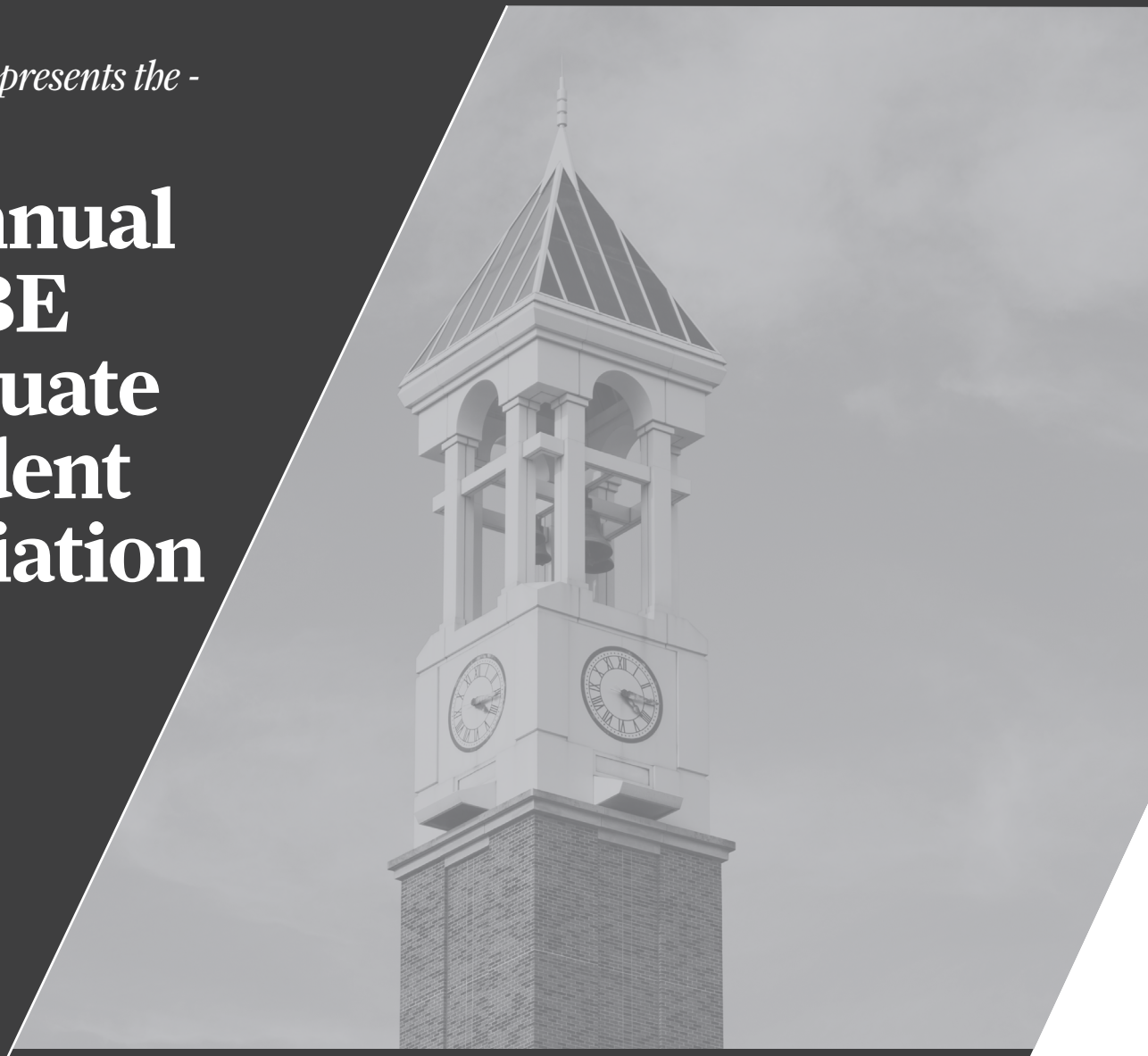
PURDUE UNIVERSITY | Agricultural and Biological Engineering

- presents the -

7th Annual ABE Graduate Student Association



GRADUATE INDUSTRIAL RESEARCH SYMPOSIUM

PURDUE UNIVERSITY | Agricultural and Biological Engineering

Proceedings of the

7th Annual ABE - GSA Graduate Industrial Research Symposium

Friday, February 7th, 2020

Wilmeth Active Learning Center (WALC)
Purdue University

"Building Blocks for a Healthier Future"

Agricultural and Biological Engineering Graduate Student Association - Purdue University -

We would like to thank the following sponsors for their generosity and support to make this symposium possible:

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Additionally, we would like to thank the following companies for their attendance:

ADM, Caterpillar, Indiana Department of Natural Resource - Division of Water, MZ Venture Partners, Terra Drive Systems, Inc., USDA-NRCS

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Agenda

Registration and Reception **9:00 - 10:30 AM**
Wilmeth Active Learning Center (WALC) **3138**

Oral Presentations (Session I) **10:30 - 11:30 AM**
WALC **3121**

Environment & Natural Resources Engineering

WALC **3127**

Biotechnology/Regulations & Food Process Engineering

Oral Presentations (Session II) **11:30 AM - 12:30 PM**
WALC **3121**

Bio-energy & Biological Engineering

WALC **3127**

Machine Systems & Agricultural System Engineering

Lunch, *Industry Panel and Networking Session** **12:30 - 2:00 PM**
WALC **1132**

Poster Session **2:15 - 3:45 PM**
WALC **2087**

3 Minute Thesis Competition **4:00 - 5:00 PM**
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Awards Ceremony **5:00 - 6:00 PM**
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Dinner and *Keynote Speaker** **6:00 - 7:30 PM**
WALC **1108**

*Meal provided.

Welcome from the Department Head

Welcome to the 7th Annual ABE Graduate Student Symposium!

I hope that you will find the day's events stimulating and informative. The ABE Graduate Student Symposium leadership team has put in a significant effort to organizing the presentation sessions, industry panel discussion, poster session, and three minute thesis competition.

There will be ample opportunities to network and discuss research with current students, prospective graduate students, faculty, staff, alumni, and industry visitors. Please take advantage of this opportunity to interact with people you may not have had opportunity to do so in the past. While ABE is "camping out" in Lilly Hall, it has been more difficult to find these opportunities on a day-to-day basis.

The facilities in WALC are wonderful for events like this! We will be fortunate to be moved into our new space in the new ABE building for next year's symposium. If you're visiting campus today, I hope you can take a few minutes to venture down to where the old ABE building was to see the incredible progress on our outstanding new space.

