Iowa Water Center
Annual Technical Report
FY 2017
Introduction

The Iowa Water Center entered its twelfth year with Dr. Richard Cruse as director during this project year. Successful 104b and information transfer projects guided the continued stability and growth of the Center in FY2017.
Research Program Introduction

In FY2017, the Iowa Water Center focused the RFP on nutrients and their impact on Iowa's waters and water management decisions. In addition to the typical seed grant program, IWC also sought applicants from graduate students nearing the end of their studies for a $5,000 grant allowing them to complete additional research objectives of products beyond the scope of their current water related funded project. The seed grant project funded an additional year for FY2016 project titled, "The role of iron mobility from anoxic sediments in stimulating harmful algal blooms", PI Elizabeth Swanner, Department of Geological & Atmospheric Sciences, Iowa State University. The Graduate Student Supplemental Research Competition funded three projects in FY2017:

• “Simulation of Watershed-Scale Nitrate Transport in Fractured Till Using Upscaled Parameters Obtained from Till Core,” PI Nathan Young, Ph.D. Candidate, Iowa State University

• “Quantifying the Role of Soils in Salinization: Winter Road Maintenance Impacts to Runoff and Right-of-Way,” PI Rebecca Kauten, PhD Student, University of Iowa

• “Enhancing phosphate removal in woodchip bioreactors,” PI Emily Martin, MS Student, Iowa State University

Additionally, a 104(g) National Competitive Grants Program project was funded for Iowa. The three-year project titled, "Fate and Ecological Impacts of Pharmaceuticals in a Temperate Stream Dominated by Wastewater Effluent" by PIs Gregory LeFevre, Rebecca Klaper, Dana Kolpin, and Luke Iwanowicz started on 09/05/17.
The role of iron mobility from anoxic sediments in stimulating harmful algal blooms

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>The role of iron mobility from anoxic sediments in stimulating harmful algal blooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2016IA267B</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/1/2016</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2018</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104B</td>
</tr>
<tr>
<td>Congressional District:</td>
<td>IA-004</td>
</tr>
<tr>
<td>Research Category:</td>
<td>Biological Sciences</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>Geochemical Processes, Nutrients, Water Quality</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Elizabeth Swanner</td>
</tr>
</tbody>
</table>

Publications

There are no publications.
1. Problem and Research Objectives

Cyanobacterial harmful algal blooms (CyanoHABs) in freshwaters, are increasing in frequency and severity in Iowa’s lakes. While excess nutrients due to heavy agriculture in the state are certainly important in stimulating HABs, this work looks at whether a secondary factor may be related to iron availability to Cyanobacteria. Cyanobacteria, which can release toxic compounds during blooms, have higher cellular demands for iron than other eukaryotic phytoplankton. In high productivity lakes, we hypothesize that decaying organic material can increase hypoxia in lake bottom waters, which can cause microbial mobilization of mineral iron out of sediments. We wonder if sedimentary fluxes of iron could therefore provide a feedback loop, further stimulating cyanoHABs.

Our scientific objectives are to:

1. Determine whether water column iron concentrations correlate with the presence and abundance of cyanobacteria and HABs and the absence of eukaryotic phytoplankton in a way that is distinct from the influence of P and nitrate.
2. Determine the potential of sediments to release iron, and quantify Fe fluxes.

Our hypothesis is that Fe(II) fluxes will increase from the sediments throughout the summer, corresponding to the onset of HABs. We anticipate that shallow lakes/sites will be most affected, because the sedimentary source of iron is proximal to the photic zone. We hypothesize that increasing anoxia through the summer will correspond to a shift from eukaryotic algae to cyanobacteria. We are investigating East Lake Okoboji, which is relatively shallow (mean depths 10 feet) has had Microcystis (toxin-producing cyanobacteria) blooms in recent years, and West Lake Okoboji, with a mean depth of 38 feet, which tends not to have such severe blooms, except in shallow areas.

2. Methodology

Our approach was to sample five sites in East and West Okoboji nine times throughout the HAB season in 2017 (see diagram above). Two sites (one in each lake) were shallow (1 m); two were intermediate depth (3 m); and one was deep (18 m). We took samples and made measurements for dissolved oxygen, temperature, microcystin, dissolved iron, ammonium, nitrate, and phosphate (total and dissolved).

To track the bloom, we employed a novel method (in its application to samples retrieved directly from lakes) called in vivo fluorescence. Surface water samples were measured in the
multi-wavelength fluorometer to assess the composition of the phytoplankton community based on the spectral characteristics of chlorophyll present in each class of phytoplankton (e.g. cyanobacteria, green algae, diatoms/dinoflagellates, and phycoerythrin-containing phytoplankton). The accuracy of this method is being validated with traditional optical microscopy counts.

