Title: The Quantification and Treatment of Contaminants of Emerging Concern For Improving Environmental Health

Participating Departments:

- Civil and Environmental Engineering
- Bioinformatics
- Chemistry
- Engineering Technology
- Geography and Earth Sciences

Area Lead: Olya Keen

Submission Category: Existing and Emerging Excellence

Keywords: urban water, public health, contamination mitigation, environmental quality, pollution control

Executive Summary:

Emerging contaminants are a broad class of chemical, physical and biological substances of emerging environmental concern. Substances belonging to this class include pharmaceuticals and personal care products, perfluoroalkyl substances (PFAS), flame retardants, plasticizers, pesticides, novel disinfection byproducts, microplastics, nanoparticles, and antibiotic resistant genes and organisms, among other categories. The class also includes emerging public health threats with environmental relevance, e.g. the novel coronavirus.

A group of eight researchers from five departments in our university is devoted to studies on all aspects of emerging contaminants. This group has achieved extensive national and international prominence individually and in collaborative efforts, as detailed in the submitted documents. The effort by the interdisciplinary group of researchers representing this area has encompassed the fate and transport of these contaminants in the environmental systems, their occurrence, prevention and mitigation of their release with the emphasis on water treatment, modeling of sources and impacts, and environmental and public health implications. The water treatment aspect of this area also includes the development of novel methods and materials, as evidenced by a number of individual and collaborative patents submitted by the group.

Emerging contaminants as a class have been a focus of public scrutiny in the past decades. For example, the presence of a wide range of chemicals and pathogens in drinking water as a result of human activities has captivated the popular press, as well as the scientific community. As such, this has become a topic of increased interest from funding agencies. The group representing this area has been able to achieve national and international recognition for their efforts, and has been covered in popular press along with extensive contribution to peer-reviewed scientific literature. This group has secured over $10,000,000 in funding as PIs in individual and collaborative projects and over $13,000,000 in funding as co-PI in collaborations outside of this core area.

Apart from intra-institutional collaborations by the members of this core area, each has been involved in research collaborations with other institutions in the country and internationally. This group is also characterized by a strong collaborative relationship with the local water utilities which emphasizes the applicability of the research products derived from this group's efforts.

Evidence of Strength and Excellence:
This research group includes multiple collaborations that have existed for years and have generated significant joint products including published papers, funded proposals, and awarded patents. Additionally, we have received acknowledgement in the press both locally and nationally for our research efforts. While each member of our group has excelled independently, our areas of strength and expertise include several subareas of collaboration:

1. *Environmental fate of emerging contaminants* (Keen, Sun, Munir, Gibas, Schlueter, Clinton, Rice-Boayue)
2. *Novel treatment processes to address emerging contaminants* (Keen, Sun, Amburgey, Poler, Munir)
3. *Systems approach to emerging contaminants* (Rice-Boayue, Clinton, Amburgey, Sun, Munir, Keen)
4. *Environmental tracking of the novel coronavirus for rapid response* (Munir, Gibas, Schlueter)

Research: The strong, well-established working relationship of our group can be demonstrated by our collaborative peer-reviewed articles. Drs. Gibas, Keen and Clinton collaborated to determine that most antibiotic resistant genes were removed by the treatment process; however, low concentration antibiotic release suppresses microbial functional pathways in the receiving stream which may impact environmental health (Clinton et al. 2020; Lambirth et al. 2018). We have also contributed to sustainability in water purification systems (Sahu et al. 2018) and environmental buffers for contaminant attenuation (Brown et al. in progress).

Patents: Our research group also demonstrates expertise in moving research from the laboratory to the public as evidenced by the several approved patents (see references). We consider this a critical component of our research that makes our advances more accessible to non-academic entities.