Please come back next year to visit the new spaces and to see how ABE is moving forward into the next 150 years of Purdue and the second 100 years of ABE!

Sincerely,

Nathan S. Mosier
Professor and Head
Agricultural and Biological Engineering

Keynote Speaker
Dr. Bhimu Patil

Inaugural University Professor and Interim Head, Department of Food Science and Technology

Director, Vegetable and Fruit Improvement Center

Director, USDA National Center of Excellence
Texam A&M University

Dr. Bhimu Patil has received his Ph.D. in Horticulture from Texas A&M and his B.S. and M.S. in Agriculture from the University of Agricultural Sciences-Bangalore and Dharwad. Dr. Patil's research focuses on the broader impacts of fruits and vegetables on human health. His work also examines the effects of harvesting and post-harvesting practices on fruit and vegetable quality. He is currently the lead PI, along with 23 co-PIs, for the USDA-SCRI-CAP project: Table to Farm: A sustainable, systems-based approach for a safer and healthier melon supply chain in the U.S. Dr. Patil's research has been recognized with many honors and has produced a remarkable publication and funding record. He has secured $17 million for his research and educational programs, published 201 peer-reviewed articles, and been invited to present at 48 international meetings during which he has given 16 keynote/plenary talks, and at 98 national and 51 regional meetings. The research and educational outreach programs led by Dr. Patil at the Vegetable and Fruit Improvement Center have received substantial attention and Dr. Patil has been interviewed and/or his work has been published in 135 articles from various news media including the Associated Press, Reuters, the Wall Street Journal, and Fox Health Channel. He has been an invited speaker, including keynote and plenary speaker, for his scientific research and educational excellence by several countries including Australia, Brazil, Belgium, Canada, China, France, Israel, India, New Zealand, Portugal, South Africa, South Korea, Spain, Sweden, Thailand, Turkey, UAE, and different states in the USA.

He has received numerous awards and honors. Five professional societies (American Chemical Society, American Society for Horticultural Sciences, Brazilian Horticulture Society, Indian Horticulture Society, TAMU AgriLife recognized Patil as a Fellow, a title bestowed on those who have made exceptional contributions to research and academia.

He has developed three multi-disciplinary and multi-state courses ("Science of Foods for Health", "Phytochemicals in Fruits and Vegetables to Improve Human Health", "The Nexus of Food & Nutritional Security, Hunger and Sustainability") with support from three USDA-Challenge grants.

Industrial Panel Participants

Dr. Dennis R. Buckmaster
Professor, Agricultural & Biological Engineering
Dean's Fellow for Digital Agriculture
Purdue University

Keith Harmeyer
Caterpillar, Inc.

Dr. Jian Jin
Assistant Professor, Agricultural & Biological Engineering
Purdue University

Daniel Skelton
Hydraulic Control Engineer
Terra Drive Systems, Inc.

Dr. Mohit Verma
Assistant Professor, Agricultural & Biological Engineering and Biomedical Engineering
Purdue University

Three Minute Thesis (3 MT)

Developing Novel Manufacturing Processes to Formulate Robust Amorphous Solid Dispersions for Oral Drug Delivery
Sonal Bhujbal

Predicting Anaerobic Digester Performance
Sarah Daly

Engineering Fungi for Sustainable Agriculture, Energy, and Health
Casey Hooker

Exploring the Unknown in Bacteriophage Proteins
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Hyperspectral Phenotyping of Traits Related to Nitrogen, Abiotic and Biotic Stress, and Genetically Derived Characteristics in Grain Crops
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Oral Presentations

Bio-energy & Biological Engineering

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Global Proteome Analysis of Phage Ochi17-infected Mycobacterium Smegmatis Reveals Novel Insights in Phage-Bacteria Interaction
Ikenna Okekeogbu

Biotechnology/Regulations & Food Process Engineering

Evaluating the Shear Stress Difference Between Extrusion and Offline Capillary Viscosity Measurements
Troy Tonner

Integrated Techno-economic and Life Cycle Assessment on Craft Beer Production at Microbrewery
Belen Salazar

Performance of Novel Portable Solar Drying Technologies for Small and Mid-size Growers of Specialty Crops Under Indiana Weather Conditions

Diana Ramirez

Environmental & Natural Resources Engineering

Menstrual Cups for Women's Empowerment

Pranav Mohan

Economic and Energy Impacts of Wind Energy Expansion in the US Using Multi-Regional Input Output (MRIO) Tables

Venkata Sai Gargeya Vunnava

Land Use of Power Generation Technologies and Fuels

Elizabeth Wachs

Machine Systems & Agricultural Systems Management

HAWTs with Hydrostatic and Regular Transmissions

Antonio Esquivel

Development of Analog Experimental Crop Growth Environments for Planetary Exploration

Oscar I Ojeda

Hyperspectral Data Applied to Food Security

Raquel Peron

Poster Abstracts *

1. Educational Hydraulic Trainer

Hassan Assaf

Parker Hannifin's hydraulic trainers provide the students the opportunity to apply what is learned in the classroom to a real-world hands-on experience. This great tool can run 35 lab experience to educate the next generation of engineers. The rapid development of science and technology in the last decade, especially in fluid power, motivates us to upgrade this trainer with the latest available technology. The goal of this work is to develop the next generation of the hydraulic trainer (elements of connectivity, advanced DAQ, and control will be used) with more advanced fluid power
applications.

2. A combined computational and live-cell imaging approach to analyze tissue morphogenesis

Samy Belteton

Leaf size and shape are strongly influenced by the growth behaviors of the epidermal tissue. Between episodic phases of isotropic expansion, the prevailing cell type in this tissue, the pavement cell, undergoes drastic shape changes characterized by local protrusions known as lobes into the neighboring cell. The lobed morphogenesis of pavement cells is highly affected by the disruption of the cytoskeleton network. Microtubules are implicated in cell morphogenesis, largely based on their importance in patterning cellulose deposition. The re-enforcement of the cell wall with microfibrils, directed by cortical microtubules, restricts local cell expansion parallel to the fibers orientation effectively promoting local transverse expansion. However, the mechanism by which local microtubule-cellulose ordering drives lobe initiation remains unknown. Most information pertaining to the involvement of microtubules in pavement cell morphogenesis has been extrapolated from single snapshots or from limited time-lapse intervals of lobed cells. These studies failed to accurately capture lobe initiation events and relevant microtubule organizations. We hypothesize that patchy sub-cellular anisotropic expansion at the periclinal wall drives lobe formation. We are quantifying the 3D geometry of lobe morphogenesis and creating validated finite element models to predict cell wall stress-and-strain patterns along the cell boundary. Correspondences between these predicted maps and sub-cellular strain is being tested with new types of fiducial markers. Correlations among cell wall stress, microtubule organization, and shape changes are analyzed using high temporal-and- spatial resolution time-lapse imaging. A robust method for microtubule segmentation was developed to quantify their organization, occupancy, and persistence as a function of lobe initiation. An analysis of how feedback controls among cell geometry, cell walls stress, and the microtubule-cellulose system controls lobe formation will be presented.