To determine whether iron was released from sediments, we measured dissolved iron concentrations at every 3 m depth from surface to bottom of each site. We also collected shallow sediment cores from each site several times throughout the season. We used voltammetric microelectrodes and a micromanipulator to measure dissolved Fe(II) in sediment porewaters.

3. Principal Findings and Significance for the project year 3/1/17-2/28/18

In vivo chlorophyll measurements using the fluorometer successfully followed a cyanobacterial bloom from July through October, distinguishing cyanobacteria from other eukaryotic phytoplankton. The shallower East Okoboji (max depth 6 m) had about 10-fold higher concentrations of chlorophyll from cyanobacteria (max 45 µg L\(^{-1}\)) than West Okoboji (max depth 43 m; max chlorophyll 0.8 µg L\(^{-1}\)). Microcystin concentrations ranged from 5 to > 50µg L\(^{-1}\) in East Okoboji, while it was below detection in West Okoboji (<0.2 µg L\(^{-1}\)). Cyanobacteria and toxins persisted into October 2017. Schematic results are presented in a figure below.

Periodic hypoxic conditions were observed in bottom waters from a few sites during July and August, but no site was ever completely anoxic. Although voltammetric microelectrode profiles of sediment core porewaters occasionally detected aqueous Fe(II), it was not consistent enough to provide fluxes of sedimentary Fe to the water column. Furthermore, our water column profiles of dissolved Fe concentration did not increase with depth, which would be expected if Fe fluxes were coming from sediments. Because the dissolved Fe concentrations systematically dropped in both lakes throughout the summer, we proposed that sedimentary Fe minerals do not contribute to the lake Fe reservoir. Instead, we now suspect that the reservoir of Fe in the lake is drawn down by biological activity, and this Fe is released through decay of sedimented organic matter back into the lake over the winter. In support of this idea, dissolved Fe measurements that we made under ice from samples taken in February 2018 have the same Fe concentration as those from May 2017, before the bloom season. We are now investigating the hypothesis that cyanobacteria experience Fe starvation in mid- to late-summer, and may produce toxins such as microcystin to either acquire Fe, regulate Fe homeostasis, or for ecological competition, all ideas that have support from the literature.
4. Any notable achievements or awards resulting from work on this project

- A proposal based on preliminary findings of the *in vivo* fluorescence aspect of the work was submitted with collaborators at ISU and was selected for funding beginning in January 2018 (EPA-G2017-STAR-A1, Freshwater Harmful Algal Blooms: “A systems approach for understanding, predicting, and managing harmful algal blooms in Midwestern lakes.” PI: A Howe, Co-PI: K Ikuma, E Swanner, & J. Choi. 2018-2020 ($760,000 to ISU).
- PhD student Tania Leung received a Bowen Award, a $2000 scholarship from the Department of Geological & Atmospheric Sciences.
- PhD student Tania Leung presented a poster on this project at the Midwest Geobiology Conference in September 2018.
- Swanner initiated a collaborative pre-proposal for USGS 104g in February 2018 with collaborators from ISU and the USGS; we were not invited to submit a full proposal.

5. Publication citations associated with the project

We are currently preparing a manuscript detailing the results of the project, and anticipate it will be submitted in winter 2018-2019.
Enhancing phosphate removal in woodchip bioreactors

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>Enhancing phosphate removal in woodchip bioreactors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2017IA271B</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/1/2017</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2018</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104B</td>
</tr>
<tr>
<td>Congressional District:</td>
<td>IA-004</td>
</tr>
<tr>
<td>Research Category:</td>
<td>Water Quality</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>Agriculture, Non Point Pollution, Water Quality</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Emily Martin, Michelle Soupir</td>
</tr>
</tbody>
</table>

Publication

1. Problem and Research Objectives

Intensive farming and fertilizer application in the Upper Midwestern United States, coupled with an extensive subsurface tile drainage network has contributed to excessive nutrient loading to surface waters. Woodchip bioreactors are a cost effective and minimally invasive edge-of-field method designed to remove nitrate (NO$_3^-$) from subsurface drainage. There is potential to expand the range of pollutants removed by woodchip bioreactors to include phosphorus (P) by adding biochar as an amendment. The goal of this study was to assess biochar biomass source and pyrolysis temperature identify optimal treatment for to enhanced denitrification and P removal in woodchip bioreactors.

