Second
ORNL Symposium
On Water-Energy Nexus
Hosted by TTU

July 10, 2015

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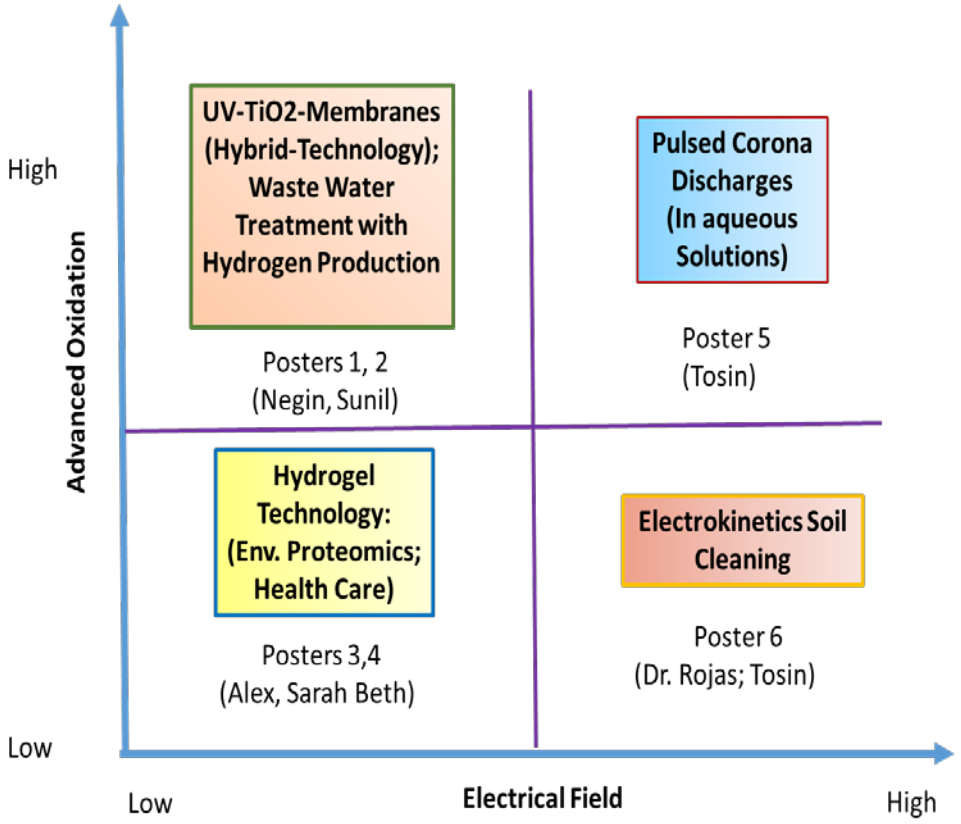
Advanced Oxidation and Electrical Field Technology in Wastewater Treatment and Soil Cleaning-Dr. Pedro E. Arce's Group

Selected Projects



Collaborators

- Dr. J. Robby Sanders (ChE)
- Dr. Satish Mahajan (EE)
- Dr. Holly Stretz (ChE)
- Dr. Y. Liu (Mathematics)
- Dr. M Machida (Mathematics)
- Dr. Laura Arias Chavez (ChE)
- Dr. Veronica Carranza (SP, Brazil)

Funding Sources

CONICYT-Chile, Sao Paulo Univ. Foundation (Brazil), TTU-Research Office, Center for Manufacture Research (TTU), College of Engineering (TTU), Water Center (TTU), CRMC-Cookeville, TN, ORNL

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Hydrogeology/Hydrology

Research involves use of hydrochemistry and environmental isotopes to study hydrological and chemical processes, and to understand questions related to water quantity, quality, dependent ecosystems, and availability of watersheds

