Welcome to 2019 Annual Report of Environmental Biotechnology & Bioenergy Laboratory (EBBL).

This is our last annual report from Virginia Tech, because EBBL is being moved to Washington University in St. Louis (WashU). It was a tough decision to leave Virginia Tech. As some of you may know, I am a WashU graduate with my PhD granted in 2007. My PhD adviser Dr. Lars Angenent left WashU one year after my graduation for a position at Cornell University. So, my expertise will fill in the gap of environmental biotechnology and wastewater treatment in terms of both research and teaching at WashU. I deeply appreciated the support and opportunities at Virginia Tech that helped to further develop my career and cultivate EBBL to be a very productive and collaborative platform. We are all proud of being Hokies!

To conclude our last year at Virginia Tech, I would like to thank all the EBBL members, alumni, collaborators, and friends, for your contributions to the lab. Moving lab (and my family) would certainly create challenges and difficulties, but our lab continued to perform well. Our members won the first place in WaterJAM poster competition in Wastewater category for the 5th consecutive year. Three lab alumni landed faculty positions at US and Chinese universities.

In 2019, we welcome two new PhD students and one visiting postdoc. We also graduated two PhD students (both of them continued to postdoc positions at Stanford and USC) and two MS students. Several visiting scholars completed the visit and returned to their home institutions. We have had a good year with authoring/co-authoring 21 journal papers, three of which were featured as Cover Articles.

I was appointed as a Co-Editor of Journal of Hazardous Materials (JHM), a high-profile environmental engineering journal. I also received a Dean’s Award for Excellence in Research and a CAPEES/NANOVA Frontier Research Award.

I am excited to start a new page of EBBL at WashU and look forward to working with all of you in 2020!
**2019 New Members**

**Fubin Liu** joined EBBL as a PhD student after completing his MS & BS at Tsinghua University. He has had a great track on bioelectrochemical systems and works on our new collaborative project with Alexandria University in Egypt.

**Yanran Xu** came to EBBL as a PhD student from the University of Michigan Ann Arbor where she completed a MS study. She received a BS from Tongji University. Yanran works on improving anaerobic digestion for value-added resources.

**Dr. Lingen Zhang** joined EBBL as a postdoctoral research associate. He completed his PhD training at Shanghai Jiaotong University. He is working on recovery of valuable metals from wastewater by electrochemical methods.

**Jessie Chung** has completed her MS study in EBBL and will join CDM Smith as a consulting engineer. She worked on leachate treatment by membrane distillation. She was the President of VWEA student chapter at Virginia Tech.

**Yuan Pan** has completed his visiting research in EBBL and returned to Northeastern University (China) to continue his PhD study. He has published two journals papers and has one submission under review.

**Xuejiao Ma** has completed her visiting research in EBBL and returned to China University of Geosciences Beijing to continue her PhD study. She has worked on electrochemical nitrate removal and has one submission under review.

**Dr. Qingjie Hou** has completed his visiting research at EBBL and returned to Shandong University. He has worked on modifying ion exchange membranes for microbial fuel cells and expects to finish one manuscript.

**Shiqiang (Nick) Zou** has completed his PhD in EBBL and moved to Stanford University as a postdoctoral research associate. Shiqiang has a very productive publication record and has actively participated in various activities.

**Wei Wang** has completed her visiting research in EBBL and returned to China University of Geosciences Beijing to continue her PhD study. She published one journal paper about bacterial deposition of catalysts in MECs.


We are fortunate to move from one of the best American college campuses to another best college campus. In Niche’s 2020 Ranking of Best College Campuses in America, WashU ranks #2 and Virginia Tech ranks #3.

We were selected as one of 14 teams to receive grants from US-Egypt Science and Technology Joint Fund. Our collaborator Prof. Salah Hassouna at Alexandria University will work with us to develop innovative technology for resource recovery from wastewater via integrated BES and FO systems. The Egyptian Co-PI Dr. Hanna Moustafa will join us at WashU as a Postdoctoral Research Associate funded by Egyptian Government.

Dr. Mohan Qin has accepted a tenure-track assistant professor position at University of Wisconsin – Madison. She will be joined by her husband – Dr. Haoran Wei who also starts a faculty position in the same department.

Dr. Heyang (Harry) Yuan has begun his independent research career as a tenure-track assistant professor at Temple University and successfully recruited his first PhD student.

Dr. Simiao Wu has completed her PhD study at Shanghai University, and accepted a Lecturer position at Nanjing University of Finance & Economics. She spent two years in EBBL as a CSC-funded visiting PhD student.

UVA wins?!

After 15-year consecutive loss, UVA finally beat VT in 2019 Commonwealth Cup.

Seriously, is this really EBBL progress?

The rivalry between VT and UVA is one of most memorable things. One team’s dominance is not a rivalry. You got to let the other team (e.g., "UVA") to win sometimes...

Editorship

Dr. He joined Journal of Hazardous Materials (JHM) as a Co-Editor. JHM is a top-tier journal in Environmental Engineering and focuses on the fate/removal of materials that have hazardous effects on human and environment. Its latest impact factor is 7.650 and CiteScore is 7.91.
Syeed Md Iskander won the Gold Award on the 35th Annual Research Symposium by VT Graduate Student Assembly. Shiqiang won the Silver Award from the same symposium.

**EBBL’s Winning Tradition Continued at WaterJAM 2019**

The EBBL members have actively participated in 2019 WaterJAM and continued our winning track:

- Zixuan Wang won the poster competition in Wastewater category ($1,000);
- Yuan Pan won the 2nd place in Digital Knowledge Competition;
- Bing Xu is a team member that won the 2nd place in Student Water Challenge.