2. Methodology

Biochars originating from six biomasses were sourced from the BioCentury Research Farm in Boone, IA and one additional biomass from the City of Ames, IA Public Works. Of the six biomasses, two were hardwood woodchips, two were softwood woodchips, and two were herbaceous materials. The hardwood woodchips were Red Oak and Ash, both sourced from Central Iowa. The softwood woodchips were Mixed Pine from Michigan and Loblolly Pine (Pine-Southern Yellow) from the Southern United States. The herbaceous materials were Switchgrass and Corn Stover, both harvested locally. For the control, Ash woodchips were used without biochar addition. The Ash woodchips used in the control were obtained from the City of Ames, IA Public Works and had particle sizes >1 in. The biochar was created using three temperatures of slow pyrolysis by ARTichar (Prairie City, IA). Each biomass was produced at 400°C, 600°C, and 800°C to create a total of 18 biochars.

Particle Size

Particle size analysis was performed to assess the effects of pyrolysis temperature on particle size and nutrient removal capabilities. Four sieves were used (2 mm, 1 mm, 0.5 mm, and 0.25 mm) with a bottom pan to capture anything less than 0.25 mm. Each biochar had some loss to shaking due to the fine particle sizes, which was accounted for as dust. Before testing, the total amount of biochar being sampled was weighed. The pans were covered and shaken for three minutes to complete one test. After shaking, the biochar and sieve or pan was weighed and recorded. The sieve or pan weight was subtracted to get the final total for each particle size.

P sorption

For P sorption batch test experiments, 162 50 mL centrifuge tubes were label and filled with one gram of biochar (9 tubes for each biochar sample). A 500 mg P L$^{-1}$ solution was made with solid Potassium Phosphate Monobasic (KH$_2$PO$_4$) and 0.01 M Potassium Chloride (KCl) solution. From the 500 mg P L$^{-1}$ solution, standards were made at: 0, 0.2, 0.5, 1, 5, 10, 50, and 100 mg P L$^{-1}$. For each of the 18 biochars, 25 mL of the 9 P solution concentrations were added. For the 0 mg P L$^{-1}$ concentration, only 0.01 M KCl solution was added to the centrifuge tubes. The centrifuge tubes were sealed and placed horizontally on a reciprocal shaker for 24 hours at room temperature. Next, the samples were centrifuged for 15 minutes at 7,800 RPM and filtered through a 0.45 µm glass microfiber filter. The filtered samples were analyzed for dissolved
reactive P (DRP) on a Seal Analytical AQ2 automated spectrophotometer at a wavelength of 660 nm using method EPA-145-A, Rev. 1.

**Nitrate and Phosphate Batch Test**

For the NO₃⁻N batch test, 350 grams of Ash woodchips was mixed with 30 grams of biochar for a ratio of 12:1 (8.33%) and put into a 5 L container with 3 L of deionized (DI) water. This ratio was similar to the ratio used by Christianson et al. (2011) of 7-14% in a study also examining the effects of pyrolysis temperature on biochar as a bioreactor amendment. Three denitrifying microbes (*Bradyrhizobium japonicum*, *Pseudomonas stutzeri*, and DN-8A) were added with 5 mL of broth solution (Henry et al., 2004; Hendriks et al., 2000; Tiedje 1994). This mix was allowed to soak for 24 hours to allow microbial acclimation and to allow the biochar and woodchips to flush any nutrients to avoid an initial spike during the test. After 24 h, the biochar woodchip mix was drained and 2 L of nutrient solution was added. The nutrient solution was made to 30 mg L⁻¹ NO₃⁻N and 10 mg L⁻¹ PO₄³⁻ using KNO₃ and KH₂PO₄ - PO₄ with DI water, respectively. Samples were collected at 0, 4, 8, 12, and 24 hours. The samples were immediately filtered through a 0.45 µm glass microfiber filter and acidified using sulfuric acid (H₂SO₄).

Because the samples were filtered through a 0.45 µm glass microfiber filter, the P was considered dissolved reactive phosphorus (DRP). Samples were stored at 4°C until they were tested using the Seal Analytical AQ2 automated spectrophotometer using method EPA-114 for NO₃⁻N and EPA-146 for DRP.

3. **Principal Findings and Significance for the project year 3/1/17-2/28/18**

NO₃⁻N removal was not correlated with particle size, but the NO₃⁻N removal rates did have a positive correlation with pyrolysis temperature (r = 0.58, p < 0.05). When compared to a woodchip-only control, biochar produced at 800°C removed significantly more NO₃⁻N (p < 0.05). By biomass, Corn Stover removed the most NO₃⁻N on average and 30 percent more than the control, but this was not statistically significant. 11 of the 18 biochars leached PO₄³⁻ into the solution even when accounting for a 24-hour soaking period. As pyrolysis temperature increased, the amount of PO₄³⁻ leached decreased (r = -0.67, p < 0.05). More long-term studies are needed to understand the potential of biochar pyrolyzed at high temperatures to enhance nutrient removal in woodchip bioreactors.