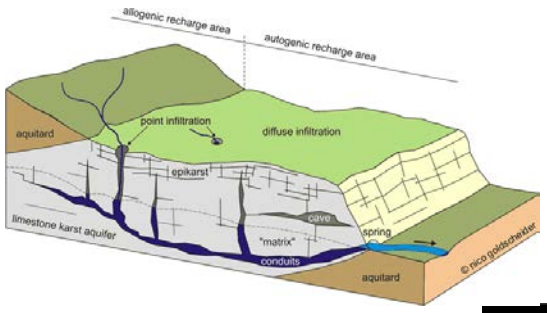
Research Interest Areas

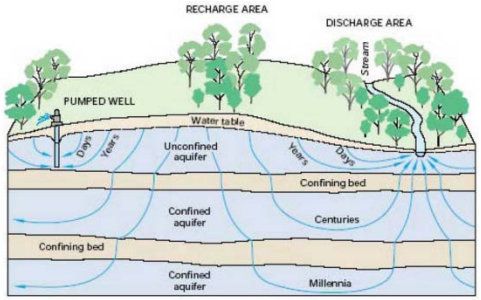
- Hydrogeology of Intermontane basins
- Hydrogeology of mined watershed
- Hydrogeology of Karst watershed
- Effect of aqueous geochemistry on biological processes and solute transport

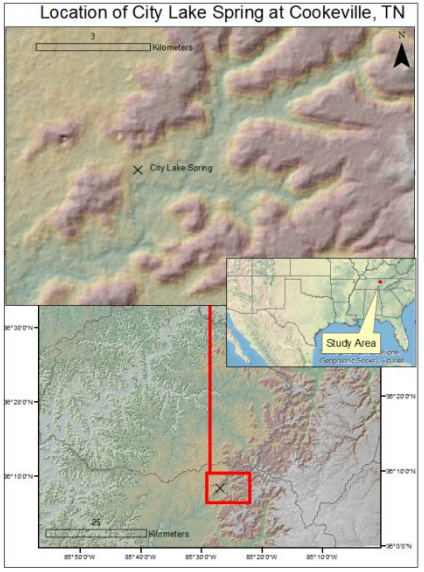
Joseph Asante
Earth Sciences

Ongoing Research Projects

- I am working with undergraduate students in the department of Earth Sciences on developing a new technique for karstic aquifer systems contamination risk assessment







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Fisheries Science

Applied research aimed at conserving and enhancing recreational, commercial, and imperiled fish species

Research Interest Areas

- Thermal ecology of fishes
- Conservation of caviar-producing species
- Optimizing management strategies for recreational fisheries
- Adaptive management of regulated rivers
- Invasive species biology

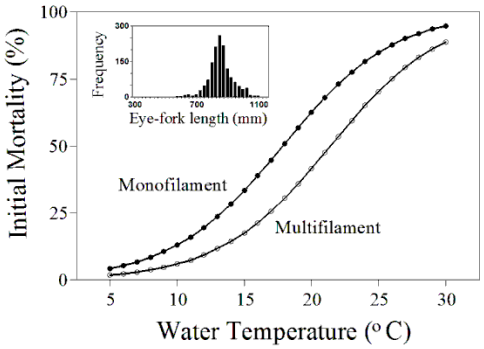
Phil Bettoli

U.S. Geological Survey

Tennessee Cooperative Fisheries Research Unit

Ongoing Research Projects

- Distribution and impact of invasive Asian carp
- Population dynamics of catfish in Tennessee reservoirs



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USGS

Technical Director, iCube

Developing immersive visualizations introducing new concepts and difficult to comprehend topics.

David Brown
Research

Research Interest Areas

- **Immersive Visualization**
- **Virtual Reality**
- **Simulation Development**
- **Education**

Ongoing Research Projects

- Constructing 3-D virtual representation of Fort Louden and the Tuskegee Cherokee settlement circa 1750
- Creating 3-D model of tornado activity focusing on training civilians proper safety protocols
- Developing immersive simulation showcasing benefits of lightweight manufacturing of automobiles
- Developing immersive simulation focused on Concussion education for football players

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Population and Community Ecology of Rare Mammals

Research Examining Habitat, Population, and Community Relationships and the Status of Rare, Threatened, Endangered, and Understudied Mammal Species