**Ordered alphabetically by last name*

3. Soybean Oil as a Bio-Solvent to Sweeten Sour Natural Gas

Emma Brace

Soybean oils are readily available bioresources composed of unsaturated fatty acids capable of binding sulfur compounds. Predictive models offer an opportunity to develop cost-effective methods using bio-based solvents to sweeten natural gas. While increases in fracking have increased availability of natural gas – a fuel that when combusted produces less greenhouse gases than coal or gasoline – natural gas is rich in hydrogen sulfide, rendering it sour gas. Hydrogen sulfide is corrosive to processing equipment and poses risks to human health and the environment. Predictive models such as COSMO-RS, the conductor-like screening model for real solvents, can be used to examine interactions at a molecular level, screen solvents, and choose process parameters. COSMO-RS was used to simulate the partitioning of hydrogen sulfide between soybean oil, high oleic soybean oil, free fatty acids, and gas phases. Predicted partition coefficient (K) values ranged from 0.16 to 0.70 for soybean and high oleic soybean oils at temperatures from 10 - 100°C; K values between 0 – 1 are indicative of hydrogen sulfide's preference for the liquid phase over the gas phase. Experimental results demonstrate the feasibility of removing H2S from gas using soybean oils and are compared to the predicted partitioning. This study provides proof-of-concept for using high oleic soybean oil as a bio-based solvent as a new method for cleaning sour gas.

4. Bio-Methane Potential Testing and Modelling in Anaerobic Digestion

Sarah Daly

Bio-methane Potential (BMP) tests are a frequently used method to determine the feasibility of a substrate for anaerobic digestion. In this study, different types of substrates (dairy manure, mixed industry wastes) were collected from several large-scale digester systems in Indiana state. Batch fermentation experiments of these substrates were conducted at mesophilic temperatures in 500 mL and 1000 mL digesters. The experiments continued until the daily methane production was less than 1% of its cumulative volume. The experimental results were compared with existing linear and non-linear models to determine their reliability in predicting methane yield.

5. Keeping the Farm Business in the Family: Examining Succession Planning among Small and Medium-sized Farm Family Businesses in Midwestern United States

Edeoba Edobor

Succession planning is a very crucial aspect of family business continuity. The successful transition of family businesses is especially important for small and medium scale family businesses which constitute the beginning phase of most businesses. This paper explores two critical aspects of succession planning namely the decision to keep business ownership within the family, and the transfer-readiness of family businesses. This study assessed potential correlates of these two constructs using data from small and medium scale farm and non-farm businesses in Midwest US. Results from a probit estimator showed that farm businesses were more likely to be kept within the family ($p < 0.01$). For the full sample, the number of generations involved in daily management, the readiness of the senior management to delegate control, and the owner experience were also found to be good correlates of the decision to keep the business within the family. For farms, we also found some correlation between the perception of the business as being successful and the decision to keep the business in the family ($p < 0.1$). Results from the probit and bivariate probit models showed that capital, and the number of generations in management are the most consistent correlates of transfer readiness for the full and farm samples. Finally, we found that female owners of farm businesses were less likely to be ready for business transfers than their male counterparts ($p < 0.01$).

6. Medical devices regulation in West Africa – A situation analysis

Abigail Ekeigwe

Harmonization of medical devices regulation is receiving strong global attention through the International Medical Devices Regulator's Forum, an offshoot of the Global Harmonization Task Force on medical devices. Other current trends include the Global Medical Devices Nomenclature and the Medical Devices Single Audit Program. The medical devices regulatory field is in a state of constant innovations; technologies and new regulations and guidelines are evolving to meet the changing needs and trends. This is a veritable development because medical devices and technologies are assuming significant strategic roles in the healthcare value chain – prevention, diagnostics, treatment and cure of diseases – in which they act as "force multipliers," affecting the economics of healthcare.

The questions then are – what is the situation of medical devices regulations in Africa? Is Africa trending along with the global harmonization of medical devices regulation? This research focuses on the state of medical devices regulations in West Africa. The research question is – what is the current state of medical devices regulations in West Africa.To answer this question, a review of publicly available data was conducted. First, the World Health Organization's website was reviewed for the most current data on the status of West African countries' medical devices regulations. Then, all the available websites of National Medicines Regulatory Authorities in West Africa were reviewed to ascertain their current medical devices regulatory status.The results show that West African countries are lagging behind in the regulation of medical devices. Only 28% and 17% of the countries have regulations and guidelines respectively. It is recommended that the international partners sensitize, educate and support the national medicines regulatory authorities in West Africa to build their regulatory framework for medical devices using the World Health Organization's model.

7. Determination of Groundwater Model Parameters by Artificial Immune Systems

Mirac Eryigit

This study proposes an optimization model using Artificial Immune Systems to determine simultaneously groundwater flow parameters such as hydraulic conductivity, transmissivity, storage coefficient and leakance. The modified Clonal Selection Algorithm, a class of Artificial Immune Systems, was used as a heuristic optimization method. MODFLOW was used in conjunction with the algorithm in MATLAB for simulating the groundwater flow. The input files for MODFLOW were obtained by GMS groundwater simulator. The model was applied to two different hypothetical groundwater systems under transient conditions to test its performance. The results demonstrated that the model could estimate the groundwater parameters successfully and was applicable for groundwater modelling.

8. HAWTs with hydrostatic and regular transmissions

Antonio Esquivel

The performance of a horizontal axis wind turbine (HAWT) with hydrostatic transmission was compared with that of a standard unit using well-controlled experiments. The power output of the hydrostatic unit is used for electricity generation, and/or reverse osmosis to obtain fresh water. Furthermore, the hydrostatic transmission allows for moving the major electro-mechanical components located in the hub to the ground level. The associated changes resulted in reductions of approximately 30% of the total mass of the unit, and of about 7 to 14% of the cost of the energy. The reconfiguration of the structure of the turbine also implied changes in the response of the system to turbulence.