4. **Any notable achievements or awards resulting from work on this project**

NA

5. **Publication citations associated with the project**

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>Simulation of Watershed-Scale Nitrate Transport in Fractured Till Using Upscaled Parameters Obtained from Till Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2017IA272B</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/1/2017</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2018</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104B</td>
</tr>
<tr>
<td>Congressional District:</td>
<td>IA-004</td>
</tr>
<tr>
<td>Research Category:</td>
<td>Ground-water Flow and Transport</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>Groundwater, Solute Transport, Nitrate Contamination</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Nathan Young, William Simpkins, Robert Horton</td>
</tr>
</tbody>
</table>

Publications

1. Problem and research objectives:

Nitrate contamination from agriculture is a major water-quality problem in Iowa and a contributor to hypoxia in the Gulf of Mexico (Burkart and James, 1999). Shallow groundwater is the primarily source of nitrate to the contamination of surface water in the state (Cambardella et al., 1999; Moorman et al., 1999). More recently, the groundwater contribution to tile drainage has been cited as a major contributor to contamination of the Raccoon River drinking water for the City of Des Moines (Tomer et al., 2003; Hatfield et al., 2009; Eller, 2015). Despite its importance to water-quality discussions, simulations of nitrate transport in groundwater to predict present and future concentrations in Iowa’s till-dominated watersheds are simplistic and rely on incorrect conceptual models. To date, black box, lumped parameter, or porous media (unfractured) models (Du et al., 2005; 2006; Schilling et al., 2013; Liang et al., 2015; McLellan et al., 2015) have been brought to bear on the problem, despite previous studies showing that fractures in till control solute (nitrate and pesticide) transport (Helmke, 2003; Helmke et al., 2005a,b). As a result, broad agricultural policies regarding water quality may have been promulgated based on simulations that do not represent real-world conditions and physical processes.

There is a need for an approach to watershed nitrate investigations that accurately represents the physical processes of groundwater flow and transport of nitrate in a 3-D, deterministic, distributed parameter, and holistic hydrologic framework. Such an approach would contain the following key items:

1. A straightforward field/laboratory method to acquire data on till fracture properties, such as fracture density, aperture, and orientation;
2. A method to estimate solute transport parameters using those properties, specifically including matrix diffusion of nitrate between the till matrix and the fractures;
3. A method to scale-up fracture flow and solute transport data from the core scale to the watershed scale.
4. Implementation of a model code that will simulate fracture flow at the watershed scale and do so within a reasonable computation time.

The project outlined in this proposal seeks to address these items and apply field sampling, energy industry-developed tools, and a 3-D hydrologic model to investigate fracture-controlled nitrate transport in groundwater at the watershed scale. The methodology will allow fracture flow to be modeled in watershed projects conducted in Midwest glacial environments and hence provide better predictions of nutrient flux from agricultural activities.

2. Methodology

This research has five primary components, each utilizing different methods and facilities:

1. Till core acquisition: 16-cm-diameter core excavated from North Dakota Access Pipeline trenches.
2. Numerical model experiments using information in (2) at the core scale to estimate REV size and EPM properties.
3. Laboratory column studies on 16-cm-diameter cores to serve as basis of comparison with computationally-derived parameters from (3).

4. Watershed scale modeling using the EPM data generated in (3) and (4) to investigate potentially enhanced nitrate flux in till at the watershed scale.

Funds from this grant will be directed towards component four. In order to determine how successful my numerical methods are at representing the hydraulic influence of fractures, the results of the core-scale numerical experiments will be compared against results of a suite of cores taken from three trenches associated with the Dakota Access Pipeline on Iowa State land. The opportunity to acquire these cores was unexpected, and, as a result, the costs of lab equipment associated with the expanded suite of experiments was not in my project budget. A total of 17 0.5-by-0.5-m blocks of till were carved out of the sidewalls of three separate trenches, representing a 4.5 mile transect of our study watershed. From these large blocks, a 16-by-16-cm subsample was carefully carved out in order to maintain the undisturbed nature of the fractures, and to prevent the creation of secondary features. After excavation, these subsamples were fitted into cylindrical PVC casings, and paraffin wax was poured between each sample and the casing to form a wax seal approximately 0.5-cm thick in order to prevent sidewall flow during the column experiment (Grisak and Pickens, 1981; Helmke, 2003). Room for a 0.5 cm sand pack was left at the top and bottom of each core, and a perforated tube was threaded through the pack to ensure uniform saturation of the core. Core ends were capped with rubber-coated plywood and sealed with silicone caulk. In the lab, cores will be inverted in order to saturate them from the bottom up, and a constant unit gradient will be imposed across the sample using a Mariotte bottle. After steady flow through the columns is established, a potassium bromide tracer will be added to the Mariotte bottle, and bromide concentrations in the core effluent will measured using the flow-through bromide electrodes that are requested as part of this proposal. Because of the anticipated slow rate of flow in the cores, the use of multiple electrodes simultaneously in multiple cores will accelerate data collection substantially.