Dr. Brian Carver
Dept. of Biology

Research Interest Areas

- Winter Ecology of Bats and Implications for Impacts from White-Nose Syndrome
- Population Status of Understudied Mammal Species
- Management of Rare Mammals
- Ecology of Bats in Eastern North America

Ongoing Research Projects

- Winter Ecology of Threatened Northern Long-eared Bats
- Ecology of Sympatric Southeastern Myotis and Rafinesque's Big-eared Bats
- Distribution and Habitat Associations of Eastern Spotted Skunks in Tennessee
- Small Mammals in Hemlock and Associated Forest Stands

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Membranes for Sustainability at the Water – Energy – Food Nexus

(1) New membrane applications for better resource production and recovery and (2) Nano-scale design and fabrication of membranes to support these applications

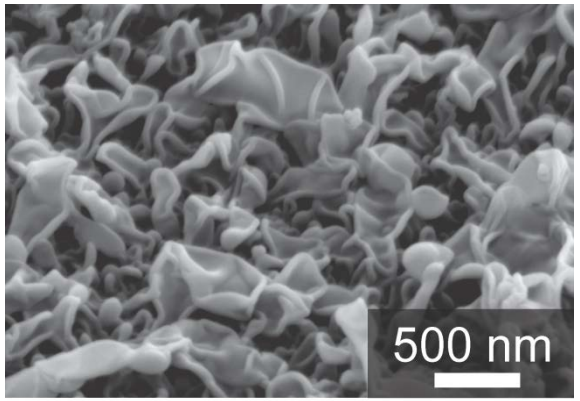
Research Interest Areas

- Forward osmosis and reverse osmosis for lower-impact separations in the water, agricultural, and manufacturing sectors
- Pressure retarded osmosis for clean, renewable energy from salinity gradients (in nature or in anthropogenic waste)
- Novel membrane structures and materials for reduced fouling

Laura H. Arias Chavez
Chemical Engineering

Ongoing Research Projects

- Recovering water and products from wastewater for the oil & gas industry and the food processing industry
- Investigating the role of membrane active layers in fouling
- Removing recalcitrant contaminants in industrial wastewater (*collaboration with P. Arce*)
- Modelling the effect of membrane support layer structure on performance in forward osmosis (*collab. with E. Languri*)



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Stream Fish and Macroinvertebrate Ecology

Investigating freshwater fish and macroinvertebrate communities in relation to management of lotic aquatic resources.

Research Interest Areas

- Restoration and management of native fish populations
- Habitat use by rare lotic fishes and macroinvertebrates
- Responses of macroinvertebrate and fish communities to environmental disturbances
- Aquaculture

Brad Cook
Biology

Ongoing Research Projects

- Assessment of southern Appalachian brook trout propagation for restoring Tennessee populations

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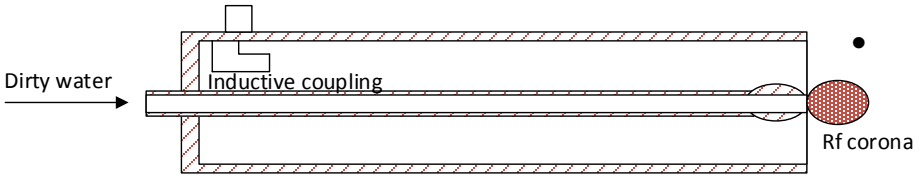
Center for Energy Systems Research (CESR)



Research Interest Areas

- RF Plasma for Water Cleanup
- Pumped Storage Integration

Robert Craven
R&D Engineer

Ongoing Research Projects

Smart Grid Test Beds

- Microgrid testbed
  - Two synchronous generators
  - Line impedance
  - Solar emulator
  - Wind emulator
  - Load box
  - Central Control
  - Historian
- Power Grid Testbed
  - 6 generators, 40 busses, loads, etc.
- DC Bus Testbed
  - Programmable loads, inverters, generators, etc.

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Biological Wastewater Treatment Processes and Environmental Microbiology Research

Understanding the structure and function of microbial communities in engineered systems, with the ultimate goal of improving environmental and public health.