9. Extruded zein to enhance gluten-free doughs rheological properties

Enrico Federici

Gluten-free products demand has constantly rise in the last year, due to increasing number of celiac consumers. Furthermore, a growing number of consumers decide to remove or reduce gluten from their diet. However, gluten removal remains a major technological challenge, in fact gluten-free product are generally of lower quality compared to gluten containing options. Zein is potentially a useful ingredient for gluten-free breads based upon previous studies forming viscoelastic doughs when mixed above the glass transition temperature. However, zein based doughs didn't show strain hardening behavior, which is an important property for breadmaking of wheat bread. To enhance zein as an ingredient for gluten-free breads, doughs were made with extruded zein at different temperatures, water and starch mixtures. Mixograph properties, creep-recovery and extension test were performed to evaluate the dough rheological properties. SDS-page were performed to investigate change in zein molecular weight after extrusion. Different doughs prepared showed a comparable elasticity to wheat dough control. Extrusion of zein at 160°C increased viscosity and strain-hardening behavior. Both smaller peptides and large aggregates were observed by SDS-PAGE in zein extruded at 160°C, potentially explaining different rheological properties of doughs incorporating zein extruded at 160°C. This study showed how the addition of zein extruded at 160°C generated strain hardening behavior, which in wheat doughs has been correlated with bread quality and gas retention, thus extruded zein will be of potential interest in the production of bread.

10. Magnetic Drug Filtration for cancer chemotherapy

Wonseok Heo

Drugs used in cancer chemotherapy target specific sites of the disease, where higher drug concentrations are desirable; however, the increase dosing can cause side effects. We collaborate with the University of California San Francisco on developing catheter-based devices to selectively remove specific drugs from the blood stream in order to reduce systemic toxicities. This work is focused on a magnetic filter device which can capture chemotherapy agents bound to the Ferumoxytol, i.e. FDA-approved superparamagnetic iron-oxide nanoparticles (SPIONs). After the drugs injected in the supplying arteries have had an effect on the tumor, their excessive amount can be filtered by an arrangement of cylindrical magnets deployed in the draining veins during the procedure.

The motion of the SPIONs is governed by both magnetic and hydrodynamic forces and thus depends on the magnetic field gradient and fluid velocity. In this study, alternative configurations of the magnetic filter were examined to optimize SPIONs capture. Multi-physics CFD simulations were conducted for cylindrical magnets with diametrical and axial magnetization. Magnetic devices with different spacing between the magnets were simulated and the numerical results were compared to in vitro experiments. Furthermore, the magnets deployed in series and in parallel were evaluated. Preliminary results show that placing the magnets in the near-wall regions where velocity is decreased can improve particle capture as compared to the original design with the magnets deployed along the centerline of the vessel. Filtering devices with various configurations and magnetic parameters will be further analyzed by coupling hemodynamics, electromagnetism, and particle dynamics, in order to optimize filtering performance. The ultimate goal is to develop a device filtering up to 90% of the toxins in the first pass, without causing flow stagnation and thrombosis.

11. Unlocking and characterizing novel biosynthetic capabilities of anaerobic fungi for biotechnology

Ethan Hillman

Anaerobic fungi are potentially powerful platforms for biotechnology that remain unexploited due to a lack of genetic tools. These fungi have the largest repertoire of enzymes for degradation of lignocellulose and are native to the competitive gastrointestinal tracts of large herbivores where they are the primary degraders of plant biomass. While these enzymes have been noted for their value to the bioenergy sector, anaerobic fungi hold enormous potential for natural products, which historically form the basis of some of the most critical drugs in modern medicine, such as penicillin and lovastatin. Each of their genomes encode as many as 20 biosynthetic gene clusters (BGCs) that may produce novel medicines; however, the cryptic expression of these BGCs hinders our ability to characterize them in the lab. My work focuses on creating a genetic toolbox that enables further study and exploitation of these degradative enzymes and BGCs. Specifically, this toolbox will be comprised of promoters, terminators, selection markers, reporter genes, plasmids, and CRISPR-based gene editing systems that will allow us to unlock the potential of these fungi for biofuel production and drug discovery. To date, I have demonstrated the functionality of a putative promoter, introduced heterologous proteins, and directed protein expression to several intracellular compartments. Once this system is optimized, these tools will enable biofuel production, characterization of novel BGCs, as well as direct and indirect engineering strategies of anaerobic fungi that enable valuable products to be made from plant waste material.

12. Leveraging epigenetics as a genome engineering tool in anaerobic gut fungi

Casey Hooker

Early diverging anaerobic fungi (phylum Neocallimastigomycota) encode the largest array of lignocellulose degrading enzymes in the fungal kingdom, and are therefore poised to advance renewable biochemical technologies. However, there is a lack of tools to genetically engineer these organisms. Similarly, the role of chromatin structure in regulating gene expression has not been determined for any organisms in this phylum. We are building a genome engineering toolbox for this phylum using a novel isolate of Neocallimastix as a model system (Neocallimastix sp. Gf-Ma). Specifically, our lab is investigating the role of histone post translational modifications and their relation to carbohydrate active enzyme expression on different substrates. Using histone deacetylase inhibitors to control H3K4 and H3K27 trimethylation, among others, we are able to increase xylanase activity by almost 100%. Similarly we have also characterized the role of DNA methyltransferase inhibitors and their role in gene expression. Current efforts are aimed at developing methods to reproducibly isolate fungal histone proteins for ChIPseq analyses. Traditional methods to isolate histone protein from fungi rely on enzymatic lysis due to the thick and recalcitrant cell wall, however we show that these enzymes cleave the histone N-terminal tails, and are thus not suitable for fungal cell lysis. Our studies demonstrate for the first time that anaerobic fungi use epigenetic mechanisms for carbohydrate active enzyme expression and establish their role in lignocellulose hydrolysis. Our work provides insight into the mechanisms that control anaerobic fungal plant-degradation abilities and develops facile tools to enhance activity for efficient plant degradation.

