



2019 Research at SERL

The Charles E. Via, Jr. Department of Civil and Environmental Engineering
National Capital Region (NCR) Campus



2019 Highlights:

- Awards
- Grants
- Innovations
- Publications
- Enrollments
- Sponsors

Dear Friends,

The Sustainable Environment Research Laboratory (SERL) enjoyed great success at all level during 2019 as this annual report details. The breadth and depth of our research continue to expand with new research directions, new funding sources, and all of the research activities of our talented graduate students.

Undoubtedly the biggest highlights of the year were the numerous professional awards and high impact publications that SERL students have accomplished, indicating that their contribution to the wastewater research and innovation was recognized in the U.S. and across the world. SERL would not have had such a successful year without the strong funding support from our new and continued sponsors such as AlexRenew, Arlington County, HRSD, ICTAS, Loudoun Water, UOSA, USDA, VAC, WSSC, and 4-VA.

Thank you for helping us make 2019 a landmark year of growth and innovation for the wastewater research. With your support, we will achieve even greater success in 2020 ahead!

Regards,

Zhiwu Wang



New students, projects, & sponsors in 2019

2019 is a bumper year for SERL, which also means 2020 is going to be a super busy year for SERL. We feel grateful for receiving unprecedented funding support from new sponsors such as Loudoun Water, ICTAS, and WSSC along with the continued support from 4-VA, AlexRenew, Arlington County, UOSA, USDA, VAC, and HRSD. The new research directions we are going to explore in 2020 include: i) understanding PFAS fate and destruction; ii) harnessing genetically modified crops for phosphorus removal of surface runoff; iii) recalcitrant organic nitrogen control for thermal hydrolysis; and iv) molecular mechanism of aerobic granulation. In order to successfully accomplish these demanding research goals, SERL enrolled following three talented young men and are still recruiting more prospective graduate students.



Mr. Hao Luo started his Ph.D. candidacy in SERL in Spring 2019.



Mr. Jeffrey Nicholson joined SERL as a PhD student in Summer 2019.



Mr. Jiefu Wang started his Ph.D. candidacy in SERL in Fall 2019.

New Grants in 2019 (\$484,656)

- Innovative biological and physicochemical removal of Per- and Polyfluoroalkyl Substances (PFAS) from Wastewater – A platform for building long-term partnerships between VT and NC A&T in Water Treatment Technologies, 12/1/2019-6/30/2021
- Continuous flow aerobic granulation in real domestic wastewater – Phase 2 Study, 5/1/2019-7/31/2020
- Molecular biology methods for understanding aerobic granulation in wastewater treatment systems, 7/1/19-6/30/20
- A test of method to maintain the uninterrupted high ammonia removal efficiency during the bioreactor startup for continuous flow aerobic granulation in real municipal wastewater, 6/1/19-5/31/20
- Development of a sustainable treatment system for poultry litter with maximum value recovery, 7/1/19-6/30/22
- A transdisciplinary approach to phosphorus reclamation, 7/1/19 – 6/30/21
- Identification of the source and cause of the biosolids odor emission in western branch water resource recovery facility, 9/1/2019-5/31/2020
- Potential impact of the recalcitrant dissolved organic nitrogen formation as a result of the thermal hydrolysis on the Loudoun Water reclamation plant operation, 5/1/2019 - 12/31/2020
- Effect of thermal hydrolysis pretreatment on high solids anaerobic digestion, 7/1/19-6/30/20
- Effect of Class A biosolids production on the fate and transport of PFAS on farmland, 7/1/19-5/30/20



Recognition in 2019

1	Yewei Sun	Ph.D.	Grizzard Fellowship Award	Nov 12, 2019	\$2,500
2	Yewei Sun	Ph.D.	WaterJam 1 st Place Poster Award	Sep 12, 2019	\$1,000
3	Yewei Sun	Ph.D.	VWEA Sonny Roden Graduate Scholarship	Sep 10, 2019	\$2,500
4	Yewei Sun	Ph.D.	Featured talk in 2019 WEFTEC conference	Sep 24, 2019	
5	Zhaohui An	Ph.D.	Sussman Foundation Internship Award	Mar 19, 2019	\$6,825
6	Timothy Robert Kent	M.S.	AEESP Master's Thesis Award	May 16, 2019	\$1,000
			Total		\$13,825



Yewei Sun is indeed the champion awardee of 2019. He received three awards and one featured talk in a national conference. *Left & Middle*: Yewei was awarded the VWEA Sonny Roden Graduate Scholarship; *Right*: Yewei received a 1st place award in the WaterJam poster competition, which will also cover his travel to AWWA-ACE conference.