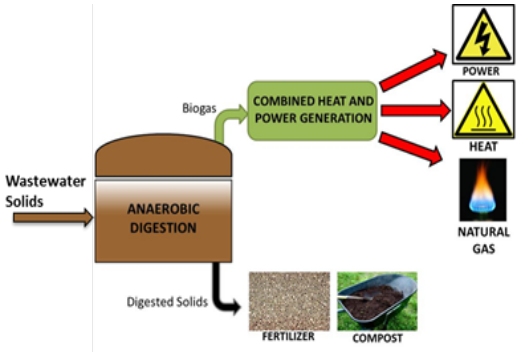
Tania Datta

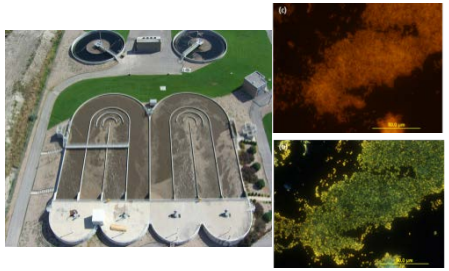
Research Interest Areas

- Biological Nutrient Removal Processes from Wastewater
- Environmental Microbiology
- Bioenergy Production through Anaerobic Processes
- Sustainable Decision-Making
- Water and Sanitation in Developing Countries

Ongoing Research Projects

- Linking complex organic feedstock characteristics to microbial metabolism in anaerobic codigester processes
- Understanding the structural and functional diversity of microbial communities involved in biological phosphorus removal process in water reclamation facilities
- Development of a holistic decision-making framework for sustainable solids waste management alternatives





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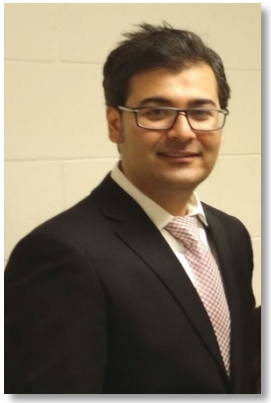
Computational Modeling and Experimental Investigation of Membrane for Sustainability at the Water – Energy Nexus

(1) Computational modeling of transport phenomena in membranes
(2) Fabrication and modification of nano-composite membranes with enhanced properties

Research Interest Areas

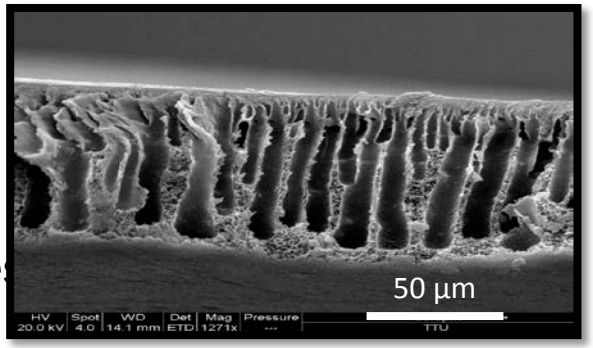
- Simulation and modeling of transport phenomena in membranes (computational fluid dynamics)
- Mixed matrix nanoparticle-polymer membranes: synthesis, fabrication, characterization, modification and performance for water treatment
- Natural organic matter aggregations and interactions in water purification



Milad R. Esfahani, Ph.D.
Water Center

Ongoing Research Projects

- Modelling and experimental investigation of the effects of membrane support layer structure on forward osmosis performance (*Advisors: Drs. Languri and Chavez)*
- Nanocomposite membrane antifouling enhancement: Effect of titanium dioxide nanoparticles and multiwall carbon nanoparticles
- Investigation of humic acid aggregation behaviors during the membrane filtration (Collaboration with Dr. H.Stretz)



TiO_2 -MWCNT nanocomposite ultrafiltration membrane

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Molecular Approaches to the Assessment and Conservation of Biological Diversity

We are applying sophisticated molecular tools to improve the management strategies for conserving imperiled and endangered aquatic biodiversity,