From the bromide concentration data, breakthrough curves will be constructed and compared to core-scale HydroGeoSphere model results from component (3). The hydraulic conductivity (K) for each column will be computed using Darcy’s law and the measured total discharge (Q). The fracture porosity for each column will also be computed using the Cubic Law, and results will be compared with the fracture porosity of the stochastically-generated fracture networks contained in my core-scale models (Snow 1969; Helmke et al., 2005a).

3. Principal Findings and Significance for the project year 3/1/17-2/28/18

Flow experiments on the excavated till cores began shortly after the start of the funding period. The first three cores that were studied (one from Trench 1, two from Trench 2) had hydraulic conductivity values that ranged from $1 \times 10^{-4}$ to $5 \times 10^{-8}$ m/s, likely owing to the fact that the small sample size resulted in a variable amount of fracture connectivity in each core. These very high and very low K values (for till) resulted in flow rates that were either too fast or too slow for the flow-through bromide electrode to register a clear signal, despite its performing well during our proof-of-concept work. As a result, we had to abandon the prospect of using flow-through electrodes, and instead switched to measuring bromide concentrations in core effluent with a bromide probe and a fraction collector. Due to the length of time that it takes for a
single experiment to complete, and the fact that we only have one working fraction collector (replacements or repairs exceed the amount of the initial grant funds) we are only halfway through the suite of samples we collected. Experiments are currently continuing on the remaining samples from Trenches 1 and 3, the results of Trench 2 are shown in Figure 1.

![Figure 1](image.png)

**Figure 1.** Panel diagram showing stratigraphy of the second of the sampling trenches in our study area of Walnut Creek Watershed. Our data points are in black. Fracture intensity and log K include values taken another site approximately 500 meters away in order to provide additional hydrogeologic context for our data (Mohanty et al., 1994; yellow point), Johnson (1995; blue points) Helmke et al., (2005a; green points).

The results of flow and transport experiments conducted on cores from Trench 2 show that K and fracture intensity generally decrease with depth, which is supported by other studies that have been conducted in our study area (Johnson 1995, Helmke et al., 2005a,b). The increase in K around 2.75 m of depth may be a product of the till being slightly sandier as a result of the overlying interbedded sand lens, or due to our samples capturing a greater-than-average number of fractures—a distinct possibility given their small size.

The long runtimes of our laboratory experiments gave us ample time to work on the modeling component of the project. Perhaps the most significant finding for this project year was the identification of a representative elementary volume (REV) for our unit of study, the fractured till of the Dows Formation. We estimated the REV to be the critical volume after which changes in hydraulic conductivity with increasing block size are extremely small (Wang et al., 2002). Numerical simulations on model grids containing fracture networks representative of the
Dows Formation, indicate that the REV ranges in size from block volumes of around 5 m$^3$ for depths to 1 meter, and 7 m$^3$ for depths of 3 meters and below, as shown in Figure 2.

![Figure 2. REV estimation for models with fracture intensities that are representative of 1 meter of depth (blue) and 3 meters of depth (gray).](image)

These results indicate that laboratory experiments conducted on volumes of till smaller than these REV values will result in an insufficient number of fractures being contained in the sample, leading to results that may not be representative. Given that the samples we are running in the lab are substantially smaller than the REV size (0.0085 m$^3$), we are currently unsure how representative the values we obtain will be.

In addition to identifying the REV for the Dows Formation, a MATLAB script was developed to compute 3-D hydraulic conductivity tensors for both the matrix and fracture domains of the numerical models used in REV identification. The use of these tensors in a dual-continuum model has shown promise as a pathway for upscaling the anisotropy and preferential pathways imparted by fractures to the plot or watershed scale. A manuscript detailing the K tensor determination program is currently in preparation.

Citations


Johnson, B.J. 1995. Assessment of the fate and transport of nitrate in groundwater within the Walnut Creek watershed. Retrospective Theses and Dissertations. Iowa State University.