Funding: The group has extensive collaborations with utilities both locally and in other states, with many of the projects receiving either financial or research support from Charlotte Water and Charlotte Mecklenburg Stormwater. Collaborators also include USGS, EPA, AWWA, California and NC state agencies, and a number of other universities. Independently we have received funding from the NSF, NC WRRI and other agencies resulting in total PI funding >$5M (Table 1). Additionally, a number of collaborative grants were received by the group, some of the examples including: “Environmental Monitoring Lab and SAR-COV-2 detection on campus wastewater” (PI **Gibas**, co-PI **Munir,** co-PI **Schlueter,** $5M in CARES Act funding), “The role of environmental buffers in water reuse” (PI **Keen**, co-PI **Munir**, >$100k); “Evaluation and optimization of engineered media amendments for contaminant removal in stormwater runoff filtration systems (PI **Sun**, co-PI **Munir**, co-PI Vinson, $310k).

Outreach and Awards: Various projects by the group have received popular media attention. Research by **Dr. Keen** was selected for press release by American Chemical Society in 2015 for the work with the fate of antibiotics in disinfection processes, which resulted in numerous popular press publications in 10 countries and five languages. She was featured as an Emerging Investigator by the *Environmental Science: Water Research and Technology* journal in 2019 and completed an interview with NC Water Resources Research Institute on algal toxin work in 2021 (to be published). **Dr. Sun’s** research work and engagement in the executive committee of the

NC PFAS Testing Network was reported by multiple media in the state. **Dr. Rice-Boayue's** work on endocrine disrupting chemicals in streams has been featured in *Inside Science*. COVID-19 monitoring of city wastewater by **Dr. Munir** received coverage from the NC Office of Strategic Partnerships.

The individuals in this group have been active in serving as experts in the field with a number of entities of local and national significance, e.g. **Dr. Keen** was a Chair of the Organic Contaminants Research Committee for 3 years for the American Water Works Association, and **Dr. Rice-Boayue** served on the Mecklenburg County Soil and Water Conservation District advisory board.

The members of the group received recognition for their efforts from a number of prominent entities, such as best paper awards from the International Ultraviolet Association, the Water Environment Federation, the American Water Works Association, and the journal of *Environmental Science and Technology Letters*. Dr. Rice-Boayue was a finalist for the AAAS Fellowship and a recipient of the Fulbright Fellowships for her work at Burkina Faso.

Broader Impacts: We are committed to education at all levels from undergraduate to PhD students. The broader impacts by the group include workshop and conference symposium organization, volunteering at local high school science events, development of open-use web tools, and bringing certain contaminants to public attention (e.g. **Dr. Sun's** work that brought the issue of PFAS contamination in NC water resources to the attention of the local residents, water utilities, state and local governments, and led to the statewide effort of investigating and solving this problem).

Institutional Growth: We have established a diverse, interdisciplinary research group to address questions of emerging contaminants from the perspectives of engineering, chemistry, bioinformatics, and earth sciences. Targeted support from UNC Charlotte in the forms of equipment acquisition and improvements, cluster-hires, and RA supports to increase both the number and diversity of students in this field would move this research forward to both a national and international level.

Table 1: PI contribution to the scientific literature, research funding in this area secured over the past 5 years as PIs and co-PIs, and the number of PhD students mentored.

Name	Publication citations	Funding as PI	Funding as co-PI	PhD students	Masters' Students	Undergrad Students
Amburgey	214	167k	-	6	5	12
Clinton	946	1.6M	1.2M	1	11	30
Gibas	1100+	2.9M	1.2M	5	15	8
Keen	400+	800k	700k	4	7	7
Munir	1445+	223k	2.5M	3	2	4
Poler	500	540k	1.1M	6	12	84
Rice-Boayue	350+	380k	-	2	2	1
Schlueter	6500+	1.5M	6.2M	7	10	39
Sun	500+	1.98M	100k	2	3	6

Alignment with Regional and National Priorities:

The source, transport, and fate of contaminants are critical environmental issues that have impacts from local to global scales. Our established and future research has potential to transform not only the Charlotte region, but is applicable at the national and international scales.