13. Influence of Surface Compositional Difference on Surface Energy During Powder Flow

Camila Garcia Jange

In this study, the dominant intermolecular interactions at powder surfaces were investigated using inverse gas chromatography. Silica beads coated with molasses, corn starch, butter, or wheat gluten were used as model powders to emulate the interactions of surface components present in common food powders. The flow properties of the powders were analyzed using a rotational shear cell device at ambient conditions (25 ºC and 40 % relative humidity). A positive correlation ($r = 0.72$, $p < 0.05$) between the acid-base ratio (accounting for the ratio between the number of electron acceptors to electron donor surface sites) and the flow factor (flowability indicator, ffc at 1 kPa pre-shear stress) was observed for all the size ranges of surface-modified silica beads and industry-grade powders (modified corn starch and palm oil powders). The results depict the importance of acid-base surface components in understanding the mechanistic influence of pre-load molecular dynamics on the bulk flowability.

14. Analysis and inference of initial data used to establish a One Health AMR surveillance system

Sneha Jha

Relevant antimicrobial resistance (AMR) data was integrated from publicly available datasets that included data contributed by the National Antimicrobial Resistance Monitoring System (NARMS) and National Center for Biotechnology Information (NCBI). In order to model a real-time monitoring algorithm to detect emergence of new AMR phenotypes and spread of existing AMR phenotypes across species, thorough analysis of these data was necessary.

15. Functional Analysis of Bacteriophage Proteins

Emily Ann Kerstiens

Purdue partners with the SEA-Phages program to allow undergraduate students to discover and analyze the genomes of novel bacteriophage, viruses that infect bacteria. When annotating these genomes, there are many proteins that do not have a known function because the current methods of assigning functions do not yield any results. This project studies Purdue phage genomes, the proteins found in these genomes, and specifically focuses on finding new ways to assign function to those that currently have none.

16. Inertial migration of a deformable capsule in an oscillatory flow in a microchannel

Ali Lafzi

Dynamics of a single deformable capsule in an oscillatory flow of a Newtonian fluid in a microchannel is studied numerically. This type of flow enables the focusing of any type of extremely small biological particle by eliminating the necessity to design impossibly long channels. The equilibrium position of the capsule changes with the addition of an oscillation frequency to the pressure gradient wave. This change also depends on the capsule deformability and channel flow rate.

17. Microstructure of the cacao powder and the relevant of lipids content in a fluidized setting.

Hector Lozano-Perez

Stickiness and low flowability phenomena are detrimental and commonly encountered during various unit operations, more specifically during fluidization in the manufacturing of powders. This research deals with having a fundamental understanding of the microstructure of the cacao powder. The cacao granules consist of a binary system, an internal structure and lipid layers at the surface. Higher pressure in the pressing step led to a decrease of the lipid content in the particle. Additionally, fine particles obtained by appropriate milling exhibited better consumer satisfaction and acceptability. This research evaluated how the amount of lipids contained in the particle affect the performance of cacao powder during fluidization.

18. Menstrual Cups for Women's Empowerment - A case study in Northern India

Pranav Mohan

Menstrual management is in need of attention in urban and rural India. The lack of proper waste disposal causes disposable products to clog toilets or contribute to disease prevalence when thrown in open landfills and ponds. The taboo and stigma surrounding menstruation contributes heavily to the lack of sufficient education and discussion regarding menstrual management products. Through a grant called the Project for Peace: Menstrual Cups for Women's Empowerment, we introduced a sustainable menstrual management product: the menstrual cup. Our survey consisted of 200 responses from volunteers who used the menstrual cup. The phone-survey was conducted over a five-month period. Results post-menstrual cup use included 50% of respondents stating that it was easier to discuss menstruation; 98% reported no odor; 92% stated increase environmental consideration with menstrual cycle. Additionally, 38% of menstrual cup users reported having leaking issues. Further research is being conducted regarding how to identify the cause and address the solution to the leakage problem that users experienced.

19. Low-Cost, User-Friendly Biosensor for Bovine Respiratory Disease (BRD)

Suraj Mohan

Pathogenic bacteria and viruses pose serious health concerns and economical burdens in modern day animal agriculture. Due to the long processing times of traditional diagnostic tests, typical treatment of diseases caused by these biological agents involves trial-by-error antibiotic cocktails. However, this treatment strategy often results in antibiotic resistant bacteria and an increased risk of livestock death before successful care. As such, there is a growing need to develop diagnostic tests that can detect the presence of these disease-causing pathogens at a fraction of the time of traditional assays. This project aims to address such a need by developing a paper-microfluidic biosensor capable of testing animal samples for multiple infectious bacteria and viruses in a matter of hours rather than days. By applying alternative DNA-detection technologies and basic optical recognition, this biosensor will be capable of being more accurate and precise than traditional PCR screenings, while also being field deployable.

20. Areca Palm Sheath, a Bio-Degradable Alternative for Plastic

Debapriya Pinaki Mohanty

One common and short-term use of plastics is in the food industry e.g., packaging and cutlery. This has spawned interest in finding bio-degradable material replacements that are mechanically, physically and aesthetically equal to if not superior to plastics. Areca palm sheath, a plant-based bio-degradable material, can be used for manufacturing various cutlery such as plates, bowls, and spoons. This is already in practice in India and other South Asian countries for more than a century, despite little knowledge about the mechanical and physical properties of this material. One major limitation of the material of relevance to the food sector is its hydrophilic nature: water penetration into the sheath causing the material to soggy. To advance the shelf life of the material, it is therefore critical to understand the nature of diffusion of water through the sheath. In this study, we report on results of an investigation of diffusion of water through the sheath. We measure the diffusion coefficient and directly observe the progression of the water front within the sheath. Areca sheath has a porous microstructure and it takes ~ 30 minutes for the water to penetrate through the thickness (~ 3 mm) of the sheath. We study the effect of temperature (250C to 800C) and NaCl concentration on the diffusion process. With increases in NaCl concentration, the diffusion coefficient of water increases and become maximum at ~ 5% of NaCl concentration, after which diffusion coefficient drops. The diffusion coefficient of water increases with temperature. Two possible ways of reducing diffusion are demonstrated; 1) by coating the surface with edible hydrophobic substrates such as bees' wax and carnauba wax, and 2) by reducing the porosity of the material through compression of the sample.