4. Awards

2016: Geological Society of America--Hydrogeology Division Student Research Grant Award
(Awarded shortly after submitting this grant proposal)
2017: 2nd Place, Student Research Talks – Modflow and More! 2017

5. Publication citations from this project


Quantifying the Role of Soils in Salinization: Winter Road Maintenance Impacts to Runoff and Right-of-Way

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>Quantifying the Role of Soils in Salinization: Winter Road Maintenance Impacts to Runoff and Right-of-Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2017IA273B</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/1/2017</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2018</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104B</td>
</tr>
<tr>
<td>Congressional District:</td>
<td>IA-002</td>
</tr>
<tr>
<td>Research Category:</td>
<td>Water Quality</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>Non Point Pollution, Water Quality, Geochemical Processes</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Rebecca Kauten</td>
</tr>
</tbody>
</table>

Publications

There are no publications.
OVERVIEW: This study applies new approaches to quantify the role of sediment in metal mobilization during winter runoff conditions. The objective is to expand sampling and analysis from winter roadway runoff to also consider soil quality as a means of characterizing the fate and transport of soluble pollutants in winter road maintenance regimes; thus reducing water contamination potential from winter road maintenance activities.

METHODOLOGY: Sampling locations for water chemistry analysis were also the source of sediments for analysis. Samples collected to date were air dried, ground with a mortar and pestle, and sieved through a mesh #20, 850 micrometer sieve. After initial preparation, samples were analyzed with a Niton XL3t on the soil setting modified to 60 seconds on the main, low, and high ranges.

INITIAL OUTPUTS: Sites sampled include two locations in Cedar Rapids and one location in Coralville. See attached map for site locations. In all instances the top three inches of soil were analyzed and compared. Due to differences in road conditions, such as having gravel shoulders, ditches, etc., each site sampling distance differs. Samples from the Harding site were collected two, four, six and eight feet away from the roadway. The McLoud Run site soils were collected two feet away from the road, including soils between the road and a paved bike path. At this site, both the top and bottom three inches of soil were analyzed from a 15 foot distance away from the road.

Samples were also collected from Iowa Highway 965 in Coralville, Iowa, at distances of one, five and ten feet from the roadway. In addition, samples were collected from locations within a bioretention cell adjacent to the roadway. Samples were analyzed from the top, middle and lower three inches of soil probe cores collected from the edge and center of the cell. Sediment accumulated behind a v-notch weir installed as part of the wet chemistry study associated with this site were also analyzed.

NEXT STEPS: Due to the delayed initial funding award, additional sampling has been delayed to spring of 2018. However, spring sampling will include analysis of sediment samples provided by the City of Cedar Rapids, collected during spring street sweeping activities. While not part of the initial scope of work, this additional data will enhance the project by providing insight to metal concentrations specifically sourced to sediments accumulating on streets.

Plans are to complete sediment sampling April to May, 2018, compare results to winter sampling wet chemistry data and compare concentrations of metals as part of the final analysis.
Fate and Ecological Impacts of Pharmaceuticals in a Temperate Stream Dominated by Wastewater Effluent

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>Fate and Ecological Impacts of Pharmaceuticals in a Temperate Stream Dominated by Wastewater Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2017IA276G</td>
</tr>
<tr>
<td>USGS Grant Number:</td>
<td></td>
</tr>
<tr>
<td>Start Date:</td>
<td>9/5/2017</td>
</tr>
<tr>
<td>End Date:</td>
<td>9/4/2020</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104G</td>
</tr>
<tr>
<td>Congressional District:</td>
<td></td>
</tr>
<tr>
<td>Research Category:</td>
<td>Water Quality</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>Wastewater, Water Quality, Toxic Substances</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Gregory LeFevre, Rebecca Klaper, Dana Kolpin, Luke Iwanowicz</td>
</tr>
</tbody>
</table>

Publications

There are no publications.
TITLE: Fate and Ecological Impacts of Pharmaceuticals in a Temperate Stream Dominated by Wastewater Effluent

Principal Investigator:

Gregory H. LeFevre; Assistant Professor, Department of Civil & Environmental Engineering; University of Iowa; gregory-lefevre@uiowa.edu; 319-335-5655

Co-Principal Investigators:

Rebecca D. Klaper; Professor, School of Freshwater Sciences; University of Wisconsin—Milwaukee; Director of the Great Lakes Genomic Center; rklaper@uwm.edu, 414-382-1713

Dana W. Kolpin; Research Hydrologist, Project Chief of the USGS CECs in the Environment Project, U.S. Geological Survey; Illinois-Iowa Water Science Center; dwkolpin@usgs.gov; 319-358-3614

Luke R. Iwanowicz; Research Biologist, Bioassay Core Technology Team Leader of the USGS Environmental Health Mission Area, U.S. Geological Survey; Leetown Science Center; liwanowicz@usgs.gov; 304-724-4550

