KU CEAE
Civil, Environmental and Architectural Engineering

KU TORP
Tertiary Oil Recovery Program

**Joint Industry Project: Sustainable Hydrocarbon Recovery in Unconventional Reservoirs**

**Thrust Area 1: Produced Water Treatment**

The University of Kansas' (KU) **Civil, Environmental, and Architectural Engineering Department** (CEAE) and **Tertiary Oil Recovery Program** (TORP) have joined together to build a team of researchers dedicated to developing sustainable energy approaches and protecting our nation's water resources.


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| **Principal Investigator (PI):** | **Dr. Karen Peltier (TORP) (kpeltier@ku.edu, 785-864-2912)** |
| **Co-PIs:** | **Dr. Steve Randtke (CEAE) (srandtke@ku.edu),** |
| | **Dr. Belinda Sturm (CEAE) (bmcswain@ku.edu)** |
| | **Dr. Edward Peltier (CEAE) (epeltier@ku.edu)** |
| **Team:** | **post-doctoral associate (1), field liaison engineer (1)** |


## Projects

The goal of KU's produced water treatment research is to develop new, economical methods for treating water focusing on gaps in current technology. Two key targets have been identified and are listed below. By listening to our partner's needs and learning from their expertise, we intend to grow these areas and develop new ones, accelerating technology development and solving problems.

### 1. *Removal of naturally occurring radioactive materials (NORMs) and scale-causing minerals using nanotechnology*

Polyelectrolyte complex (PEC) systems have been used extensively for the encapsulation of chemicals, primarily to protect nanosized packets in harsh environments prior to release. These complexes have been widely implemented in drug delivery schemes by pharmaceutical companies. TORP has successfully developed PECs for oilfield applications, including the entrapment of chemicals as disparate as enzymes and chromium ions.

The goal of this research is to develop new PECs capable of entrapping strontium, barium, and radium cations in produced wate. Due to their chemical similarities (all are alkaline earth metals in Group 2 of the periodic table, although only radium is radioactive in its naturally occurring form), similar PEC formulations can be developed to entrap all three metals. Once the PEC is formed around the metal cation, depending on its size and electrostatic properties, it will either settle out or can be easily filtered. Because PECs are simple to use, produce a small volume of sludge, and can be regenerated for reuse once they have been separated from the produced water, they could be significantly more economical than current water treatment techniques when it comes to scale prevention (strontium and barium) and radionuclide (radium) removal.

### 2. *Application of fluidized bed biological reactors for organics removal*

In wastewater treatment, fluidized bed reactors are used to increase contact between chemical contaminants and reactor components, speeding up reaction rates and enabling the processing of large volumes in less space. Typically, a fluid, in our case produced water, is passed through a granular solid material at high speeds such that the solid material is mobilized. This material can be an ion exchange resin, activated carbon, or even a biofilm deposited on a substrate. The choice of solid component depends on the contaminant being targeted.

Research will focus on the removal of organic carbon species found in produced water, including dispersed oil, production chemicals such as surfactants and polymers, and production solids, which cause fouling. Microbes suited for breaking down produced water organic components in the presence of high salinity can be grown on support materials to form biofilms and used in fluidized bed bioreactors to break down organic materials by converting them into smaller, more manageable compounds. By using a fluidized bed reactor design, we will maximize the reaction efficiency between the biofilm and the produced water enabling the continuous processing of produced water.

Removal of organic chemicals is particularly important if saline produced waters are to be processed through membrane treatment for desalination and reuse. In membrane filtration units, suspended or dissolved organic compounds contribute to membrane fouling, decreased fluxes, and increased operating costs.

## Benefits to industry

- Strong track record with industry-focused research.
- Access to faculty and researchers who are experts in their field.
- Opportunities to meet students actively engaged in research, trained by a solid community of faculty and support staff with industry training and who value industry sponsored projects.
- Extensive experience working with Kansas-area producers to perform field tests.
- Fully equipped laboratories.

## Experience

By bringing together CEAE faculty members and TORP researchers, KU has created a cross-disciplinary team that understands both water quality issues and the needs of the oil and gas industry.