21. Farm-Related Injuries and Fatalities Involving Children, Youth and Young Workers during Manure Storage, Handling and Transport

Mahmoud Nour

Manure storage, handling, and transport facilities and equipment have been recognized as being associated with life threatening hazards on many livestock farms. These hazards have been documented in prior research as including: 1) exposure to toxic manure gases or lack of adequate oxygen in enclosed structures which can be fatal to both humans and livestock; 2) below and above ground liquid manure storage structures that have the potential risk for drowning and falling; and 3) mechanical hazards associated with manure handling and transport equipment, including entanglement, road collisions, runover and equipment failure. Over the past 40 years, Purdue University's Agricultural Safety and Health Program (PUASHP) has collected, documented, and maintained data regarding agricultural-related injuries and fatalities associated with agricultural confined spaces. As part of ongoing surveillance, a total of 369 fatal and non-fatal cases relating to manure storage, handling and transport equipment, and facilities have been documented. Of these, 89 have involved children, youth and young farm workers ages (birth–21) documented between 1975 and 2019. The purpose of this study was to summarize these 89 documented cases to better understand contributing factors and to develop recommendations for evidence-based strategies to reduce the frequency and severity of these incidents. Though recognized as not comprehensive for all incidents of this type, the data represent the largest data set known to exist and provides insight into a previously unstudied hazard facing children and youth living and working on, and visiting farms as non-workers.

22. Global proteome analysis of phage Ochi17-infected Mycobacterium smegmatis reveals novel insights in phage-bacteria interaction

Ikenna Okekeogbu

The potential for phages to serve as both therapeutic agents and in broad applications ranging from food bio-preservation, wastewater treatment, and disease diagnosis, has led to renewed interest in the study of phage-bacteria interactions. Phages attack their hosts by hijacking their molecular machinery and using it for their own replication, subsequently shutting off the host macromolecular synthesis. However, not much is known about how this mechanism occurs, especially at the translational level. A total of 2,188 proteins were identified from label-free tandem mass spectrometry based quantitative proteomics of phage Ochi17-infected Mycobacterium smegmatis, with 299 significantly upregulated and 135 downregulated proteins. The results showed significant enrichment of homologous recombination and amino acid (arginine, proline, glutamate and histidine) metabolism pathways, and transcriptional factors, indicating phage Ochi17 DNA integration into the host's genome and a consequent hijack of the host's molecular machinery. We also reported significant differential expression of proteins involved in antibiotics metabolism, suggesting another form of antiphage response from the host M. smegmatis. This study provides the first global proteome investigation of any phage-infected bacteria with respect to the host bacterium response and would contribute in engineering phages that can overcome various defense strategies employed by host bacteria.

23. An effort at improving reliability of laboratory data in titrimetric analysis for zinc sulfate tablets using validated spreadsheet calculators

Mercy Okezue

The high cost of laboratory automation causes barriers in compliance with data integrity requirements for low-and medium income countries. Regulatory decisions are based on data from quality control tests on pharmaceutical products. The titrimetric assay for Zinc Sulfate (ZnSO4) tablets involves time-consuming steps that require mathematical formulae prone to manual calculation errors. To achieve consistency, save costs, and improve data integrity, validated spreadsheets were developed for the two critical steps in the analysis of ZnSO4 tablets: standardization of 0.1M Sodium Edetate (EDTA) solution, and the complexometric titration assay procedure.

The United States Pharmacopoeia method was used to create a process flow for the assay of ZnSO4 tablets and the different formulae were inputted into spreadsheets to automate calculations. Steps were created within the automated system to ensure validity of replicate analysis in titrimetric procedures. Validations were conducted using five data sets of manually computed assay results.

The acceptance criteria set for the protocol were met as there were significant P-values ($\alpha < 0.05$, at 95% Confidence Interval) from students' t-test evaluation of the mean values for manual-calculated and spreadsheet results at all levels of the analysis flow.

Right-first-time analysis and principles of data integrity were maintained through the use of validated spreadsheet calculators in titrimetric evaluations of ZnSO4 tablets. Human errors were minimized in titrimetric analysis calculations when procedures were automated in quality control laboratories. The assay procedure was achieved in a time-efficient manner with greater level of accuracy that promoted cost savings for laboratory business models.

24. Monitoring stored grain to manage quality

Akhere Olenloa

The increased production and ever-rising demand of grains for food, feed, fuel and biobased products emphasizes the importance of good grain storage management to prevent deterioration and financial losses. A common approach of stored grain monitoring is the continuous measurement of spatial temperature, moisture content and carbon dioxide (CO_2) of the bulk stored in a bin or flat storage structure to determine when grain is going out of condition. However, the challenge with current monitoring systems is that they do not provide stored grain managers with effective and simple analytical tools that would interpret the vast amount of data collected to help make better actionable and timely management decisions. Additionally, while CO_2 has been shown to provide a timely indication of stored grain going out of condition in a bin, understanding of CO_2 data in relation to stored grain condition is still vague. In this study, three experimental set-ups monitoring stored shelled corn in mini-bins (55 gallons) were carried out under indoor room temperature condition. The temperature, moisture and CO_2 levels of the stored grain in the mini-bins at 14.5%, stored grain at 14.5% with a small controlled volume at the center having 18% and stored grain at 14.5% with a small controlled volume having an elevated insect pest (maize weevil) population were monitored. In another setup, 500 bu pilot bins with about 14.5% shelled corn, temperature, moisture and CO_2 levels were also monitored. Research on how to analyze the data to clearly determine the stored grain condition and its value over time is one of the major goals of this effort.

25. Effect of phenolic compounds and ash on enzymatic liquefaction of corn stover pellets

Maulik Patel

Utilization of biomass for biofuels or other industrial production is advantageous due to its low cost and environmental friendly nature. However, for industrial scale utilization of it, high loadings (> 20% w/v) of biomass across the process are necessary. Handling of high solids biomass slurries is difficult and costly. Improvement of slurries characteristics will lead to less downtime and better yields. The enzymatic hydrolysis of untreated biomass can change its physical property and can make it to flow (liquefaction). At high solids loadings, there are multiple inhibitors that may limit enzyme efficiency and liquefaction. The impact of individual inhibitors during liquefaction is not known. In this work, phenolic compounds and ash were evaluated. Corn stover pellets were liquefied at three solid loadings (1%, 15% and 30%) with 1FPU/g corn stover pellets (or 2.25 mg protein/ g corn stover pellets Celluclast 1.5L) in a stirred reactor with 600ml reaction volume at 50 ºC and 180 rpm, all activities were measured after 2 hours. The enzyme activity decreased with the increasing biomass loading and associated phenolic content. At the lowest solids loading, endoglucanase activity was reduced by 45%, xylanase by 35%. The increase in the phenolic content at 30% solids, may be associated to the reduction of 78% of endoglucanase activity, and removal of all xylanase activity, since phenolics are known to strongly inhibit cellulolytic and hemicellulolytic enzymes. A protective effect was observed when ash was added. When ash (10%) was added to 20% solids, only 3% reduction in endoglucanase and 19 % reduction in xylanase activity after 2h were observed compared to 58% loss of endoglucanase and 95% loss of xylanase without ash. These results provide information needed for the further development of enzyme liquefaction and enzyme preparations used.