**Recognition 2019**

Syeed Md Iskander won the 1st Place Presenter on the Annual Research Symposium of VT Alpha Epsilon (The Honor Society of Agricultural, Food, and Biological Engineering).

Jessie Chung and Zixuan Wang received their MS degrees as our last batch of MS graduates at Virginia Tech. Jessie will start her consulting engineer career at CDM Smith and Zixuan will begin his PhD study at WashU. Congratulations!

Dr. He was elected to be a member of US National Committee Board of International Water Association. He will be a Co-Chair of the 10th IWA Membrane Technology Conference, which will be at WashU in 2021.

Dr. He received Dean’s Award for Excellence in Research from College of Engineering, Virginia Tech.

**EBBL’s Winning Tradition Continued at WaterJAM 2019**

Akshay Jain was selected to participate in the Preparing the Future Professoriate: Global Perspectives program and visited universities mostly in Switzerland during the summer of 2019.

Syeed Md Iskander was selected as a 2019 Diversity Scholar by the Office of Recruitment, Diversity, and Inclusion, Graduate School, Virginia Tech.

The EBBL members participated in the 2019 Big Event at Virginia Tech, a student-run day of service that has grown into the second largest event of its kind in the nation.

Yuan Pan won the poster competition in Wastewater category ($1,000);
**FO Membrane Modification for Reducing RSF**

Forward osmosis (FO) has emerged as a promising membrane technology to yield high-quality reusable water from various water sources. A key challenge to be solved is the bidirectional solute flux (BSF), including reverse solute flux (RSF) and forward solute flux (FSF). Herein, zwitterion functionalized carbon nanotubes (Z-CNTs) have been coated onto a commercial thin film composite (TFC) membrane, resulting in BSF mitigation via both electrostatic repulsion forces induced by zwitterionic functional groups and steric interactions with CNTs. At a coating density of 0.97 g m⁻², a significantly reduced specific RSF was observed for multiple draw solutes, including NaCl (55.5% reduction), NH₄H₂PO₄ (83.8%), (NH₄)₂HPO₄ (74.5%), NH₃Cl (70.8%), and NH₄HCO₃ (61.9%). When a synthetic wastewater was applied as the feed to investigate membrane rejection, FSF was notably reduced by using the coated membrane with fewer pollutants leaked to the draw solution, including NH₄⁺-N (46.3% reduction), NO₂⁻-N (37.0%), NO₃⁻-N (30.3%), K⁺ (56.1%), PO₄³⁻-P (100%), and Mg²⁺ (100%). When fed with real wastewater, a consistent water flux was achieved during semi-continuous operation with enhanced fouling resistance. This study is among the earliest efforts to address BSF control via membrane modification, and the results will encourage further exploration of effective strategies to reduce BSF. 


**MER Treatment of Leachate UVQS**

Persistent UV quenching substances (UVQS) in landfill leachate can affect the effectiveness of UV disinfection in domestic wastewater treatment systems when leachate is being co-treated. As a result, effective onsite leachate pre-treatment will have to be implemented to reduce the UV quenching capability. Herein, a membrane electrochemical reactor (MER) was developed and investigated for treating UV quenching organics contained in landfill leachate. Compared to a control reactor that did not have a membrane separator, the MER achieved significantly higher removals of both dissolved organic carbon (61.5 ± 4.1%) and UV254nm absorbance (63.4 ± 8.4%). This enhanced performance was likely due to the combined effects of humic acid precipitation and augmented oxidation of organics. The MER was able to remove 89.1 ± 2.9% of total nitrogen from the leachate while recovering about 51% of the influent ammonia in the catholyte, in comparison to 38.1 ± 4.4% of total nitrogen removal by the control reactor. The MER consumed significantly less electrical energy with specific energy consumption of 70.62 kWh kg⁻¹ DOC or 33.03 kWh kg⁻¹ sCOD, compared to that of the control reactor (211.8 kWh kg⁻¹ DOC or 55.02 kWh kg⁻¹ sCOD). A current density of 20 mA cm⁻² was considered optimal in terms of both UVQS removal and energy efficiency. Consideration should be given to the spacing of electrodes to minimize internal resistance and also to avoid trapping of the produced gas bubbles. These results collectively suggest that the MER is a promising onsite pretreatment approach for landfill leachate and further exploration of this technology should be encouraged. 


**Rotating Anode in MFCs**

Mixing plays a key role in both electricity generation and organic removal in microbial fuel cells (MFCs) via affecting substrate distribution and internal resistance. Herein, two mixing methods, anode electrode rotation and anolyte recirculation, were investigated in terms of energy consumption and production. Anode electrode rotation could increase the maximum power density and COD removal by 81.5 and 45.7%, respectively, when the rotating speed increased from 0 to 45 rpm. Likewise, anolyte recirculation also improved the power density and COD removal by 43.1 and 30.1%, respectively, at an increasing rate from 0 to 300 mL min⁻¹. The enhancement of electricity generation became less significant at a high mixing level, likely because that substrate supply was relatively sufficient and other factors posed more effects on electricity generation. The MFC with anode electrode rotation achieved a higher energy balance (e.g., 0.254 kWh kg COD⁻¹ at 35 rpm) than the one without any mixing (0.124 kWh kg COD⁻¹), while anolyte recirculation led to a lower or even negative energy balance compared to that with no mixing. The results of this study have demonstrated energy advantages of anode electrode rotation and encouraged further exploration of energy-efficient mixing methods for MFC operation. 

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