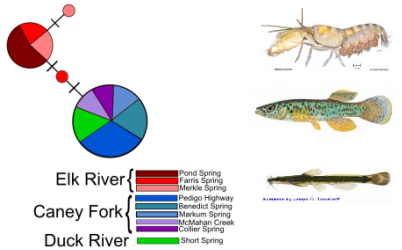
Research Interest Areas

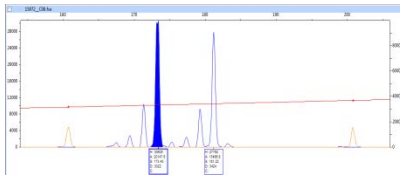
- Assessing levels of biodiversity at the species level.
- Examining patterns of divergence in incipient species.
- Identifying units of conservation and management priorities.
- Developing environmental DNA sampling techniques for defining the distribution of endangered and imperiled aquatic species.

Dr. Carla Hurt
Assistant Professor of Biology

Ongoing Research Projects

- Microsatellite approach for assessing the success of stocking and recruitment in Sauger.
- Next-generation GBS approach to measuring the rate and pattern of DNA substitutions in the nuclear genome.
- Evaluating ESUs and MUs in the imperiled Barrens Topminnow
- Environmental DNA assessment of the distribution of the endangered pygmy madtom





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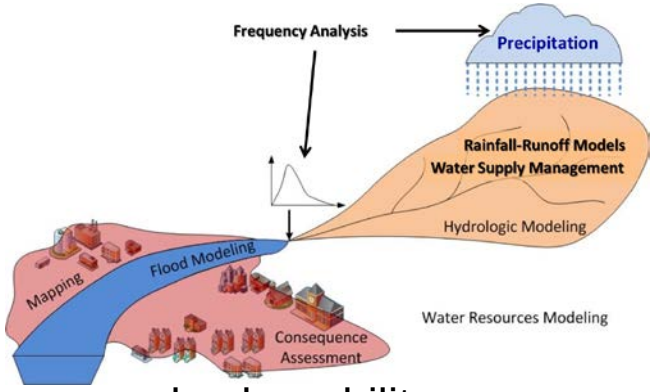
WAter Resources Modeling & Simulation (Tech-WARMS)

Our broad research focus aims "***at understanding the complex interplay water resources has with climate, urbanization, energy development, and how that affects infrastructure sustainability & resilience.***"

Alfred J. Kalyanapu
Civil and Environmental Engineering
http://www.techwarms.org

Research Areas & Interests

- Advanced Scientific Computing
- Flood Modeling and Simulation
- Monte Carlo based Uncertainty Analysis
- Natural Hazards and Extreme Events
- Watershed Hydrology
- Integrated Watershed Management



Ongoing & Recent Projects

- Extending projected PMP/PMFs to flood risk consequences and vulnerability assessment (*ORNL Collaboration* - Drs. Shih-Chieh [ESD] and Anantharaj [NCCS])
- Development of Watershed Quality Index for Watershed Management
- River Conveyance Correction for using digital topographic data for flood risk modeling
- Risk and reliability analysis for dam gate optimizations in a Dam network
- Probabilistic framework for dam breach modeling and simulation
- Flood impacts on Agricultural Production in Tennessee and Cumberland River Basins

Robert Kissell

I study factors affecting population size and model habitat selection; I work primarily with mammals and typically address questions at the landscape level.

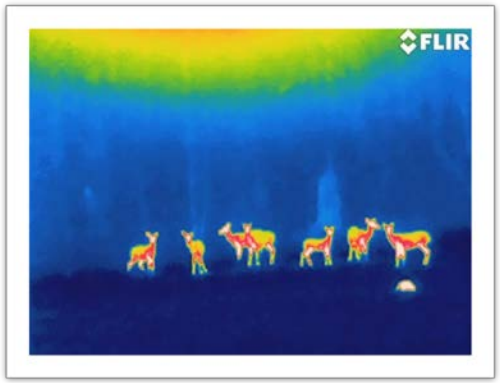
Department
of Biology

Research Interest Areas

- **Population ecology of mammals**
- **Species-habitat associations**

Ongoing Research Projects

- Factors Affecting the Distribution of Long-tailed Weasels
- Relationships among Density, Harvest, and Landscape Metrics for White-tailed Deer in Tennessee