26. Gradual Acclimatization of Anaerobic Digesters to Biodiesel Waste Products

Jennifer Rackliffe

The biodiesel industry produces organic byproducts such as biodiesel wastewater and crude glycerol. These byproducts have little value without additional treatment but disposal can be costly. Anaerobic digestion (AD) is one potential treatment method that can add value to the waste through production of renewable methane gas. While previous studies have shown that digestion of crude glycerol and biodiesel wastewater is possible, few have attempted to demonstrate gradual acclimatization to these feedstocks. Using semi-continuous digesters, gradual acclimatization was demonstrated using two different loading rates and two inocula. Clear differences were shown between the treatments. More research is needed to determine optimal acclimatization rates.

27. The biochemical impact of diet on the dynamics of gut microbiome in infants

Sainitya Revuru

Colonization of gut commences immediately after birth and is crucial in the development of infants. Breastfed babies possess better immunity than those fed with infant formula. Effect of formula feed on gut microbiome is poorly understood. The paper hypothesizes that modulating dietary components of infant formula can help in predicting and controlling infant microbiome to our favor. The biochemical link is highlighted through the structure-function interplay between dietary changes and gut bacterial colonization. Initially, select species of interest of intestinal microbiota were identified and selected. A chemically defined media (ZMB1) was developed to support high density growth of bacteria of interest. The density of cell growth over time was measured using spectrophotometry and growth curves were obtained from which analysis of how different carbon sources affected the growth of each microbe individually was carried out. The results highlight the biochemistry behind the experiment where the structure of the carbohydrate influences its uptake by bacteria. Growth of E.coli LF-82 and B.fragilis is observed in all the concentrations in the case of monosaccharides but for certain di-saccharides the growth depends on the type of glycosidic bond. These assays and functional profiles of bacteria help determine which sources of carbohydrates will promote the colonization of bacteria of interest in the gut-microbiome of the infant and which species are effective in modulating their own niche.

28. Enzymatic decay in epoxidation processes

Elena Robles Molina

Candida antarctica lipase B (CALB) is a promiscuous enzyme with the ability to perform several reactions. In the case of epoxidation of alkene materials, such as Soybean Oil in contact to Hydrogen Peroxide in a reactor under mild reactions. The results obtained reflect that CALB performs hydrolysis of triglycerides and synthesis of peracids with different reaction rates. The segmentation of the process presents a feasible alternative for an industrial process and further developments to a continuous reactor inside a packed bed of Immobilized CALB

29. Integrated techno-economic and life cycle assessment on craft beer production

Belen Salazar

Beer has been part of the civilized culture dating back to 5,000 B.C. and it is still one of the most important beverages in many countries. Beer can be produced at different scales, nowadays, craft brewery (microbrewery) has become more popular and represents 13.2% of the beer sales in the U.S. in 2018. Nonetheless, craft brewers face many challenges due to energy efficiency, resulting in low profitability margins and poor environmental performance. Therefore, there is a necessity for tools to analyze the energy efficiency profile of microbrewery and assess potential improvement strategies based on holistic modeling. This study developed an integrated Techno-Economic Analysis (TEA) and Life Cycle Assessment (LCA) to (i) evaluate the economic profitability of replacing the conventional steam boiler in a microbrewery facility by a a continuous water heater, and (ii) compare the environmental performance of ale and lager beer brewing at industrial and pilot scale. Labor, packaging and raw materials were the major operating costs of microbrewery. The simulation results of the average electricity and natural gas uses for craft beer production agreed well with the primary measurements. The net present value and internal rate of return obtained from the TEA indicated that the investment project of new water heating system would not be profitable. Moreover, the sensitivity analysis showed that the profit margins of the water heating system increases if the microbrewery increases its productivity. Beer processing accounted for the largest portion of the global warming, terrestrial acidification, freshwater eutrophication and water consumption of craft beer, and fermentation and maturation operations were the main contributors. The results obtained from this study can facilitate the decision-making process of microbrewers, technology providers and stakeholders to achieve a more sustainable beer production.

30. Strategies to improve the performance of a hydraulic crane

Annalisa Sciancalepore

Hydraulic machines are often characterized by high energy consumption and oscillatory behavior of their systems. Both of these phenomena affect considerably the behavior of load holding machines, such as the hydraulic crane taken as a reference machine for this study.

It is mandatory for load handling machines to be equipped with poppet components which guarantee the load holding function although they introduce oscillations in the system. Traditionally, the machine oscillations can be reduced by using a proper valve setting of the holding component, but it introduces high energy losses in the system.

Thus, this study aims to overcome these shortcomings by proposing different control strategies for two hydraulic configurations applied on the hydraulic crane: counterbalance valve with open center system and independent metering with poppet configuration.

A novel control strategy with a change of the valve setting is proposed for the counterbalance valve with over center configuration to improve the energy saving and the oscillatory behavior of the system. Whereas, an adaptive control strategy is developed in this work to overcome the same issues of the independent metering architecture.

Moreover, for the independent metering system prognostic strategies are successfully simulated using a neural network approach in order to prevent possible damage or failure of the system. In fact, malfunction of the components accentuates the energy consumption and the machine dynamics.

The control strategies tested on an ATLAS crane showed that the novel control strategy in the open center hydraulic circuit reduces the energy consumption of the system by 34% and the adaptive control strategy used in independent metering improved the dynamic behavior by 12%.

31. Discussion of Modeling Bacteriophage Infection

Gillian Smith

Purdue University partners with the SEA-PHAGES program to create curriculum in which undergraduate students can discover and analyze the genomes of novel bacteriophage, viruses that infect bacteria. These novel phages are archived, sequenced, and annotated to gain a larger understanding of how they function and of their applications. However, the intricacies of phage infection are mainly unexplored, especially when tied to real data. In this project, the infection rate of selected Purdue phage will be modeled with respect to lipidomic and proteomic data in order to delve deeper into the complexity of bacteriophage infection.

