Dear Friends,

I intentionally held off this report until the last day of the year to make sure there were no more misfortunes in 2020. Now I can speak with confidence that we all have survived 2020 with success. It was an unusual year, taking all of us by surprise. When the University labs and offices were locked down, I was so worried about students’ livelihoods and study. When God closes a door, he also opens a window for us. Looking back at 2020, I found it was an unfortunate year but with so many fortunate opportunities for us. The research grants we received in 2020 actually doubled that in 2019. We also published more peer-reviewed journal papers than any preceding years. Most importantly, two outstanding graduate students from my lab were awarded Ph.D. degrees and started their new careers in 2020. Moreover, as detailed in this report, our Sustainable Environment Research Laboratory (SERL) was also relocated to new spaces kindly provided by Loudoun Water for easy access to real wastewater samples and in-situ data. With such a strong research team tried and true in 2020, I am optimistic about our 2021 ahead!

Thank you all for your trust and persistence in 2020! Let’s embrace 2021 with added confidence and resolution. The world will become better because of your and my unremitting efforts!

Regards,

Zhiwu Wang
2020 was a devastating year for our society. Despite the lockdowns across the world, researchers like us are up to the challenge and ready to win the fight. With strong collaborators, transformative ideas, and supportive funding agencies, we successfully solicited $857,051 research dollars in 2020 to sustain our research effort in years to come. These funded researches will create innovative solutions to protecting the health of living organisms and improving the quality of the environment. Briefly, in collaboration with researchers from Kansas State University and Old Dominion University, we won a research grant from National Science Foundation (NSF) to develop cutting-edge technology capable of harnessing ocean protist for toxic hydrothermal liquefaction wastewater treatment. In a broader collaboration with researchers from University of Maryland, Naval Research Laboratory, Idaho National Laboratory, and quasar Energy Group, we won an even larger funding support from the Department of Energy (DOE) for the development of a novel technology to convert food waste to renewable bioplastics. Besides these federal grants, we also received grant support from new industrial sponsors such as Fairfax County and Hazen & Sawyer for the development of a partial denitrification-anammox bioprocess for saving the energy and chemicals in the course of biological nitrogen removal. Gratefully, we received continued funding support from AlexRenew, Arlington County, ICTAS, Loudoun Water, WSSC, and UOSA for continuous flow aerobic granulation, thermal hydrolysis/anaerobic digestion, biosolids management, and odor control.

New Grants in 2020 ($857,051)

- Title: Continuous Flow Aerobic Granulation Phase III study. Sponsor: Upper Occoquan Service Authority. Duration: 8/1/2020-12/31/2020
- Title: A Novel Biological Valorization of Hydrothermal Liquefaction Wastewater with Marine Protist and its Granulated Phenotype. Sponsor: National Science Foundation-PRM (2001568). Duration: 7/1/2020-6/30/2023
- Title: Effect of polymer addition on anaerobic digestion of high solids biosolids pretreated with thermohydrolysis (Phase II). Sponsor: Washington Suburban Sanitary Commission and Arlington County. Duration: 1/1/2021-12/31/2021
- Title: Sustainable urban farming system. Sponsor: Alexandria Renew Enterprises. Duration: 1/1/2021-12/31/2021
- Title: Evaluating the impact of thermal hydrolysis on dissolved organic nutrient formation at the Broad Run Water Reclamation Facility. Sponsor: Loudoun Water. Duration 1/1/2021-12/31/2021
2020 Alumni and Enrollment

While the whole world paused in 2020, we had two new Doctors of Philosophy born in our team. I can proudly call Yewei and Dian Dr. Sun and Dr. Zhang now. Right before the campus shutdown, Yewei and Dian successfully defended their dissertations. With the large number of peer-reviewed papers published by each of them in renowned international journals, I am not surprised that their degree committees unanimously approved their dissertations titled “Advanced Biofilm and Aerobic Granulation Technologies for Water and Wastewater Treatment” and “Effects of process intensification techniques on biosolids management”. Of course, only virtual commencement was provided in this special year. Hopefully, they can have opportunities to walk in doctoral gowns and have tassels flipped when the pandemic is behind us. Right after their graduation, Yewei joined Hazen & Sawyer as a Scientist, and Dian became an Engineer in Stantec. Let’s wish them the best in their continued endeavors in the field of wastewater treatment.

2020 was also a hard year for new student recruitment when so many international airlines were grounded and oversea embassies were closed. Fortunately, we have two outstanding new students joining our team to carry on our research success. Mr. Rafael Iboleon received his B.S. in Environmental Science from Virginia Tech and joined us as a M.S. student when we were shorthanded in Fall 2020. He will deepen Dr. Dian Zhang’s recalcitrant nitrogen research in the field of thermal hydrolysis pretreated anaerobic digestion. Ms. Xueyao Zhang received her B.S. from Beijing University of Civil Engineering and Architecture and her M.S. from University of Southern California in 2020. She flew to Virginia right before the new year to get ready for her Ph.D. study starting in Spring 2021. She will open up a new research direction into the domain of pure culture biogranulation.

