



My 2022 selfie

2022 Highlights:

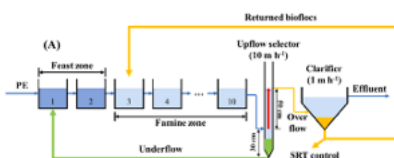
- **\$1,008,675 grants**
- **5 Awards**
- **2 Graduation**
- **1 Enrollment**
- **7 New Projects**
- **44 Publications**
- **3,227 ft² new lab**
- **Wonderful Moments**



WILEY



Cover page of WER Journal



Continuous flow aerobic granulation

Dear Friends,

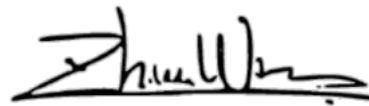
To my team, 2022 is a year of freedom and transition. The lingering COVID-19 pandemic was finally behind us in this year. The lab space issue that has limited our development for many years was finally resolved by joining the Department of Biological Systems Engineering (BSE) at Virginia Tech. Unprecedented scale of funding support was also received to unleash our potential research capacity. Within this year, we visited 7 conferences and in-person presented 31 talks and 8 posters across the U.S. The year 2022 marked the beginning of a new era of Wang's Sustainable Environment Research Laboratory at Virginia Tech.

Leveraging the 3,227 square feet high-bay pilot lab newly provided by BSE in Human and Agricultural Biosciences Building 1 (HABB1) on the main campus of Virginia Tech, Wang's team was able to win a \$2.4M research grant support from the U.S. Department of Agriculture (USDA) for pilot demonstration of our technology capable of converting organic wastes into marketable bioplastics that offers an affordable solution to solving both the food waste and plastic pollution in one technology. This upscaled study is built on the preliminary data collected by my Ph.D. candidate, Ms. Xueyao Zhang, during the pandemic, which just shows our team's unstoppable commitment to the environmental sustainability research.

2022 was also a rewarding year to our team. a Ph.D. student and a M.S. student have successfully defended their dissertation and theses and joined their dream jobs upon graduation. Besides, almost all student awards issued by the WaterJam conference were harvested by my team members. In collaboration with Dr. Feras Batarseh, we also won a 1st place award in the WEFTEC conference. Our success has been reported by both local and international media, giving us unprecedented national and international exposures. For a more detailed summary of our fruitful 2022, please refer to the content of this annual report.

Regards,

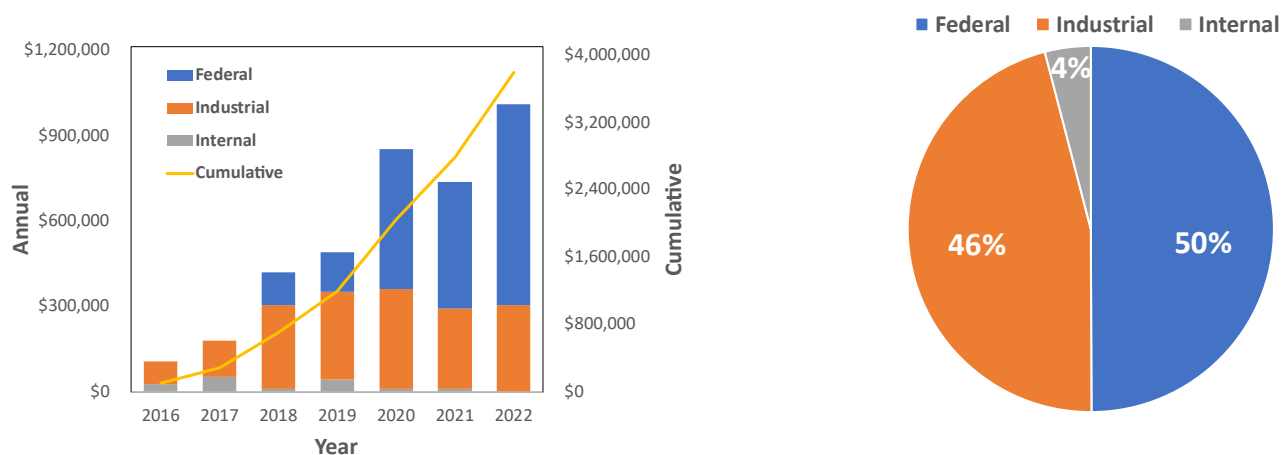
Zhiwu (Drew) Wang




We got lab spaces!