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Energy Sector's Water Use

A Core Challenge: Interdependence of energy systems and local availability of water often in large quantities

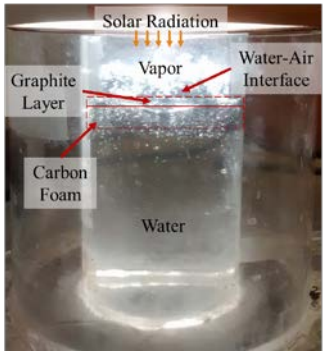
Research Interest Areas

- **Energy System's Cooling Tower**: To improve the cooling tower efficiency to work with no or minimum water loss.
- **Solar Evaporation and Boiling Improvement**: Significantly improved solar evaporation at the water-air interface.
- **Forward Osmosis Water Treatment**: Forward osmosis membrane support layer improvement.

Ehsan Languri, PhD
Mechanical Engineering
elanguri@tntech.edu

Ongoing Research Projects

- Cooling tower efficiency improvement: dynamic modeling, field demonstration and testing (with Dr. Cunningham)
- Solar Heat Localization at Water-Air Interface: experimental and numerical modeling
- Forward Osmosis Water Treatment: numerical modeling on membrane redesign using CFD (with Dr. Chavez)



Enhanced Boiling

Cooling Tower

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Virtual Reality Marketing & Education

Implementing emerging business technologies to assist organizations in marketing critical public policy challenges like environmental stewardship and public safety.

Research Interest Areas

- **Virtual Reality in Education**
- **Opening Minds to Advanced Manufacturing**
- **Traffic Safety Education**
- **Marketing for Public Policy**
- **Conservation Education**

Kevin Liska

Ongoing Research Projects

- Oculus Rift project with TN Aquarium
- Virtual reality education in areas of climate change, water conservation, traffic safety, and fire safety.
- App development for student advising
- MakerMinded.org – ReduceTnCrashes.org

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Integration of Renewable Energy (Water) Sources with the Electrical Grid

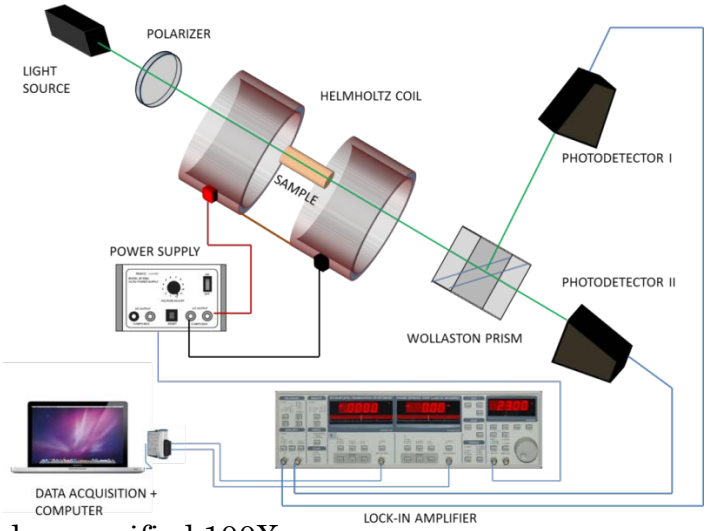
Satish M. Mahajan
Director, Center for Energy Systems Research (CESR)

Research Interest Areas

- **Electrical Power generation with Artificial Leaf, Salinity Differences, etc.**
- **Advanced Sensors with Real Time Reporting Capabilities**

Ongoing Research Projects

- **Wind Emulator using DC machines**
- **Vehicle to Grid (V2G) integration in the grid**
- **High Resolution Magneto-optic and Fiber-optic sensors**