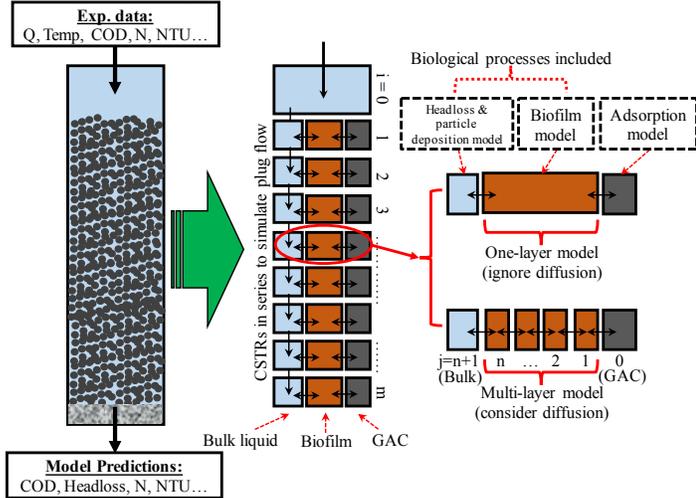


Timothy Robert Kent only spent a little bit more than one year in my lab during which he published research papers in two high impact journals, namely *Biotechnology Advances* (12.831) and *Environment International* (7.943). Hence, I was not surprised to see him receiving the AEESP Thesis Award (*left*) even though himself considered it as a long shot. We appreciate HRSD's support of Tim's research and study. Notably, VT swept three out of the four best dissertation and thesis awards in 2019 AEESP conference. See Dr. Amy Prudent and Dr. Peter Vikesland's teams (*right*).



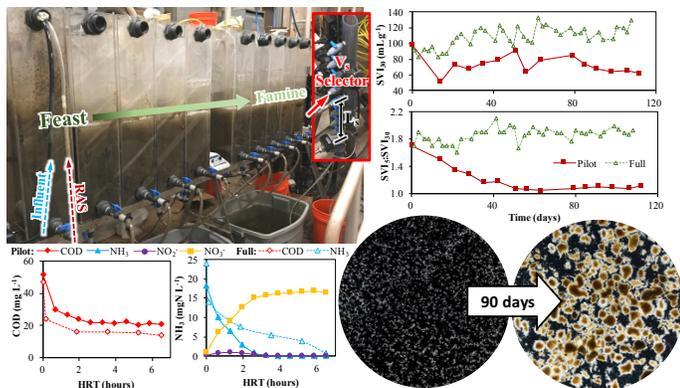
Left: Yewei Sun gave his featured talk in 2019 WEFTEC; *Middle*: For Yewei's contribution to the process intensification research in UOSA for protection of Occoquan Lake, he received 2019 Grizzard Fellowship Award. We all miss Dr. Grizzard so much; *Right*: Zhaohui An received 2019 Sussman Internship Award for his research work with local Utilities.

The performance of biologically active filtration can be mathematically predicted and optimized



In this study, a modeling framework was developed to simulate biologically active filtration (BAF) headloss buildup in response to organic removal and nitrification. This model was calibrated and validated with data collected from a pilot-scale study used for potable water reuse and a full-scale facility used for potable water treatment. The model prediction provided insights that biofilm growth rather than particle deposition primarily contributes to the headloss buildup. Therefore, biofilm control is essential for managing headloss buildup and reducing the backwash frequency. Model simulation indicated that the BAF performance in terms of pollutant removal per unit headloss is insensitive to the BAF bed depth but can be effectively improved by increasing the media size. *Source: Water Research, 167, 115128*

The very first continuous flow aerobic granulation bioreactor in the world was demonstrated in UOSA



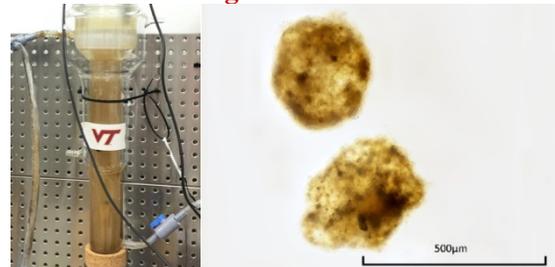
This pilot study verified the feasibility of achieving successful aerobic granulation in continuous flow infrastructure of modern wastewater treatment plants fed with primary effluent with seasonal temperature variation between 10 and 22.5 °C. *Source: Science of The Total Environment, 688, 762-770*