2022 New Research Grants

In 2022, a record high of \$1,008,675 share of research grants had been received by Dr. Wang's lab to support the research activities of all his team members, maintaining an increasing trend of annual funding income continued in the past seven years. Again, the composition of these research grants stroked a perfect balance between the federal and industrial supports, namely 46% from industrial sponsors and 50% from federal governments, providing funding security to ensure the stable operation of our research activities in the years to come. The \$2.4M USDA pilot demonstration project led by Dr. Wang team was built on the success of his ongoing DOE grant for the development of a biotechnology that can valorize food wastes for bioplastic product biomanufacturing. The goal is to prove its economy viability and measure its environmental impact. This three-year national collaborative project led by Virginia Tech will be performed in cooperation with researchers from University of Missouri, Iowa State University, and quasar Energy Group. Meanwhile, we also for the first time received a research funding from the Department of Defense (DOD) for developing a cutting-edge technology to destroy PFAS brought with the biosolids during land application. Besides these federal grants, continued funding support from our industrial partners such as Upper Occoquan Service Authority (UOSA), Washington Suburban Sanitary Commission, Arlington County, and AlexRenew Enterprise kept us digging deeper into the fields of bioprocess intensification, recalcitrant nitrogen removal, thermal hydrolysis pretreatment enhanced anaerobic digestion, and mainstream partial denitrification anammox. It is these multiple years of persistent funding supports from our industrial partners that have offered us opportunities to evaluate the real-world benefits and challenges those utilities may face upon the installation of these game-changing technologies. We are so blessed with these diversified funding sources from both federal and industrial sponsors to ensure sufficient financial support of our graduate students' research and education. Their successful career development is our ultimate goal!



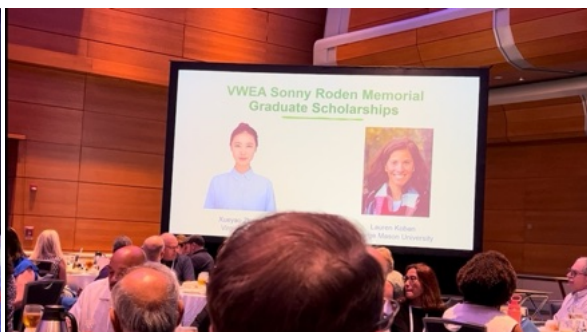
New Grants in 2022 (\$1,008,675)

- Zhiwu Wang (PI) \$663,837 01/2023- 12/2025, Pilot demonstration of a modular bioprocess system for manufacturing consumer bioplastic products from food wastes, funded by U.S. Department of Agriculture, along with Young Kim and Haibo Huang from Virginia Tech, Caixia Wan from University of Missouri Columbia, Mark Wright from Iowa State University, and Yebo Li, Xumeng Ge from quasar Energy Group, \$2,400,874 in total
- Zhiwu Wang (Site-PI) \$40,000 05/2023 – 04/2024, Low-temperature Catalytic Thermal Treatment and Microwave, funded by Department of Defense, along with Fen Xiao (PI) at University of Missouri Columbia and Wen Zhang at New Jersey Institute of Technology, \$200,000 in total
- Zhiwu Wang (PI) \$55,000 09/2022 – 03/2023, Digestibility, Dewaterability, and Drying Property Evaluation for Morris Forman Biosolids Processing Solution, funded by Louisville MSD
- Zhiwu Wang (PI) \$33,833 01/2022-5/2022, Potential impact of the recalcitrant dissolved organic nitrogen formation as a result of the thermal hydrolysis on the Loudoun Water reclamation plant operation, funded by Loudoun Water
- CAWRI (PI) \$50,000 01/2022-12/2022, Partial denitrification anammox feasibility study, funded by AlexRenew Enterprise
- CAWRI (PI) \$65,000 01/2023-12/2023, Recalcitrant Nitrogen Control with Aluminum Addition Prior to Belt Filter Press Dewatering of Thermal Hydrolysis Pretreatment-Enhanced Anaerobic Digester Effluent, funded by Washington Suburban Sanitary Commission
- CAWRI (PI) \$50,000 01/2023-12/2023, Pilot scale understanding of the dewaterability of sludge to be produced from thermal hydrolysis and mesophilic anaerobic digestion at Arlington Water Pollution Control Plant, funded by Arlington County

2022 Awards, Enrollment, and Graduation



Virginia Tech team won 1st place in 2022 AWWA Student Water Challenge



Ms. Xueyao Zhang won 2022 VWEA Sonny Roden Graduate Scholarship

In 2022 WaterJam conference, students from Virginia Tech won all student awards across the board. The Virginia Tech team made of **Ms. Xueyao Zhang**, **Mr. Jiefu Wang**, Ms. Amanda Darling, Mr. Ben Winter, and Ms. Katie Scott won the 1st place in 2022 AWWA Student Water Challenge competition after hours of design and presentation. This win was meaningful as it brought the trophy back to Virginia Tech after several years losing it during the pandemic.

