2023 is a year of "conferences". The EBBL members have attended various state, national, and international conferences, including Joint MO WEA/AWWA meeting, WEF Biosolids conference, Borchardt Conference, AEESP, WEFTEC, ACE23, Mid-American Environmental Engineering Conference, and CWI annual research symposium. I made a trip to Korea in late November/early December, gave seminars at two Korean universities, and delivered a plenary talk at the WaterEnergyNexus Conference. In addition, we organized the 10th IWA Membrane Technology Conference at WashU. Conferences are always the place to meet with our lab alumni.

We welcomed a visiting PhD student, a new PhD student, and several undergraduate researchers to the lab. Zixuan has won several awards at the university and national levels. We also had good presence in our neighbor state by winning the first place at the Intelligent Water Challenge by IWEA, a team led by Jiasi. We sent the first team ever to represent the State of Missouri at the regional and national student design competition. Those who won the cash awards continued our lab tradition by bringing food and drink to the group meeting. In March, I received a professorship and became the Laura & William Jens Professor.

As always, thank you for a wonderful year of 2023 and look forward to working with all of you in 2024!

Zhen (Jason) He
Laura and William Jens Professor
Matthew Ferby presented his research at the MWEA/MO-AWWA Joint Annual Meeting (3rd place in poster competition), IWA MTC, AEESP conference, and MAECC. He became a PhD candidate.

Fubin Liu presented his research at the Borchardt Conference, IWA Membrane Technology Conference, and AEESP conference. He published a co-1st author review paper in CREST and became a PhD candidate.

Yue Rao published her first journal paper in Journal of Cleaner Production and had her second paper accepted by Bioresource Technology before the New Year. She presented her research at MWEA/MO-AWWA Joint Annual Meeting and AEESP.

Shruti Kadam is a leading graduate student on our DOE project about nutrient recovery to support algal growth. She is a part of team to attend the state competition and then the national design competition on behalf of Missouri.

Yanran Xu led a paper about machine learning predication of phosphorus published in ES&T Water. She also led our effort of collaborating with industries such as KimHEC and Buckman on data science for water/wastewater treatment.

Kaichao Yang had a very busy year. He published four journal papers in premier journals like Water Research and Journal of Hazardous Materials. He participated in the state and national design competition, and several conferences.

Paloma Paiva Santiago officially joined the EBBL as a PhD student. She came from Brazil, and completed her BS at Federal Institute of Ceará and MS at Federal University of Ceará. She works on our DOE project about biogas upgrading.

Jiasi Sun published her first paper in Water Environment Research about machine learning predication of biogas production (Cover Artile). She led a team to win the first place at the Intelligent Water Challenge by IWEA.

Po-Chang Wu came from Taiwan and joined the EBBL as a visiting PhD student. He is currently a PhD student of environmental engineering at National Taiwan University. At WashU he is working on electrochemical removal of heavy metals.

Michelle Kane participated in the biogas upgrading project as an undergraduate researcher. She is also playing soccer for a club. Michelle will study abroad in Scotland in the spring of 2024. We wish her the best and look forward to seeing her again.

Zixuan Wang became "the EBBL’s richest person of 2023" by winning several awards. He published a research paper in ES&T and a co-1st author review paper in CREST. He also had a busy summer by attending three conferences and then paid a visit to UIUC.

Ariel Richards came to the EBBL as an undergraduate researcher. She is a dual-degree student from Grinnell College. Ariel participates in our NSF project about VFA production through inhibiting methanogens in anaerobic digestion.

Daran Anand continues his undergraduate research in the EBBL. He co-authored a paper with Zixuan about phosphorus removal in ES&T. He was a member of team involving Shruti and Kaichao for state/national design contest.

Marcelle Santana Rovira joined the EBBL as an undergraduate researcher. She comes from Puerto Rico. She works with Shruti on our DOE project about nutrient recovery and CO₂ capture to support algal growth for sustainable carbon management.

Wesley Beamer conducted the summer researcher in the EBBL and then continued to do an independent study in the fall. He works with Matthew on using thermal energy from TEG to support MECs for hydrogen production.
Kaichao, Shruti, and Daran formed a team to participate in the student design competition organized by Central State Water Environmental Association. They represented the State of Missouri to attend the national competition at WEFTEC. It was arguably the first team from Missouri.

Zixuan has won several awards in 2023, including co-winner of Graduate Student Flash Talk Competition at the CWI annual research symposium, the CAPEES-Elsevier Outstanding Graduate Award, and Chinese Government Award for Outstanding Self-Financed Students Abroad.


She also won the Best Interdisciplinary Approach Award at the 2023 Mid-American Environmental Engineering Conference.

In the Fresh Ideas Student Poster Competition of the Joint MO MWEA/AWWA Meeting, Kaichao won the 1st place and Matthew won the 3rd Place in the Wastewater Category.

