studies). The methods are generally able to predict Chl-a variations in selected lakes; however, they seem to have different performance accuracy when they are used for shallow and deep parts of the lakes. The results indicate the remote sensing observations could be used for monitoring lake water quality. However, they should be calibrated and developed when they are used at the regional scale.

Integrative System Approach To Investigate The Effect Of Contaminant Mixtures In The Efficiency Of Bioremediation Processes

Project Type: Annual Base Grant
Project ID: 2019NJ182B

Project Impact:

Environmental contamination is usually made of complex mixtures of metals and organic compounds. Furthermore, these contaminants can interact with indigenous mineral phases and organic matter, a unique microbiome, and local vegetation. This project has focused on the Ringwood/Ford Superfund site where soil and water are contaminated mainly with lead, arsenic, chloroethane, benzene and 1,4-dioxane. This site is in the lands of the Ramapough Lenape Nation Turtle Clan community in the Borough of Ringwood, County of Passaic, New Jersey. In this research, we are investigating the role of the plant endophytes and rhizosphere microorganisms as main drivers for contaminant mobility and bioavailability. This research has detected a new class of contaminants in the Ringwood/Ford Superfund site, per- and polyfluroalkyl substances (PFAS). Field measurements are combined with in vitro and hydroponic experiments to assess the mechanisms of PFAS plant translocation and microbiome changes. In vitro experiments showed that endophytic microbial community decreased PFAS toxicity to Poa reptans seedlings and prevented PFAS uptake by the plant. Hydroponic investigation on PFAS uptake by Arabidopsis thaliana shows PFOA greater mobility and translocation than PFOS, but greater toxicity to the plant with exposure time. Furthermore, PFOA exposure changed the microbiome of Arabidopsis thaliana. Ongoing research is continuing to investigate PFAS mixtures to elucidate the differences between different functional groups, C-chain length, and different biochemical properties. This work is expected to provide a holistic understanding of the fate and transformation of PFAS within environmental compartments, and it will inform future remediation strategies and exposure prevention alternatives.

Biotic And Abiotic Transformation Of Fluorotelomer Carboxylic Acids During Wastewater Treatment Processes

Project Type: Annual Base Grant
Project ID: 2019NJ183B

Project Impact:

Fluorotelomer Carboxylate Acids (FTCAs) are the essential precursors of perfluoroalkyl carboxylic acids(PFCAs) and common biotransformation intermediates of other precursor compounds. They have been frequently found as dominant per- and polyfluoroalkyl substances (PFASs) in landfill leachates, which are subsequently discharged into municipal wastewater treatment plants (WWTPs).

In this study, the biodegradability of 6:2 FTCA and 5:3 FTCA was investigated in microcosms that contained activated sludges collected from 4 municipal WWTPs in north NJ and NYC. After 7 days of incubation, 53.4~81.7% of 6:2 FTCA and 22.6~67.8% of 5:3 FTCA disappeared, respectively. Though short-chain PFCAs (PFHxA, PFPeA, PFBA) were identified as the products of biotransformation 6:2 FTCA and 5:3 FTCA, their biotransformation pathways were postulated distinctive. Significant defluorination (0.012~ 0.037 mM F-) was observed for 6:2 FTCA treatments. In contrast, only minimal fluoride (<0.004 mM) was detected in 5:3 FTCA treatments. In comparison with the abiotic controls, 25~37% of 6:2 FTCA was lost due to abiotic processes, while abiotic removal of 5:3 FTCA was lower than 6%. The overall fluorine mass recoveries were lower for 6:2 FTCA (20~51%) than those for 5:3 FTCA (45~87%), suggesting the existence of unknown fluorinated metabolites of 6:2 FTCA biotransformation. Further, 16S rRNA amplicon sequencing revealed the addition of FTCAs increased the relative abundances of three genera, Zoogloea, Nitrospira, and Dechloromonas, consisting of essential players for nutrient and pollutant removal in activated sludge treatments.

Overall, our study is the first report on the FTCA biotransformation by municipal activated sludges. Comprehensive investigation of defluorination products and microbial ecology helped shed light on the biotransformation mechanisms of FTCAs and other PFAS precursors that are widespread in our aqueous environment.

Identification And Characterization Of Organotin Pollution In Northern New Jersey Estuary

Project Type: Annual Base Grant
Project ID: 2019NJ184B

Project Impact:

This project aims to perform a holistic investigation of organotins (OTCs), a historic but overlooked contaminant in surface water and sediment in the New Jersey Harbor Estuary. The concentrations, chemical forms, water-sediment phase distribution, and possible sources of nine organotin species (e.g., methyltins, butyltins and phenyltins) were all investigated. OTCs were not found in these five water samples, but butyltins and methyltins were detected in all of the surface sediments. The sum of OTCs ranged from 73.5 ± 10.7 to 101.7 ± 15.2 ng Sn g-1 dw. For the Passaic River Estuary (NB1) and Hackensack River estuary (NB2), methyltins of up to 65.9 and 68.0 ng Sn g-1 dw showed much higher levels than butyltins. This is probably due to the heavy industry activities in the nearshore area (i.e., textile plants, plastic factories). While OTCs were dominated by butyltins, in particular tributyltin (TBT), in the remaining three sites (accounting for 60%-79%). TBT is a well-known antifouling paint aimed to protect the submerged water structures from biofouling, but also an endocrine disruptor which can induce the imposex in female bivalves. The levels of TBT were all higher than the 10 ng Sn g-1 dw of Spanish sediment quality guidelines (SQG) except for site NB1 which even exceeded the Australian SQG. The potential ecological risks related to TBT, therefore, are still a serious problem in the Newark Bay. However, phenyltins were all below the detectable levels in the whole area. Tri-phenyltin has been widely used as biocides in mariculture and agriculture. No contamination of phenyltins may result from the weak farming works locally. Based on the above results, it can be concluded that land-based sources (e.g., sewage discharge, runoff) are probably one of the predominant pathways of OTCs entering the coastal zones. The current levels of tributyltin (TBT) are sufficient to pose ecosystem threats based on the risk assessment. Hence, the issues of OTC contamination in the Newark Bay should not be neglected.