1. Problem and Research Objectives. Wastewater effluent contains a complex mixture of anthropogenic chemicals, such as pharmaceuticals, collectively known as “contaminants of emerging concern” (CECs). Many wastewater-derived CECs have demonstrated deleterious effects to aquatic organisms, including endocrine disruption, development of intersex characteristics, and reduced fecundity. CEC impacts to ecosystems can be magnified under low-flow conditions where wastewater effluent represents a substantial or majority of streamflow. Effluent dominated streamflow conditions are becoming increasingly common in temperate regions (in addition to arid regions) and are expected to increase due to climate change, population shifts, and changing land uses. For example, prolonged drought increases relative concentrations of wastewater effluent from lack of dilution. Impacts to aquatic organisms are often the result of complex CEC mixtures during extended exposure, including uncharacterized compound interactions. Current understanding of CECs in the environment does not adequately account for complex interaction effects, how the complex mixtures evolve spatially / temporally, or how complex mixture composition relates to biological effects. There is a critical need to understand how changing CEC complex mixture composition relates to biological effects to better protect ecosystem health in freshwater resources and inform stakeholder decisions (e.g., wastewater treatment design / operation). In the absence of such knowledge, aquatic ecosystem degradation may occur, with implications to fish populations and associated food webs. The central objective of this research is to quantify the differential attenuation of pharmaceutical CECs and corresponding biological activity in a temperate stream dominated by wastewater effluent, with the goal of linking complex mixture composition to effects.
2. **Methodology.** The central research objective is being evaluated via two **specific project objectives** and associated **methods:** 1) Quantify changes in CEC complex mixture composition through space and time, and 2) Measure and relate the biological impacts of organisms to changing chemical exposure. During Year 1, bimonthly water samples are being gathered at four previously established sites (upstream, WWTP outfall, 100m downstream and ‘gage’ 5km downstream). Chemical composition of the 13 most abundant compounds / metabolites from preliminary investigation being quantified via liquid chromatography with tandem mass spectrometry (UIowa). Monthly samples are being quantified at the USGS National Water Quality Lab (110 compounds). During the monthly sampling, flows are also being measured. Water samples are being shipped to Wisconsin for estrogenicity exposure tests using laboratory quantitative PCR-based fish gene expression tests (UW-M) and to West Virginia for bioluminescent yeast (estrogenicity) nuclear receptor activation bioassays (USGS). During Year 2, in-stream caged fish experiments will be conducted to evaluate CEC exposure effects during reproduction (UW-M). Concurrent streamflow (USGS) and CEC chemical measurements will occur (UIowa). Water samples will be collected for laboratory batch tests (UIowa) to determine bulk chemical attenuation kinetics. During Year 3, data and statistical analysis will determine relationships between changing chemical composition exposure and quantified biological effects, providing predictive power to CEC attenuation, **linking CEC presence with effects.** Results interpretation and report writing will occur Year 3.

A schematic summary of the chemical sampling and analysis methods for the UIowa samples are shown below:
3. **Principal Findings and Significance for the project year 3/1/17-2/28/18.** The project began in September 2017. Thus far, we have been collecting water samples, measuring flows, and have chemical preliminary data. The exposure studies and bioassays are ongoing (data forthcoming). A few key Take-Home Findings of Significance from the Preliminary Data are summarized briefly below:

- Under low-flow conditions, the temperate region effluent dominated stream becomes a losing stream due to wastewater influx. Under many baseflow measurements, the effluent comprises the majority of the streamflow. Additionally, this means that the pharmaceuticals are entering into the shallow groundwater as water is recharged.

![Graph showing flow rate](image1)

- The concentration of pharmaceuticals varied considerably in space and time, but the “top 13” compounds contributed the vast majority of the mass. A few, common compounds comprise the majority of total pharmaceutical loading in the stream.

![Graph showing concentration](image2)

(110 compounds) (13 compounds)
• The total pharmaceutical loading in the effluent varied seasonally, and much of the seasonal variation related to allergy medicines. Use of antihistamines is likely much lower during the winter due to the lack of pollen, etc.

• Differential attenuation occurs for compounds in the stream, creating a changing complex ecological exposure mixture. For example, the ratio of metformin to its metabolite decreases in along the stream length suggesting transformation, whereas venlafaxine does not. Note that both venlafaxine and its metabolite desvenlafaxine are biologically active pharmaceuticals.

Differential transformation alters Parent-to-Product ratios.
4. **Any notable achievements or awards resulting from work on this project.** Because we have only had the project for 6 months of the reporting period, our notable achievements have been the successful collection of data and methods development. No awards have been received yet, as the project has just begun.