32. Framework for water management in the FEW Nexus in a mixed land use watershed

Camilo Torres

Water governance and water management has been a topic vastly researched in the last few decades. Different approaches and tools have been considered including the Integrated Water Resources Management (IWRM). However, these approaches have not been widely implemented since they are water-focused and do not include the relationship between water and other components that are closely related. A nexus methodology has been considered as an alternative because it considers the relationship between water and other components like energy, food, land and health. Moreover, this approach, may be beneficial to decision makers and stockholders since they can recognize the impacts and potential tradeoffs they can make to optimize their resources in all the components of the nexus. This study is intended to develop a framework for a food-energy-water nexus (FEW) approach for a watershed located in the Andean region. A characterization of climate, land cover land use, water quality, and streamflow were conducted to get a better understanding of key components of the FEW nexus. The watershed studied was mainly impacted by the urban and agricultural activities in the mid and lower part of the basin. The river partly recovered after passing through the urban area; however, the river may be impaired for agricultural and human consumption without the proper treatment.

33. A rational approach for production of Nano-emulsified essential oils

Pablo Vega

Essential oils (EOs) are concentrated complex blends of natural-occurring volatile organic compounds extracted from plant tissues through mechanical processes such as pressing, steam distillation or solvent extraction. Due to their naturally occurring chemical diversity and biological versatility, the potential applications of EOs spans from the pharmaceuticals to food and agriculture.

When presented as nano-emulsions, the bioactivity of EOs and its long term stability are enhanced. However, the production of industrial-scale EO-based nano-emulsions it's been lagged by the lack of a rational approach to produce them under a cost/effective scheme.

Here, we present a simple, rapid and rational approach to produce highly stable EO-nanoemulsions (EONEs) with a low batch-to bact variablity. The bioactivity of 8 different EONEs was tested against malignant human melanoma cells. We found that Nano-emulsions containing oregano, peppermint, and red thyme significantly reduced both, the cell viability and metabolic rate of human malignant melanoma cells when tested at a concentration of 0.5mg/mL.

34. Economic and energy impacts of wind energy expansion in the US using multi-regional input output (MRIO) tables.

Venkata Sai Gargeya Vunnava

Renewable energy sources help reduce the environmental load of the energy sector. However, when new renewable energy sources, such as wind energy infrastructure is deployed in a region, it can have economic and energy consumption impacts both in the region being deployed and the regions which interact with the deployed region. In this study, an economic multi-regional input output (MRIO) table developed for the US was used to assess the multi-regional economic and energy impacts of wind energy expansion in the US. The US MRIO table was developed using the Industrial Ecology Virtual Lab project that uses non-survey approaches to build MRIO tables with the help of different national and regional level statistics followed by constrained optimization. For quantifying the impact of wind energy expansion, it was assumed that wind energy farms were installed in top ten wind energy producing states. The developed US MRIO table, coupled with input output analysis, was then used to find out how the deployment of wind energy in these ten states affect the remaining 42 regions in the US. The local impact data of installing wind turbines in each of the ten states was obtained from the National Renewable Energy Lab's Jobs and Economic Development Impact (JEDI) model which was used as the feed data to calculate final demand changes for sectors driving the total multiple regional impact using US MRIO model. The changes in economic throughputs of different economic sectors in each of the 52 regions was quantified for the year 2017. The total economic impact was found to be 26 billion dollars of which 3 billion dollars were associated with the states where no new wind energy capacity was installed. Installation of new energy production capacity also results in change in energy consumption by different economic sectors across US. Using the US-MRIO model and the energy intensity of manufacturing sectors from survey data by U.S government the energy consumption increase due to addition of wind farms was found to be about 6952 trillion of btu for the total change in economic throughput. Primary metal manufacturing and Machinery manufacturing sectors stood out amongst other manufacturing sectors with considerable change in energy consumption with an increase of 3074 trillion of btu and 1537 trillions of btu. The change in energy consumption was found at a four census (North, South, Midwest and West regions of the US) regional level.

35. Quantifying Market Barriers to the Adoption of Renewables using Portfolio Optimization

Elizabeth Wachs

Concerns about global warming have spurred large-scale investments in renewable energy, yet progress has been slower than needed to forestall these problems, in part due to barriers to social acceptance of the systemic change required. An important question remains when trying to diagnose market barriers in a dynamic political landscape in the US; what is the optimal electricity generation portfolio? Without examining this question, it is difficult to say whether market barriers exist at all. While individual technologies vary in their attractiveness for new implementation, a combination of technologies is ultimately achieved, with their own risks and complementarities. The current work looks at the optimal portfolio from a social/sustainability perspective as well as a profit perspective with special attention to defining risk factors for the two perspectives. In this way we can see the differences between what appears optimal for society versus the perspective of investors, who we postulate are the key decision makers regarding energy. The difference between the optimal portfolios from the standpoints of investors and society is likely due to market barriers, since it reflects a lack of profitability for socially desirable outcomes. Identifying risk factors is important because the political landscape is changing rapidly. Aligning social and market preferences is key to planning, and it is important to provide industry tools to diagnose risks from a social point of view.

36. Drug Recalls Analysis and Prediction

Mian Yang

Beneath the great number of recalls, vulnerable patients are endangered by the defective drugs, the companies themselves are also paying substantive financial and reputation prices. In this our study, we use python extract raw data from the public domain, use the statistical analytics tool to examine the drug recalls, and further build a prediction model for drug recall with the machine learning method.

37. Construction and Operation of a Multiplexed Microfiltration Device to Facilitate Rapid Pathogen Detection

Jessica Zuponcic

Millions of Americans contract food poisoning or are affected by microbial pathogens each year. Rapid, sensitive detection of dilute levels of pathogens in foods, produce, water, and biomanufacturing process samples is key to consumer protection; however, current enrichment methods require as much as a full day to enrich viable bacterial pathogens to detectable levels. Our lab previously demonstrated the ability to concentrate and detect dilute levels of pathogens, within eight hours, from various food matrices using microfiltration in our continuous cell concentration device (i.e. C3D) with one or two filter modules. Here, we show results from a work recently published as a short communication (Zuponcic et al. (2019) Biotechnol Progress) describing the design, materials and construction, layout, and operational characteristics of a four filter module multiplexed system based on a 4 channel device. Benefits are a 2x greater sample capacity than an equivalent duplex system (achieving the same time to result of less than 8 hours from sample preparation to detection), simpler operation, and a footprint enabling operation inside a biosafety cabinet instead of requiring a BSL-2 room. Flow rate variability through four channels fit within an operational envelope of ± 3%; flow rates are reproducible from one run to the next thus ensuring relatively simple, concurrent processing of samples. Additionally, we show results from another recently published work (Ku et al. (2019) Biotechnol Progress) where Salmonella is concentrated from spinach samples, combined with a short enrichment step, to enable rapid detection.

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