Kaichao represented MO AWWA to attend the national meeting ACE23 in Toronto.

Dr. He ran into Pranav at the WEFTEC and had a dinner gathering with Heyang, Mohan, and Haoran at AEESP.

EBBL had a joint group meeting with Dr. Dan Giammar’s lab.

We hosted the 2023 Kappe Lecture speaker Dr. Daniel Yeh of USF.
WashU hosted the 10th IWA Membrane Technology Conference. It was the first time to have IWA-MTC in the U.S. and attracted 200 attendees worldwide.

EBBL members attended the 2023 Mid-America Environmental Engineering Conference at the University of Missouri Columbia, with both poster and oral presentations.

EBBL members attended the 2023 AEESP conference in Boston, with four oral presentations and one poster presentation.

EBBL members attended the 2023 MWEA/MO-AWWA Joint Annual Meeting (Lake of the Ozarks) with both oral and poster presentations.

Zixuan and Fubin attended the Borchardt Conference in Ann Arbor.

Dr. He organized the first CWI research symposium. Zixuan participated in the flash talk.

Zixuan attended the WEF biosolids and bioresidue conference in Charlotte.


**Electrochemical P Leaching and Recovery**

Phosphorus (P) is abundant in wastewater sludge and can be a secondary P source that will contribute to a circular economy. Electrochemical systems are an emerging technology that can be used to release and recover P from wastewater sludge. This paper introduces and analyzes the state-of-the-art electrochemical methods for P release and recovery from wastewater sludge, both qualitatively and quantitatively. Electrochemical P release, which involves mobilizing P from the solid phase into the aqueous phase, is categorized into three major mechanisms, electro-biological release, anodic P release, and cathodic P release. Anodic P release has been most widely studied with a median P release rate of 92.4 mg d⁻¹. Correlation analysis revealed that the type of feed sludge, sludge P contents, sludge loading rate, and current density have a significant impact on the P release performance. The released P is subsequently separated from the heavy metal laden sludge and then recovered via different electrochemical systems such as three-chamber cells, two-chamber cells, and their variations. Those systems can achieve P recovery efficiency of 50 – 80% and a recovery rate of 2.0 × 102 – 1.8 × 103 mg P d⁻¹. Energy consumption of electrochemical P recovery is estimated at 50 – 200 kWh kg⁻¹ P but only 27.3% of literature reported such data. This work provides insights into the development and challenges of electrochemical P release & recovery from wastewater sludge and discusses the challenges that need to be addressed to advance the viability of electrochemical P recovery approach.

**Machine Learning Predication of Biogas**

Anaerobic digestion (AD) of sludge is a key approach to recover useful bioenergy from wastewater treatment and its stable operation is important to a wastewater treatment plant (WWTP). Because of various biochemical processes that are not fully understood, AD operation can be affected by many parameters and thus modeling AD processes becomes a useful tool for monitoring and controlling their operation. In this case study, a robust AD model for predicting biogas production was developed using ensembled machine learning (ML) model based on the data from a full-scale WWTP. Eight ML models were examined for predicting biogas production and three of them were selected as metamodels to create a voting model. This voting model had a coefficient of determination (R²) at 0.778 and a root mean square error (RMSE) of 0.306, outperformed individual ML models. The Shapley additive explanation (SHAP) analysis revealed that returning activated sludge and temperature of wastewater influent were important features, although they affected biogas production in different ways. The results of this study have demonstrated the feasibility of using ML models for predicting biogas production in the absence of high-quality data input and improving model prediction through assembling a voting model.

**OPB Formation and Removal**

Proper control/removal of disinfection byproducts (DBPs) is important to drinking water safety and human health. In this study, a membrane-less electrochemical system was developed and investigated to remove DBPs through integrated adsorption and reduction by granular activated carbon (GAC)-based cathode. Representative DPBs including trihalomethanes and haloacetonitriles at drinking water concentrations were used for removal experiments. The proposed system achieved >70% removal of most DBPs in a batch mode. The comparison with control tests under either open circuit or hydrolysis demonstrated the advantages of electrochemical treatment, which not only realized higher DPBs removal but also extended GAC cathode lifetime. Such advantages were further demonstrated with continuous treatment. High dechlorination and debromination efficiencies were obtained in both batch (82.2 and 94.3%) and continuous (79.3 and 87.6%) reactors. DBPs removal was mainly contributed by the electrochemical reduction and adsorption by the GAC-based cathode, while anode showed little oxidizing effect on DBPs and halide ions. Dehalogenated products of chloroform and dichloroacetonitrile were identified with toxicity reduction. The energy consumption of the continuously operated system was estimated to be 0.28 to 0.16 kWh m⁻³. The proposed system has potential applications for wastewater reuse or further purification of drinking water.


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