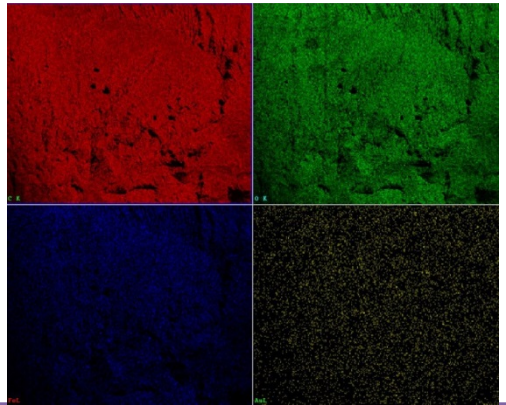


Figure: ESEM of Fe_2O_3:Au PMMA sample magnified 100X. (a) top left, carbon K energy (b) top right, oxygen K energy (c) bottom left, iron L energy line (d) bottom right, gold L energy line

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Conservation Ecology of Endangered Freshwater Fish and Crayfish

Providing scientifically sound solutions for the management and recovery of imperiled species in the Southeastern and Midwestern U.S.A.

Research Interest Areas

- Watershed Threat Analysis
- Fish and Crayfish Life History and Ecology
- Habitat Conservation Planning
- Endangered Species Management
- Population Assessment and Monitoring

Hayden Mattingly

Ongoing Research Projects

- Life history, population status, and watershed threat analysis of the Obey Crayfish
- Environmental DNA detection, habitat use, and population status of the endangered Pygmy Madtom
- Population genetics of the threatened Blackside Dace in Kentucky and Tennessee

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Stream Structure and Function Relationships

Understanding the impacts of stream physical, chemical, and biological changes on ecosystem structure, biogeochemical cycling, and energy flow.

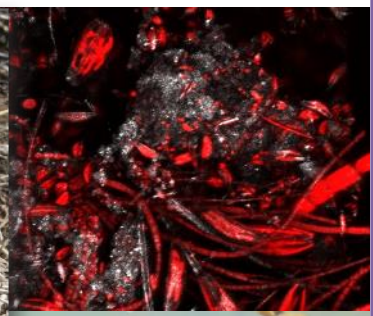
Research Interest Areas

- Stream community/disturbance ecology
- Biogeochemical cycling
- Algal ecology: diversity and function relationships
- Infrared microspectroscopy

Justin Murdock
Biology

Ongoing Research Projects

- Microbial roles in agricultural stream metabolism and nutrient cycling.
- *Didymosphenia geminata* distribution in Great Smoky Mountains National Park.
- Invasive species impacts on Southern Appalachian stream food webs.
- Detecting carbon uptake in single algal cells within natural assemblages.



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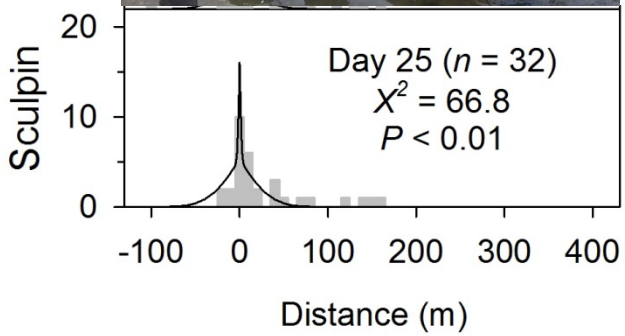
Fish Ecology and Conservation