The project team includes CEAE faculty with extensive experience with the water quality concerns associated with hydraulic fracturing fluids and produced water, including a member of the Hydraulic Fracturing Research Advisory Panel of the U.S. E.P.A.'s Science Advisory Board. Specific areas of expertise include:

- Physical/chemical water treatment processes including coagulation, chemical precipitation, adsorption, oxidation, and membrane separation processes, especially with respect to their use in removing trace contaminants
- Analysis, removal, and speciation of metals in aqueous and solid-phase systems, including advanced analytical techniques to determine metal concentrations and speciation in contaminated soils and wastewater biosolids.
- Biological processes of wastewater treatment, bioreactor operation, and the application of molecular methods in water quality analysis.
- Characterization of microbial communities, including those recovered from oil wells in the Wellington Oil Field (KS)

TORP has 40 years of experience serving the needs of the oil and gas industry in Kansas and beyond, performing improved oil recovery research in the lab and in the field. TORP's ability to listen and meet industry's needs has resulted in multiple technologies being commercialized through joint development agreements with industry sponsors.

## Key Personnel

**Dr. Karen Peltier**, the Principal Investigator, is an Assistant Scientist and Director of Laboratories for the Tertiary Oil Recovery Program at the University of Kansas (KU). Prior to joining TORP in September 2009, Dr. Peltier was a program manager at Midwest Research Institute (now MRIGlobal). She has fourteen years of analytical chemistry research experience, working on method development in both industry and academic settings for the detection of trace chemicals.

**Dr. Stephen Randtke**, a Co-Principal Investigator, is an environmental engineering professor in the Department of Civil, Environmental, and Architectural Engineering at KU, with over 40 years of experience in the field of environmental engineering with a primary focus on water quality and treatment. He currently serves on the Hydraulic Fracturing Research Advisory Panel of the U.S. EPA's Science Advisory Board and is familiar with the water quality concerns associated with hydraulic fracturing fluids and produced water.

**Dr. Belinda Sturm**, a Co-Principal Investigator, is an environmental engineering associate professor in the Department of Civil, Environmental & Architectural Engineering at KU. She specializes in biological processes of wastewater treatment, bioreactor operation, and the application of molecular methods in water quality analysis. Dr. Sturm has also worked with the oil industry in Kansas investigating microbial communities recovered from several wells in the Wellington Oil Field.

**Dr. Edward Peltier**, a Co-Principal Investigator, is an environmental engineering associate professor in the Department of Civil, Environmental & Architectural Engineering at KU, with expertise in the fate and transformations of environmental contaminants in natural and engineered systems. He has extensive research experience in the analysis, removal and speciation of metals in both aqueous and solid-phase systems, including the use of advanced analytical techniques to determine metal concentrations and speciation in contaminated soils, wastewater biosolids, and diesel exhaust particulates.

## Facilities

The Environmental Engineering laboratory facilities occupy approximately 3,000 sq. ft. in three separate laboratories; the Environmental Research Laboratory (ERL), the Sustainable Technologies Laboratory (STL), and the Environmental Instrument Laboratory (EIL), which are seaparated for quality control purposes. The ERL includes the space and equipment necessary to perform chemical and biological experiments, including bench-scale fluidized bed reactor operations. The STL includes additional sample preparation and experiment space. The EIL houses analytical equipment for the detection of chemical and biological constituents of environmental systems. These labs are supplemented by TORP's research facilities which occupy approximately 4,000 sq. ft. TORP's laboratories are equipped to perform many aspects of oil recovery research, including analytical instruments specific to oil and gas research and anaerobic chambers for oxygen-free studies. Combined, these labs are equipped with the following instrumentation:

| Target Analytes/Properties | Analytical Techniques | Instrument(s) Available |
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| Basic chemical and physical properties of water (pH, temperature, alkalinity, conductivity, TDS, density, and major ion composition), oil (viscosity), and gels (rheology) | Standard Methods | Analytical balances, pH meters (with temperature probe), conductivity meters, titrators, ion chromatograph, atomic absorption or flame photometer, densitometer, viscometers, rheometers |
| Particle size distribution and zeta potential of PECs | Laser light scattering | Particle sizer and zeta potential analyzer (dynamic light scattering and phase analysis light scattering) |
| PECs, minerals, metals, corrosion and scale products, sulfides | Elemental analysis including Ba, Sr, Ra analysis | ICP-OES, ICP-MS, Atomic Absorption, Elemental Analyzer (CHNS,-O), scintillation counter |
| Dispersed oil, production chemicals, dissolved gases, waxes, organic carbon and nitrogen | Gas Chromatography (GC), Total Organic Carbon/ Total Nitrogen (TOC/TN) Optical Spectroscopy | GC-FID, GC-TCD, GC-MS-MS, TOC/TN Analyzer FTIR, UV-Vis, Raman |
| Production chemicals | Liquid Chromatography (LC) | HPLC-ELSD, HPLC-UV-Vis |
| PEC and mineral sample structure | Microscopy | Optical Microscopy, Fluorescence Microscopy, TEM, SEM |