National Scale: Emerging contaminants have been a research priority for a number of federal agencies including the NSF and EPA. As part of NSF's 10 Big Ideas, our work fits into the "Frontier of Work at the Human Technology Frontier", "Growing Convergence Research", and "Harnessing the Data Revolution". Our work integrates with these initiatives through the development of new treatment technologies (Keen, Sun, Amburgery, Poler), the interdisciplinary composition of our efforts towards identifying, modeling, and evaluating the impact of contaminants on freshwater ecosystems (Rice-Boayue, Gibas, Keen, Clinton), and the development and application of molecular technologies and genomics to answer these questions (Gibas, Munir). These themes also align with the National Academy of Engineering 14 Grand Challenges overall in the 4 cross-cutting themes (sustainability, health, security, and joy of living) and more specifically in "Restore and Improve Urban Infrastructure", "Provide Access to Clean Water" and "Engineer the Tools of Scientific Discovery".

The EPA has several funding priorities around emerging contaminants for both water quality and treatment. For example, EPA has initiated two rounds of Request for Applications in National Priorities and an additional one in the Science to Achieve Results (STAR) Program over the past three years on PFAS studies, funded 13 research teams with almost $15M total budgets. Recently the EPA also allocated $8M for research on emerging contaminants in biosolids (a useful byproduct of wastewater treatment, with potential concerns of emerging contaminant problems).

State Scale: The state government and funding agencies have also been promoting efforts focused on emerging contaminants. The NC Water Resources Research Institute's mission includes supporting research focused on urban impacts on water quality, pollutant removal, and water infrastructure.The NC General Assembly appropriated over $5M in 2018 and continuous additional funding in following years to promote statewide research efforts on studies to solve PFAS problems in NC.

Local Scale: Our research group has well-established working relationships with Charlotte Water and Charlotte-Mecklenburg Storm Water Services where we have conducted research on water treatment, water quality, and environmental restoration. Our research aligns directly UNC Charlotte's mission of urban based research and community engagement in the area of environmental and public health.

Supporting Document: Name, title, department, and potential contribution to the group:

Olya Keen	Associate Professor, Civil and Environmental Engineering	Treatment, fate, transport and sources of emerging contaminants (in particular, pharmaceuticals, pesticides and microplastics) in wastewater, drinking water and reused water
James Amburgey	Associate Professor, Civil and Environmental Engineering	Drinking water treatment and optimization, pathogen monitoring, recreational water quality and treatment
Sandra Clinton	Research Assistant Professor, Geography and Earth Sciences	Impacts of emerging contaminants (especially pharmaceuticals and microplastics) on the ecology of freshwater ecosystems
Cynthia Gibas	Professor of Bioinformatics and Genomics	Environmental metagenomics, impacts of human activity, pandemic outbreak surveillance
Mariya Munir	Assistant Professor, Civil and Environmental Engineering	Detection, removal and inactivation of emerging biological contaminants (particularly antibiotic resistance bacteria/genes) in water and wastewater systems, Wastewater based surveillance for SARCOV-2 and other potential pathogens
Jordan Poler	Professor of Chemistry	Synthesis and characterization of nanomaterials using green and environmentally-sustainable reagents and processes; fundamental studies of molecular and nanoscale systems to understand directed and self-assembly processes; design new particles and materials with higher functionality and effectiveness for water purification and energy storage
Jacelyn Rice-Boayue	Assistant Professor, Engineering Technology	Integrated modeling of emerging contaminants (especially endocrine disrupting compounds and NDMA) for water quality assessment towards public and ecosystem health
Jessica Schleueter	Associate Professor, Bioinformatics	Genomics in Neglected Crops, SARCOV 2 genome sequencing and surveillance
Mei Sun	Assistant Professor, Civil and Environmental Engineering	Occurrence, fate, transport, and treatment of emerging contaminants (especially PFAS) in various environmental matrices