Spatial and Temporal Drivers of Fish Community Structure

Research Interest Areas

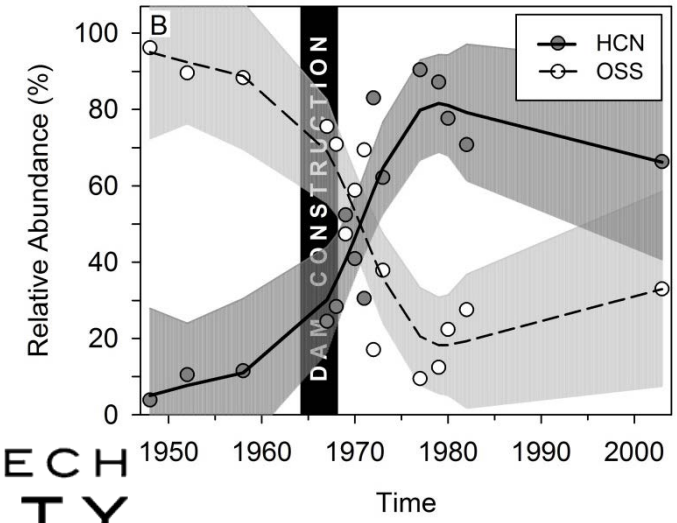
- **Stream Habitat Connectivity**
- **Fish-Flow Relationships**
- **Landscape Ecology**
- **Fish Dispersal**

Josh Perkin
Biology



Ongoing Research Projects

- Characterizing Banded Sculpin Dispersal
- Multi-Decadal Fish Community Response to Flow Regulation
- Excel-Based Fish Habitat Connectivity Metrics (Ryan McMannamay, ORNL)
- Fragmentation of Great Plains Fish Communities (Brenda Pracheil, ORNL)



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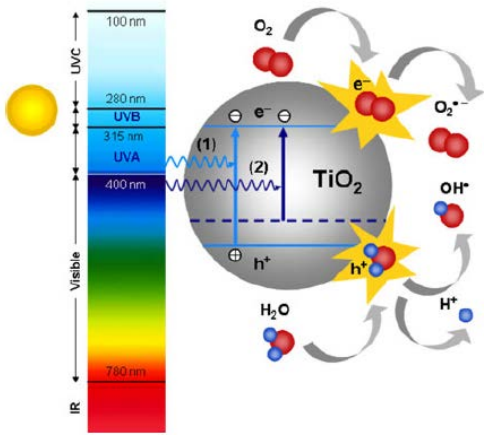
Wastewater Detox. Using Innovative Photocatalysts, Metals Recovery from Waste Streams

Developing a visible light responding photocatalyst for hydroxyl radical gen.
Understanding kinetics & hydrodynamics of metals recovery in SVFB

Research Interest Areas

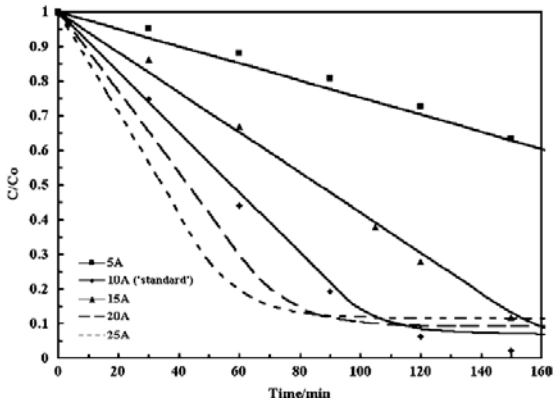
- Development of novel catalysts:
  - **PEM fuel cells**
  - **Metal-air batteries**
  - **Solar fuel generation**
  - **Solar wastewater treatment**
- Environmental Electrochemistry
  - **Pollutant re-cycling**

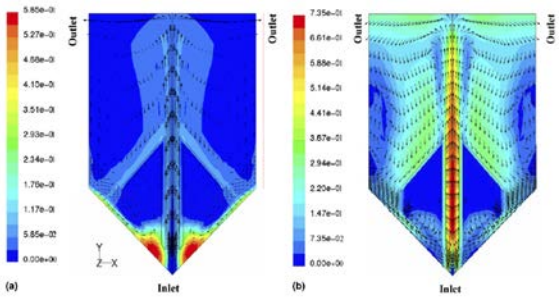


Pezhman Shirvanian

Ongoing Research Projects

- Development of guidelines for optimal design of photocatalysts for water splitting and hydrogen generation.
- Low PGM fuel cell electrocatalyst development using novel thin film technology.
- Enhancement of charge acceptance in NaMx batteries based on auxiliary networks.





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