The cerium chloride is cost-effective in controlling struvite scaling and improving sludge dewaterability



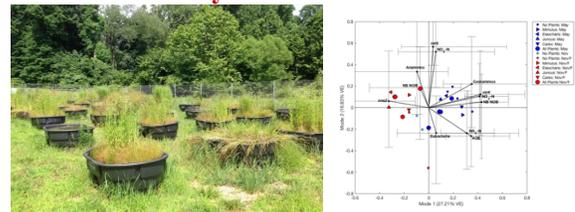
In order to control the nuisance struvite scaling issues, cerium chloride (CeCl_3) was dosed as an effective OP precipitant. The results of this study demonstrated that CeCl_3 dosing showed higher OP removal efficiency than other commonly used OP precipitants. In addition, sludge dewaterability improvement and thus lower polymer and dewatering energy demands were also observed. The seasonal dosing of CeCl_3 at UOSA provided a net annual saving of US \$47,000. *Source: Water Environment Research, https://doi.org/10.1002/wer.1150*

Mass diffusion limitation compromised NOB suppression in aerobic granules



Those NOB survived free ammonia (FA) inhibition in larger granules were forced to dwell within the granule interior, where the AOB growth slows down due to DO diffusion limitation. This means FA inhibition can be effective only in small granules or thin biofilms. *Source: Environment International, 131, 105005*

Season and fertilization affect nitrogen turnover microbial community in wetland mesocosms



Constructed wetlands effectively stored and transformed pollutants. The seasonal effect convolved with fertilization effect and appeared to be the dominant factor influencing the soil microbial community. The effects of plant species richness were more nuanced, with greater richness significantly impacting the abundance of only a subset of bacterial groups. *Source: Science of The Total Environment, 689, 269-277*