Meanwhile, **Ms. Xueyao Zhang** and **Mr. Hao Luo** also won the 2022 WaterJAM YP/Student "Fresh Ideas" Poster Contests for both water and wastewater sectors. These are the only two awards offered in Poster Contests. In addition, **Ms. Xueyao Zhang** also won 2022 VWEA Sonny Roden Graduate Scholarship. That being said, **Ms. Xueyao Zhang** won everything single award that she can possibly win in 2022 WaterJam conference. Fantastic job!

2022 was a year of transition between our old and new members. **Dr. Zhaohui An** successfully defended his dissertation titled "**Mechanistic understanding of biogranulation for continuous flow wastewater treatment and organic waste valorization**". He first-authored several journal papers and co-authored another three plus a book chapter. Most of these publications were made during the pandemic. His dissertation defense committee highly praised his productivity and unanimously approved his graduation with applause. **Mr. Tyler Kisling** also successfully defended his M.S. thesis titled "**Characterizing Kinetic Shifts in Nitrifying, Denitrifying, and Phosphorus Removing Biomass Adapting to Low DO**". He joined Virginia Tech during the pandemic and did his M.S. research onsite in Hampton Road Sanitary District using real wastewater. It was this real-world research experience that easily brought him an industrial job upon graduation.

Meanwhile, **Mr. Yitao Li** joined Dr. Wang's team as a Ph.D. student in Fall 2022. He received his B.S. in Sustainable Urban Environments and M.S. in Environmental Engineering from New York University in 2021. He was an environmental remediation engineer at Wood E&IS (now part of WSP Global) before starting his Ph.D. study at Virginia Tech. Yitao's research will focus on the intensification of biological processes during wastewater sludge treatment. He will tackle research problems involving CAMBI thermal hydrolysis pretreatment, anaerobic digestion, dewatering, thermal drying, and side-stream nutrient control.



Mr. Hao Luo won wastewater award in 2022 WaterJAM YP/Student "Fresh Ideas" Poster Contest



Ms. Xueyao Zhang won water award in 2022 WaterJAM YP/Student "Fresh Ideas" Poster Contest

Recipients	Awards	Amount
Xueyao Zhang, Jiefu Wang, etc.	2022 AWWA Student Water Challenge (1st place)	\$1,200 total
Xueyao Zhang	2022 VWEA Sonny Roden Graduate Scholarship	\$2,500
Xueyao Zhang	2022 WaterJAM YP/Student "Fresh Ideas" Poster Contest (Water winner)	\$1,000
Hao Luo	2022 WaterJAM YP/Student "Fresh Ideas" Poster Contest (Wastewater winner)	\$1,000
Feras Batarseh, Zhiwu Wang etc.	2022 Intelligent Water Systems (IWS) Competition in WEFTEC (1st place)	\$10,000



Mr. Yitao Li joined us as a Ph.D. student. He got his B.S. and M.S. from New York University.



Mr. Tyler Kisling graduated with a M.S. degree.



Dr. Zhaohui An graduate with a Ph.D. degree.

He was an environmental remediation engineer at Wood E&IS (now part of WSP Global) before starting his Ph.D. study at Virginia Tech. Yitao's research will focus on the intensification of biological processes during wastewater sludge treatment. He will tackle research problems involving CAMBI thermal hydrolysis pretreatment, anaerobic digestion, dewatering, thermal drying, and side-stream nutrient control.

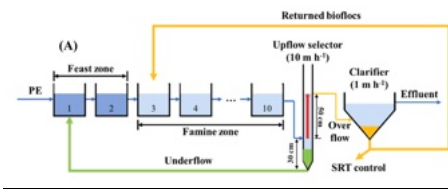
2022 Research Highlights



VFA recovery: Ms. Xueyao Zhang discovered that hydrophobic deep eutectic solvents can be used for anhydrous Volatile Fatty Acids (VFA) extraction. Integrating it with omniphobic membrane allows continuous recovery of VFA from anaerobic digesters.



PDNA research: Mr. Jiefu Wang wrapped up his partial denitrification anammox (PDNA) research conducted in a tertiary MBBR in Noman M. Cole Jr., Pollution Control Plant. He concluded that methanol is a better carbon source over glycerol for its cost and different partial denitrification mechanism.



Biological v.s. Physical selection:

Traditionally, aerobic granulation was believed to be driven by physical selection in terms of settling velocity. **Dr. Zhaohui An** for the first time experimentally demonstrated that biological selection in terms of feast/famine alternation can be superimposed on the top of physical selection for faster aerobic granulation.