Dr. Yewei Sun received his Ph.D. degree in May 2020
Dr. Dian Zhang received his Ph.D. degree in May 2020
Mr. Rafael (Rocky) Iboleon joined Dr. Wang’s team as an Environmental Engineering M.S. student in Fall 2020
Ms. Xueyao Zhang accepted offer to join Dr. Wang’s team in Spring 2021
**2020 Research Highlights**

**Feast/Famine conditions required for continuous flow aerobic granulation are better understood**

We successively published three papers in series in 2020 to evaluate, define, and predict the essential roles of feast and famine conditions in driving aerobic granulation and also proposed engineering guidelines for utilities to adopt for retrofitting existing tankage for sludge densification. Briefly, it was concluded in these studies that a feast/famine ratio <0.5 is required. The sludge morphology can quickly respond to the feast/famine conditions. A mathematical modeling framework was also put forward to design the number of tanks required at a given F/M ratio and influent loading for ensuring successful aerobic granulation.

DOI: [https://doi.org/10.1016/j.scitotenv.2020.144155](https://doi.org/10.1016/j.scitotenv.2020.144155)
DOI: [https://doi.org/10.1016/j.jwpe.2020.101800](https://doi.org/10.1016/j.jwpe.2020.101800)
DOI: [https://doi.org/10.1016/j.scitotenv.2020.141467](https://doi.org/10.1016/j.scitotenv.2020.141467)

**Free ammonia resistance can be developed in aerobic granular sludge cultivated in continuous upflow airlift reactors**

The extent of nitrite-oxidizing bacteria (NOB) resistance to free ammonia (FA) inhibition was quantified based on the kinetic response of NOB to various FA concentrations in the form of an uncompetitive inhibition coefficient. It was confirmed that the NOB immobilized in larger granules under longer term exposure to FA tend to become more resistant to FA. Thereby, it was concluded that NOB can develop strong resistance to FA after continuous exposure, and thus FA inhibition is not a reliable strategy to achieve partial nitritation in mainstream wastewater treatment. DOI: [https://doi.org/10.1002/wer.1440](https://doi.org/10.1002/wer.1440)

**Existing pre-pasteurization facility can be repurposed as an in-situ thermal hydrolysis pretreatment process for enhancing anaerobic digestion of municipal sludge**

This study found that existing pre-pasteurization system installed in utilities for the purpose of pathogen reduction actually functioned in a similar way as the thermal hydrolysis pretreatment being implemented across the world for anaerobic digestion (AD) process intensification. Because of the sludge biodegradability improvement by pre-pasteurization, high-rate AD such as the thermophilic AD can be subjected to extensive souring problems during startup. DOI: [https://doi.org/10.1039/D0EW00633E](https://doi.org/10.1039/D0EW00633E)

**Genetically modified plants can be harnessed for phosphorus recovery from surface runoff**

In collaboration with Dr. Glenda Gillaspy from the Biochemistry Department, a patent was filed in 2020 for a technology capable of harnessing genetically modified plants for phytoremediation via bio- or hyper-accumulation of P from specialty crop agricultural tailwater or urban runoff, reducing non-point source pollution and converting P enriched plant biomass byproducts into slow release, non-labile forms of phosphorus that can be used in agricultural or urban areas.

**Patent Serial No.: 63/106,408. Filing Date: October 28, 2020**
Since all international travel was banned in 2020, we timely resorted to the new norm, namely web-based academic exchange, for international collaboration. I personally fell in love with this new mode of ‘face-to-face’ communication not only because it saved tremendous travel time and money but also I found I can do it in pajamas without jet lag. In a certain sense, I appreciate the pandemic without which I won’t have realized so much can be accomplished with teleworking. I had the opportunity to interact with hundreds of researchers and engineers in the UK and China through invited talks delivered remotely. Although we never met in person, I was able to remotely collaborate with researchers from the University of Calgary in Canada on the publication of a new book chapter titled “Bioconversion of methane to chemicals and fuels by methane-oxidizing bacteria” in Advances in Bioenergy. My student Yewei even presented his biofiltration work through an online platform provided by “Environmental Perspectives” editorial board in Singapore. It was so nice to receive beautiful cookies made of all parties’ logos from our UK partners. I just still cannot make myself to eat them though. These are fantastic memories of our special 2020!
### 2020 Publications

#### Journal papers


#### Book chapter

#### Patent

#### Dissertations


#### Invited talks


#### Conference Oral Presentation


#### Technical Reports
1. Luo H. and Wang Z.W. (2020) Turning phosphorus pollution from digested dairy manure into a marketable product by using fungi, Submitted to Virginia Department of Agriculture and Consumer Services, Mar


With the rapid expansion of our research portfolio, the availability of wet-lab spaces, especially the ones suitable for wastewater research, has become a limiting factor constraining SERL development. This urgent lab space need became intensified in 2020 when the grants we received doubled previous year while most university facilities were shut down in the mid of the pandemic. In order to upgrade the SERL capacity, minimize the pandemic impact, and better serve the demand-oriented research needs at water industry frontiers, we moved SERL out of the Occoquan Watershed Monitoring Lab into transitional spaces before we can make our final move to a permanent space kindly provided by Loudoun Water. During this transitional phase, we also overflew many of our most needed research works into other local water reclamation facilities where we can tap in valuable resources such as laboratory, real samples, and upscaled bioreactor setup in close proximity. By placing and leveraging these in-situ research platforms, we were able to deliver high-impact real-world research beyond the reach of conventional university setup. We are confident that this laboratory expansion in 2020 will open a new era of wastewater treatment research for SERL, and SERL will soon become a leader for Industry-University collaborative research in the U.S. and even the world.

Contact:
Zhiwu (Drew) Wang, Ph.D., P.E.
Department of Civil and Environmental Engineering, Virginia Tech
44961 Loudoun Water Way, Ashburn VA 20147
Office: (571) 271-1757
Email: wzw@vt.edu
Web: www.water.cee.vt.edu