Publications in 2019

Journal papers

1. Sun Y., Vaidya R., Khunjar W.O., Rosenfeldt E., Selbes M., Wilson C., Bott C.B., Titcomb M., Wang Z.W. (2019) Mathematical Modeling of Biologically Active Filtration (BAF) for Potable Water Production Applications, *Water Research*, 167, 115128,
2. Kent T.R., Sun Y.W., An Z.H., Bott C.B., Wang Z.W. (2019) Mechanistic Understanding of the NOB Suppression by Free Ammonia Inhibition in Continuous Flow Aerobic Granulation Bioreactors, *Environment International*, 131, 105005
3. Yu D.J., Sun Y.W., Wang W.J., O'Keefe S.F., Neilson A.P., Feng H., Wang Z.W., Huang H.B. (2019) Recovery of Protein Hydrolysates from Brewer's Spent Grain using Enzyme and Ultrasonication, *International Journal of Food Science & Technology*, doi.org/10.1111/ijfs.14314
4. Shah P. and Wang Z.W. (2019) Using digital polymerase chain reaction to characterize microbial communities in wetland mesocosm soils under different vegetation and seasonal nutrient loadings, *Science of the Total Environment*, 689, 269-277
5. Sun Y.W., Angelotti B., and Wang Z.W. (2019) Continuous-flow aerobic granulation in plug-flow bioreactors fed with real domestic wastewater, *Science of the Total Environment*, 688, 762-770
6. Zhang D., Angelotti B., Schlosser E., and Wang Z.W. (2019) Using cerium chloride to control soluble orthophosphate concentration and improve the dewaterability of sludge: Part II. A case study, *Water Environment Research*, doi.org/10.1002/wer.1150
7. Zhang D., Angelotti B., Schlosser E., Novak J.T., and Wang Z.W. (2019) Using cerium chloride to control soluble orthophosphate concentration and improve the dewaterability of sludge: Part I. mechanistic understanding, *Water Environment Research*, doi.org/10.1002/wer.1142
8. Li X.J., Sun Y.W., Wang Z.W., He Z. (2019) Theoretical understanding of the optimum conditions for a mainstream granular nitrification-anammox reactor coupled with anaerobic pretreatment, *Science of The Total Environment*, 669 (15): 683-691
9. Ma J., Xie S., Yu L., Zhen Y., Zhao Q., Frear C., Chen S., Wang Z.W. and Shi Z. (2019) pH shaped Kinetic characteristics and microbial community of food waste hydrolysis and acidification. *Biochemical Engineering Journal*, 146, 52-59
10. Sun Y.W., Vaidya R., Khunjar W., Rosenfeldt E., Selbes M., Wilson C., Bott C.B., Wang Z.W. (2019) Mathematical modeling of deep-bed biofiltration to describe contaminant control and headloss development, ASABE 2019, Boston, Massachusetts, July 8-10
11. Sun Y.W., Angelotti, B., Brooks M., Wang Z.W. (2019) Pilot-scale evaluation of the effects of settling velocity-based selection and feast/famine conditions on continuous flow aerobic granulation, ASABE 2019, Boston, Massachusetts, July 8-10
12. Zhang D., Angelotti B., Schlosser E., Wang Z.W. (2019) Orthophosphate Control & Sludge Dewaterability Improvement by Using Cerium Chloride, WFETEC 2019, Chicago, September 23-25
13. An Z.H., Kent T.R., Bott C., Wang Z.W. (2019) Resistance of NOB to free ammonia inhibition developed over long-term acclimation in continuous flow aerobic granulation reactor performing partial nitrification, WFETEC 2019, Chicago, September 23-25
14. Sun Y.W., Vaidya R., Khunjar W., Rosenfeldt E., Selbes M., Wilson C., Bott C.B., Wang Z.W. (2019) Model-guided strategies for headloss control in the biological activated carbon filters for potable water reuse, WFETEC 2019, Chicago, September 23-25
15. Kent T.R., Sun Y.W., An Z.H., Bott C., Wang Z.W. (2019) The Impact of Free Ammonia Inhibition and Granule Size on the suppression of Nitrite Oxidizing Bacteria in Continuous Flow Bioreactors, WFETEC 2019, Chicago, September 23-25
16. Sun Y.W., Angelotti B., Brooks M., Wang Z.W. (2019) Continuous flow aerobic granulation in real municipal wastewater: a pilot-scale evaluation of the effects of feast/famine and sludge settling velocity selection, WFETEC 2019, Chicago, September 23-25
17. Zhang D., Angelotti B., Schlosser E., Wang Z.W. (2019) Dissolved phosphate control & sludge dewaterability improvement by using cerium chloride, WaterJam 2019, Virginia Beach, Virginia, September 9-12
18. Kent T.R., Sun Y.W., An Z.H., Bott C., Wang Z.W. (2019) The impact of granule size on the inhibition of nitrite oxidizing bacteria by free ammonia in continuous flow bioreactors treating, WaterJam 2019, Virginia Beach, Virginia, September 9-12
19. An Z.H., Kent T.R., Bott C., Wang Z.W. (2019) Free ammonia resistance of NOB developed in continuous flow aerobic granulation reactor performing partial nitrification, WaterJam 2019, Virginia Beach, Virginia, September 9-12
20. Sun Y.W., Vaidya R., Khunjar W., Rosenfeldt E., Selbes M., Wilson C., Bott C.B., Wang Z.W. (2019) Mathematical modeling of deep-bed biofiltration to describe contaminant control and headloss development, ASABE 2019, Boston, Massachusetts, July 8-10
21. Sun Y.W., Angelotti, B., Brooks M., Wang Z.W. (2019) Pilot-scale evaluation of the effects of settling velocity-based selection and feast/famine conditions on continuous flow aerobic granulation, ASABE 2019, Boston, Massachusetts, July 8-10
22. A Pretreatment Method for Enhanced Anaerobic Digestion of Biosolids, WFETEC 2019, Chicago, September 23-25

Conference presentations

1. Zhang D., Broderick T., Strawn M., Santha H., Wang Z.W. (2019) A Comparison Between Temperature-Phased Anaerobic Digestion and Thermal Hydrolysis As