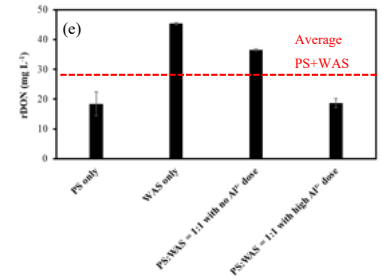
Digestate centrate reuse: The dry poultry little anaerobic digestion requires large volume of dilution water addition. Ms. Xueyao Zhang found that using forward osmosis membrane can recycle the effluent digestate centrate to close the water loop.



Integration of EBPR, Endogenous denitrification, and PDNA: Mr. Jiefu Wang wrapped up his water research foundation project demonstrating how to integrate EBPR, endogenous denitrification, and PDNA into one system for maximum reduction of external carbon addition in the course of wastewater treatment.



rDON production: Mr. Rafael Iboleon wrapped up his recalcitrant dissolved organic nitrogen (rDON) research in Loudoun Water. Based on his research, the utility decided not to use thermal hydrolysis in that the rDON produced from it may exceed the permissible total nitrogen level in the discharge

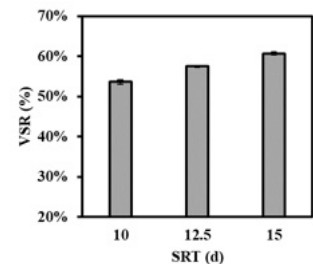


rDON control: Mr. Hao Luo's research showed that adding alum in the dewatering centrifuge can significantly reduce rDON level in centrate along with phosphorus removal and dewaterability enhancement.



Turn WRRFs into biorefineries:

Mr. Jiefu Wang's ideas about the value-added products that can be recovered from water resource recovery facilities (WRRFs) was cited as the cover page in Water Environment Research Journal.



SRT effect on THP-AD: Mr. Hao Luo found the SRT (10 to 15 days) of thermal hydrolysis-enhanced anaerobic digestion positively contributed to volatile solids reduction and cake dewaterability but not the methane yield.

2022 New Lab Spaces

BSE kindly offered Wang's team a 3,227 square feet high-bay pilot lab which is housed in a recently constructed, collaboration-friendly Human and Agricultural Biosciences Building 1 (HABB1) on the main campus of Virginia Tech. HABB1 houses approximately 101,500 gross square feet of research facilities for the departments of BSE and Food Sciences Technology. Wang's high-bay pilot lab is located on the first floor of HABB1 to meet the research needs of students, researchers, and the industrial partners. This pilot lab is a flexible processing space where equipment can be quickly installed and made ready for various types of pilot scale research activities. The pilot space features three walk-in refrigerators (two 4 °C and one -20 °C) for storing large quantity of feedstocks such as wastewater, biosolids, and food wastes for long-term pilot scale bioconversion study. A venting hood is on 24/7 for confining odour by maintaining a lower than hallway air pressure. Adjacent to the pilot lab is a large autoclave that can



101,500 square feet HABB1 building

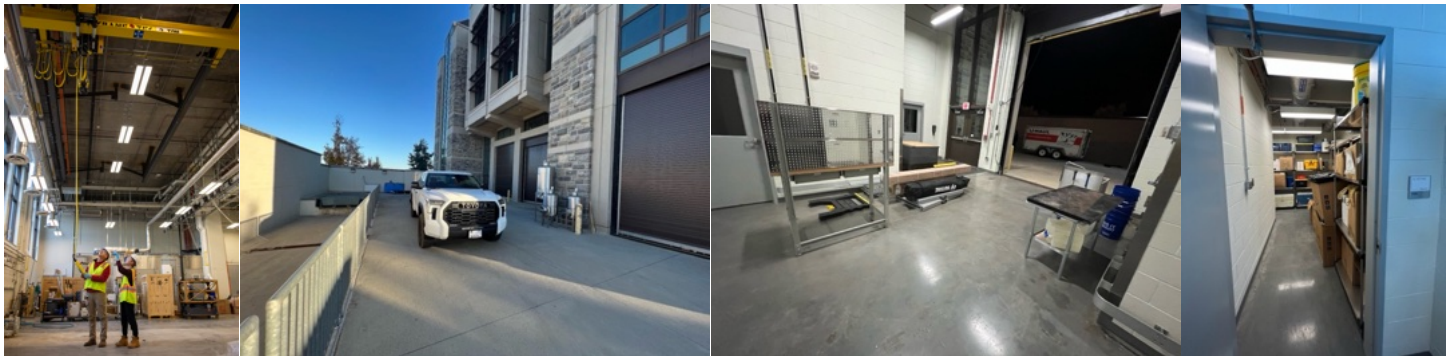


3,227 square feet high-bay pilot lab

Two 4 °C and one -20 °C

Hood and quick utility connections

accommodate large device sterilization needs. Quick connect utilities, e.g., clean steam, hot and chill water, CO₂, vacuum, compressed air, domestic water, DI water, floor drain, and distributed 208V 3-phase and 460V 3-phase power, are move-in ready. A dedicated HVAC system and floor drains are integrated to ensure optimal temperatures and cleanliness of the



Heavy duty lifting crane

Loading dock right outside the pilot lab

Garage door between loading dock and pilot lab

Storage room

space. Safety showers and eye-wash stations are distributed through the facility. A heavy-duty crane is ready on the ceiling for moving large equipment to any spot in the pilot lab. The loading dock and garage door are right outside the pilot lab for easy loading and unloading heavy items on and from truck either by floor rolling or forklifting. There is a storage room attached to the pilot lab for storing items that don't have an immediate use. It is indeed rare to see high-bay pilot space like this in a university setup. This new resource provided by BSE will allow Wang's team to develop applicable biotechnologies that are useful to stakeholders. Besides the aforementioned pilot lab, BSE also kindly provided another analytical lab space (344 square feet) equipped with a biosafety cabinet, a fume hood, a sink, autoclaves, DI water system, and bench spaces for analytical activities.



Analytical lab located within Seitz Hall

2022 Publications

Journal papers

1. Sun Y.P., Luo H., Iboleona R., Wang Z.W. (2022) Fate of Antibiotic Resistance Genes and Class I Integrons during Sludge Treatment using Pilot-scale Anaerobic Digestion with Thermal Hydrolysis Pretreatment, Bioresource Technology, 128043 DOI: <https://doi.org/10.1016/j.biortech.2022.128043>
2. Wang J.F., Sun Y.P., Zhang D., Broderick T., Strawn M., Santha H., Pallansch K., Denies A., Wang Z.W. (2022) Unblocking the rate-limiting step of the municipal sludge anaerobic digestion, Water Environment Research, e10793 DOI: <https://doi.org/10.1002/wer.10793>
3. Wang J.F., Sun Y.P., Xia K., Deines A., Cooper R., Pallansch K., Wang Z.W. (2022) Pivotal Role of Urban Wastewater Resource Recovery Facility in Urban Agriculture, Water Environment Research, 94(6):e10743. DOI: <https://doi.org/10.1002/wer.10743> (Cover Page)

Book Chapters

4. Luo H., Sun Y.P., Yin Y., Wang Z.W. (2022) Odor generation, identification, and control during anaerobic digestion of organic solid wastes. In: "Advances in Bioenergy, volume 7", Elsevier Inc., Cambridge, MA. DOI: <https://doi.org/10.1016/bs.aibe.2022.04.002>

Dissertations

5. Zhaohui An (2022) Mechanistic understanding of biogranulation for continuous flow wastewater treatment and organic waste valorization <https://vtechworks.lib.vt.edu/handle/10919/109709>

Thesis

6. Tyler Houston Kisling (2022) Characterizing Kinetic Shifts in Nitrifying, Denitrifying, and Phosphorus Removing Biomass Adapting to Low DO, M.S. Thesis, Blacksburg, Virginia Tech, USA <https://vtechworks.lib.vt.edu/items/52e8483a-2d5e-4a92-9dd2-0460e1146d8e>