12. Kent T.R., Sun Y.W., An Z.H., Bott C.B., Wang Z.W. (2019) Free Ammonia Inhibition as a Means of Suppressing Nitrite Oxidizing Bacteria in Differently Sized Granules Treating Agricultural Wastewater, ASABE 2019, Boston, Massachusetts, July 8-10
13. An Z.H., Huang H.B., Shuai D.M., Wang Z.W. (2019) Granulation of *Clostridium beijerinckii* P260 in continuous flow reactors converting food waste to butanol simultaneously recovered through pervaporation membrane, ASABE 2019, Boston, Massachusetts, July 8-10
14. Zhang D., Broderick T., Strawn M., Santha H., Wang Z.W. (2019) Process Intensification of Anaerobic Digestion through Temperature Phased Anaerobic Digestion and Thermal Hydrolysis Pretreatment, ASABE 2019, Boston, Massachusetts, July 8-10
15. Wang Z.W., Sun Y.W., Angelotti B., Brooks M. (2019) Continuous-flow aerobic granulation in real domestic wastewater, VWEA Lunch N Learn, UOSA, Centreville, Virginia, June 5
16. Zhang D., Angelotti B., Schlosser E., and Wang Z.W. (2019) Using Cerium Chloride to Control Soluble Orthophosphate Concentration and Improve the Dewaterability of Sludge, WEF/IWA Residuals and Biosolids Conference 2019, Fort Lauderdale, Florida, May 7-10
17. An Z.H., Bott C.B., and Wang Z.W., Granulation of aerobic granules performing nitrification in continuous flow air-lift bioreactors without hydraulic selection pressure, 2019 NCR Water Resources Symposium, Washington DC, April 12
18. An Z.H., Bott C.B., and Wang Z.W., Free ammonia resistance of NOB over long-term operation in continuous flow aerobic granulation reactor performing partial nitritation, 2019 NCR Water Resources Symposium, Washington DC, April 12
19. Sun Y.W., Khunjar W., Rosenfeldt E., Selbes M., Vaidya R., Wilson C., Bott C.B., Wang Z.W., Mathematical modeling of deep-bed biofiltration to describe contaminant control and head loss development for potable water reuse, 2019 NCR Water Resources Symposium, Washington DC, April 12
20. Sun Y.W., Angelotti B., Brooks M., Wang Z.W., Continuous-flow aerobic granulation in plug-flow bioreactors fed with real domestic wastewater, 2019 NCR Water Resources Symposium, Washington DC, April 12
21. Zhang D., Broderick T., Strawn M., Santha H., and Wang Z.W., Process intensification of anaerobic digestion: A comparative assessment of temperature phased anaerobic digestion and thermal hydrolysis pretreatment, 2019 NCR Water Resources Symposium, Washington DC, April 12

Conference Posters

1. Sun Y.W., Vaidya R., Khunjar W.O., Rosenfeldt E.J., Selbes M., Wilson C., Bott C.B. (2019) Mathematical modeling of biologically active filtration (BAF) for potable water production applications, WaterJam 2019, Virginia Beach, Virginia, September 9-12 (**1st place award in water poster competition**)
2. Sun Y.W., Angelotti B., Wang Z.W. (2019) Continuous-flow aerobic granulation in plug-flow bioreactors fed with real domestic wastewater, WaterJam 2019, Virginia Beach, Virginia, September 9-12
3. An Z.H., Kent T.R., Bott, C.B., Wang Z.W. (2019) Stabilization of full or partial nitrification aerobic granules in continuous flow reactors without hydraulic selection pressure, ASABE 2019, Boston, Massachusetts, July 8-10
4. An Z.H., Kent T.R., Bott C.B., Wang Z.W. (2019) Free ammonia resistance of NOB in continuous flow air-lift reactor performing partial nitritation, ASABE 2019, Boston, Massachusetts, July 8-10
5. Zhang D., Khunjar W., Wang Z.W. (2019) The effect of pH and ferric ion on recalcitrant dissolved organic nitrogen production from the thermal hydrolysis of biosolids, ASABE 2019, Boston, Massachusetts, July 8-10
6. Zhang D., Angelotti B., Schlosser E., and Wang Z.W. (2019) Orthophosphate Control & Sludge Dewaterability Improvement by Using Cerium Chloride, AEESP 2019, Tempe, Arizona, May 14-16
7. An Z.H., Kent T.R., Bott C.B., and Wang Z.W. (2019) Free ammonia resistance developed by NOB in continuous flow aerobic granulation reactor performing partial nitritation, AEESP 2019, Tempe, Arizona, May 14-16
8. Sun Y.W., Angelotti B., and Wang Z.W. (2019) Pilot-scale investigation of the effects of feast/famine conditions and sludge settling velocity-based selection on continuous flow aerobic granulation in real municipal wastewater, AEESP 2019, Tempe, Arizona, May 14-16
9. Kent T.R., Sun Y.W., Bott C.B., and Wang Z.W. (2019) Free Ammonia Inhibition as a Means of Suppressing Nitrite Oxidizing Bacteria in Granular Sludge for Continuous Flow Bioreactors, AEESP 2019, Tempe, Arizona, May 14-16