Conference Oral Presentations

7. An Z.H., Angelotti B., Brooks M., Wiloughby A., Wang Z.W. (2022) Intensification of a full-scale MLE process without anaerobic zones. WEFTEC 2022, October 10-12, New Orleans, LA
8. Wang J.F., Sun Y.W., Khunjar W., Pace G., McGrath M., Ali M., Chitrakar S., (2022) Partial denitrification with glycerol as external carbon in moving bed biofilm reactors applied for anaerobic ammonia oxidation of low nitrogen concentration secondary effluent. WEFTEC 2022, October 10-12, New Orleans, LA
9. An Z.H., Angelotti B., Brooks M., Bott C., Wang Z.W. (2022) Applying a Continuous Upflow Selector with Feast/Famine Selection for a Smooth Startup of Continuous Flow Aerobic Granulation Reactors without Performance Interruption. WEFTEC 2022, October 10-12, New Orleans, LA (Invited Talk)
10. Sun Y.W., Wang J.F., Khunjar W., Pace G., McGrath M., Ali M., Chitrakar S., (2022) Polishing Tertiary Effluent Nitrogen Via The Synergy Between Methanol-Driven Partial Denitrification and Anaerobic Ammonia Oxidation In Moving Bed Biofilm Reactors. WEFTEC 2022, October 10-12, New Orleans, LA
11. Iboleona R., Khunjar W., Pathak A., Sveum K., Schmitz B., Curtis B., Wang Z.W. (2022) Effects of thermal hydrolysis temperature and anaerobic digester solids retention time on the formation of recalcitrant nutrient species. WaterJAM 2022, September 12-15, Virginia Beach, VA
12. Sun Y.W., Wang J.F., Khunjar W., Pace G., McGrath M., Ali M., Chitrakar S., (2022) Combination of EBPR, partial Nitrification/Denitrification and anammox to achieve TIN < 3 mg/L in mainstream flows subjected to adverse weather events. WaterJAM 2022, September 12-15, Virginia Beach, VA

13. An Z.H., Angelotti B., Brooks M., Wang Z.W. (2022) Intensification of a full-scale MLE process without anaerobic zones. WaterJAM 2022, September 12-15, Virginia Beach, VA
14. Wang J.F., Sun Y.W., Khunjar W., Pace G., McGrath M., Ali M., Chitrakar S., (2022) Comparison between methanol- and glycerol-driven partial denitrification and anammox for low concentration nitrogen polishing in moving bed biofilm reactors under real-time feed forward control. WaterJAM 2022, September 12-15, Virginia Beach, VA
15. Iboleona R., Khunjar W., Pathak A., Sveum K., Schmitz B., Curtis B., Wang Z.W. (2022) Evaluating the Evolution of Recalcitrant Nutrient Formation in Thermal Hydrolysis and Anaerobic Digestion of Municipal Sludge. 2022 ASABE Annual International Meeting. July 17-20, Houston, TX, USA
16. Luo H., Taylor M., Nguyen C., Keith T., Wang Z.W. (2022) Biosolids odor control through sludge holding tank aeration. 2022 ASABE Annual International Meeting. July 17-20, Houston, TX, USA
17. Zhang X.Y., Zhang Y.X., Qing W.H., Shi J., Zhang W., Wang Z.W. (2022) Deep eutectic solvent-driven volatile fatty acid recovery from arrested anaerobic digesters in membrane contactor. 2022 ASABE Annual International Meeting. July 17-20, Houston, TX, USA
18. Zhang X.Y., Hassanein A., Amradi N., Lansing S. Wang Z.W. (2022) Potential of polyhydroxyalkanoate production from food waste by *Haloferax mediterranei*. 2022 ASABE Annual International Meeting. July 17-20, Houston, TX, USA
19. Zhang X.Y., Zhu J., Wu X., Wang Z.W. (2022) A comparison of forward osmosis and membrane distillation for water sustainable anaerobic digestion of poultry litter. 2022 ASABE Annual International Meeting. July 17-20, Houston, TX, USA
20. Sun Y.P. and Wang Z.W. (2022) Effects of thermal hydrolysis on the fate of antibiotic resistance genes in the course of anaerobic digestion of municipal sludge. 2022 AEESP Conference, June 28-30, St. Louis, MO
21. Iboleona R., Khunjar W., Pathak A., Sveum K., Schmitz B., Curtis B., Wang Z.W. (2022) Understanding Recalcitrant Nutrient Formation in Thermal Hydrolysis Pretreatment and Anaerobic Digestion of Municipal Sludge. 2022 AEESP Conference, June 28-30, St. Louis, MO
22. An Z., Jin Q., Zhang X.Y., Huang H.B., Wang Z.W. (2022) Single Culture *Clostridium Beijerinckii* Granules Cultivated For Biofuel Production. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA
23. Luo H., Taylor M., Nguyen C., Keith T., Wang Z.W. (2022) Effects of primary sludge blending and aluminum addition on anaerobic digestion of alum-laden waste activated sludge. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA
24. Iboleona R., Khunjar W., Pathak A., Sveum K., Schmitz B., Curtis B., Wang Z.W. (2022) Quantifying The Formation Of Recalcitrant Nutrient Species In Thermal Hydrolysis Pretreatment And Anaerobic Digestion Of Municipal Sludge. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA
25. Zhang X.Y., Zhang Y.X., Qing W.H., Shi J., Zhang W., Wang Z.W. (2022) Low Energy Anhydrous Volatile Fatty Acid Recovery From Arrested Anaerobic Digesters Through A Membrane Contractor Driven By A Deep Eutectic Solvent. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA
26. Zhang X.Y., Zhu J., Wu X., Wang Z.W. (2022) Application Of Low-energy Membrane Technologies For Closing The Water Loop Of Poultry Litter Anaerobic Digestion. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA

27. Hong S., Winkler M., Wang Z.W., Goel R. (2022) Integrating Partial Denitrification (PD), Enhanced Biological Phosphorus Removal (EBPR) and Anammox in a Single Stage Process Bioreactor. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 28. Wang J.F., Khunjar W., Pace G., Pathak A., McGrath M., Ali M., Sun Y.W. (2022) R-Strategy Taken by Glycerol-Driven Partial Denitrification in Moving Bed Biofilm Reactors Applied for Anaerobic Ammonia Oxidation of Tertiary Effluent. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 29. Wang J.F., Khunjar W., Pace G., Pathak A., McGrath M., Ali M., Sun Y.W. (2022) Polishing Tertiary Effluent Nitrogen via the Synergy Between Methanol-Driven Partial Denitrification and Anaerobic Ammonia Oxidation in Moving Bed Biofilm Reactors. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 30. Sun Y.W., Wang J.F., Khunjar W., Winkler M., Goel R., Wang Z.W. (2022) Smart System Automation of Modified 4-Stage Bardenpho Process by Incorporating Partial Nitrification/Denitrification/Anammox (Pdna/PANDA) for Mainstream Municipal Wastewater Treatment with Frequent Storm-Related Fluctuation. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 31. An Z., Bott C.B., Angelotti B., Brooks M., Wang Z.W. (2022) Coupling a Continuous upflow Selector with feast/famine selection for a smooth startup of continuous flow aerobic granulation reactors without performance interruption. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 32. Zhang X.Y., Zhang Y.X., Qing W.H., Shi J., Zhang W., Wang Z.W. (2022) Potential of Using Hydrophobic Deep Eutectic Solvents as a Low Energy Extractant for Anhydrous Volatile Fatty Acid Recovery from Arrested Anaerobic Digesters for Easy Downstream Conversion and Utilization. WEF Innovations in Process Engineering Conference 2022, June 21-23, Miami, Florida, USA
 33. Khunjar W., Sun Y.W., Pace G., Young A., McGrath M., Ali M., Chitrakar S., Marcos R., Wang J.F., Wang Z.W., De Los Reyes F., Azziz T. (2022) Application of partial nitrification, denitrification-anaerobic ammonia oxidation for nitrogen removal at WRRFs. The 17th IWA Leading Edge Conference on Water and Wastewater Technologies, March 28-April 1, Reno, Nevada, USA
 34. Iboleona R., Khunjar W., Pathak A., Sveum K., Schmitz B., Curtis B., Wang Z.W. (2022) Effects of Recalcitrant Nutrient Formation in Thermal Hydrolysis Pretreatment and Anaerobic Digestion of Municipal Sludge at Loudoun Water's Broad Run Water Reclamation Facility. WEF Residuals & Biosolids Conference 2022, May 24-27, Columbus. OH, USA
 35. Luo H., Taylor, M., Nguyen C., Strawn M., Racey L., Balchunas B., Moline C., Hentz L., Wang Z.W. (2022) Effects of Total Solids Contents, Solids Retention Times, and Primary/Wasted Sludge Blending on the Digestibility of Thermal Hydrolyzed Municipal Sludge. WEF Residuals & Biosolids Conference 2022, May 24-27, Columbus. OH, USA
 36. Wang Z.W. (2022) MBBR-based PANDA/PdNA Pilot at the Noman M. Cole Pollution Control Plant. 2022 VWEA Education Seminar, May 5th, Richmond, VA, USA (**Invited Talk**)
 37. Wang Z.W. (2022) Demand-Oriented Bioprocessing for Nurturing a Virtuous Circle of Research and Innovation. April 25th, New Jersey Institute of Technology, Newark, NJ, USA (**Invited Talk**)
 38. Zhang X.Y., Zhu J., Wu X., Wang Z.W. (2022) Water Recirculation in a Sustainable Poultry Litter Treatment System via Membrane Process. WaterJAM 2022, September 12-15, Virginia Beach, VA (**First Place Award in water sector**)
 39. Luo H., Nguyen C., Taylor M., Wang Z.W. (2022) Effects of primary sludge blending and aluminum addition on anaerobic digestion of alum-laden waste activated sludge. WaterJAM 2022, September 12-15, Virginia Beach, VA (**First Place Award in wastewater sector**)
 40. Wang J.F., Sun Y.W., Khunjar W., Li B., Winkler M.K., Goel R., Wang Z.W. (2022) An integration of EBPR, endogenous denitrification, and partial nitrification/denitrification/anammox (PANDA) for cost-effective nutrient removal. WaterJAM 2022, September 12-15, Virginia Beach, VA
 41. Li Y.T., Luo H., Strawn M., Racey L., Haile F., Balchunas B., Moline C., Hentz L., Higgins M., Wang Z.W., (2022) Effect of Solids Retention Times on the Performance of Pilot-scale Thermal Hydrolysis Pretreated Mesophilic Anaerobic Digestion System. WaterJAM 2022, September 12-15, Virginia Beach, VA
 42. Zhang X.Y., Zhang Y.X., Qing W.H., Shi J., Zhang W., Wang Z.W. (2022) Anhydrous volatile fatty acid recovery from arrested anaerobic digesters by deep eutectic solvents through membrane contactors. 2022 AEESP Conference, June 28-30, St. Louis, MO
 43. Luo H., Taylor M., Nguyen C., Keith T., Wang Z.W. (2022) Effect of oxidation reduction potential in the sludge holding tanks on odor emission from dewatered biosolids. 2022 AEESP Conference, June 28-30, St. Louis, MO
 44. An Z., Bott C.B., Angelotti B., Brooks M., Wang Z.W. (2022) An integration of upflow selection and feast/famine selection for continuous flow aerobic granulation without startup performance interruption. 2022 AEESP Conference, June 28-30, St. Louis, MO
 45. Wang J.F., Khunjar W., Pace G., Pathak A., McGrath M., Ali M., Sun Y.W. (2022) Low concentration nitrogen polishing via methanol- and glycerol-driven partial denitrification and anaerobic ammonia oxidation in moving bed biofilm reactors under real-time feed forward control in real tertiary wastewater. 2022 AEESP Conference, June 28-30, St. Louis, MO
- Project Reports**
46. Luo H. and Wang J.W. (2022) Effects of primary sludge blending and aluminum addition on anaerobic digestion of alum-laden waste activated sludge. Submitted to Washington Suburban Sanitary Commission, Nov 1
 47. Luo H. and Wang Z.W. (2022) Effect of solids retention times on the performance of thermal hydrolysis pretreated mesophilic anaerobic digestion system. Submitted to Arlington County Water Pollution Control Plant, Sep 3
 48. Wang J.F., An Z.H., Wang Z.W. (2022) Effects of NRCY and its location change on the start-up of physical and biological selection pressure driven sludge densification for biological nitrogen removal in plug-flow bioreactors fed with real domestic wastewater. Submitted to Upper Occoquan Service Authority, Oct 10
 49. Wang J.F., Sun Y.W., Khunjar W., Wang Z.W. (2022) Nitrogen Reduction Technology Solutions for Ocean Discharges: EBPR, Endogenous Denitrification, and PANDA. Submitted to Water Research Foundation (WRF 5117), Aug 20
<https://www.waterrf.org/resource/nitrogen-reduction-technology-solutions-ocean-discharges-cbpr-endogenous-denitrification>
 50. Pace G., Sun Y.W., Wang J.F., Khunjar W., Carroll J., and Wang Z.W. (2022) NCPCP Primary and Secondary Infrastructure Reinvestment and Optimization – MBBR PANDA/PdNA Benchtop-Scale Pilot. Submitted to Noman Cole Jr. Pollution Control Plant, Fairfax County, Jan 1
- Conference Poster Presentation**
38. Zhang X.Y., Zhu J., Wu X., Wang Z.W. (2022) Water Recirculation in a Sustainable Poultry Litter Treatment System

2022 Wonderful Moments

It feels so good to meet people in person again. For the past two year, we had to keep social distance. In the mid 2022, we finally had the freedom to visit collaborators, sponsors, and friends to exchange our ideas.



Utility members met in AlexRenew for Water Research and Innovation (CAWRI) annual progress review



Researchers, sponsors, and stakeholders met in University of Washington for developing next generation nitrogen removal technologies



Pig roast hosted by BSE's the chapter of American Society of Agricultural and Biological Engineers (ASABE)



Business lunch with Water Research Foundation managers and panelists



Members discussing CAWRI's future direction



Dr. Wang giving his opinions about the importance of applied research



Farewell party for Dr. Zhaohui An right after his graduation.



Seafood celebrating WaterJam success



Dr. Wang's team going for field sampling in a truck hauling a trailer



Attending tri-state ASABE section meeting in NC state.



Dr. Wang's team sampling municipal solid wastes in a local landfill



We won 1st place in 2022 Intelligent Water Systems (IWS) Competition