5. **Publication citations associated with the project.** No publications have yet been submitted/published because of the early stage of the project. During the phase of the project period, two conference abstracts were submitted and accepted for presentations during June 2018. One was at the International Conference on Emerging Contaminants in Oslo (presented by co-PI Klaper). The other presentation abstract accepted was to the 2018 Emerging Contaminants in the Aquatic Environment Conference in Champaign, IL (presented by Hui Zhi, graduate student of PI LeFevre). We will report the titles in the next year’s report because the talks will have been given in June 2018.
Stability in staff allowed for the continued growth of the Information Transfer program: Associate Director Melissa Miller has been with the program since 2012 and Hanna Bates joined the Iowa Water Center in late 2016. During this reporting period, Hanna’s role in Information Transfer grew as she took on more responsibilities and contributed new and creative ideas in this area.
Information Transfer 2017

Basic Information

<table>
<thead>
<tr>
<th>Title:</th>
<th>Information Transfer 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Number:</td>
<td>2017IA270B</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/1/2017</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2018</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>104B</td>
</tr>
<tr>
<td>Congressional District:</td>
<td>IA-004</td>
</tr>
<tr>
<td>Research Category:</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Focus Categories:</td>
<td>None, None, None</td>
</tr>
<tr>
<td>Descriptors:</td>
<td>None</td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>Richard Cruse</td>
</tr>
</tbody>
</table>

Publications

2017-2018 Iowa Water Center Information Transfer Project

The Iowa Water Center (IWC) places great importance on the Information Transfer aspect of its 104(b) program. Information Transfer activities achieve multiple goals for IWC: inform consumers about water related issues and research; connect researchers to complementing projects and facilitate collaboration; publicize IWC and its programs and products; and publicize and promote the Water Resources Research Institute Program and U.S. Geological Survey. IWC staff spends a significant portion of their time devoted to organizing, supporting and attending multiple education and outreach activities throughout the year. In addition to events, IWC staff prioritizes maintaining an effect web and social media presence.

Iowa Water Conference

The predominant Iowa Water Center information transfer product is the Iowa Water Conference, which was held March 22-23, 2017. The 2017 event was the 11th annual occurrence and had a theme of "Watershed Management: Partnerships for Progress." The conference has enjoyed stable participation rates the past several years, with 456 attendees, 28 attendees at the optional workshop, 34 exhibitors, and 52 poster displays. Evaluations received were positive.

Getting into Soil and Water

The 2017 edition of the publication Getting into Soil and Water, produced with the Soil and Water Conservation Club at Iowa State University, was released at the Iowa Water Conference in 2017. This 36-page publication contains articles from 19 authors, including IWC Program Assistant Hanna Bates along with representatives from all aspects of water in Iowa ranging from private industry to public research. It is available for download from http://www.water.iastate.edu/content/getting-soil-water. The 2017 publication was distributed to approximately 2000 individuals, including Iowa Water Conference attendees, high school science and vocational agriculture teachers, potential students to the Agronomy program at Iowa State University, and handed out at various conferences where IWC was an exhibitor.
Speaking engagements

Iowa Water Center Director Richard Cruse was invited to give presentations during this reporting period:


Cruse, Rick. August 5, 2017. Iowa International Agricultural Summit panel member – Environment. Des Moines, IA.


Iowa Water Center Associate Director Melissa Miller was invited to give presentations during this reporting period:


Iowa Water Center Program Assistant Hanna Bates was invited to give presentations during this reporting period:


Conference planning, exhibiting, and attendance

The Iowa Water Center and its staff assisted in planning and/or exhibiting at various events during the reporting year. At each event, staff identified themselves as Water Center representatives and shared information about IWC and its products. These events include:

- Iowa Watershed Academy - May 9, 2017
- State Interagency Missouri River Authority Meeting - June 13, 2017
- 2017 Soil Health Conference - February 16, 2017
- Conservation Districts of Iowa Annual Conference - July 17, 2017
- Prairie Lakes Conference - August 10-11, 2017
- Iowa Environmental Council 2017 Conference - October 5, 2017
- Iowa Watershed Academy - October 24, 2017
- Watershed Planning Advisory Council Meeting - October 31, 2017
- Statewide WMA Meeting - February 21, 2018

IWC staff also attended various meetings throughout the year, including those of watershed organizations and for research projects.

Web presence

The Iowa Water Center recognizes the importance of an effective web presence. To that end, IWC maintained an engaging website, bi-monthly electronic newsletters, and social media accounts on Twitter and Facebook.

Website: During the reporting period, IWC had 5,734 new users to the website (water.iastate.edu). The average session duration was 2.35 with average 2.43 pages viewed per session.

Blog: During the reporting period, IWC had 1,687 visitors with 2,681 views of the website (iawatercenter.wordpress.com).

Newsletter: Newsletters were released the 2nd and 4th Thursday of each month during the reporting period for a total of 24 newsletters. At the beginning of the reporting period, the newsletter had 220 subscribers with a 41.1% open rate and 8% click-through rate. The last newsletter in the reporting period had 247 subscribers with a 44.3% open rate and an 15% click-through rate.

Twitter: At the end of the reporting period, IWC’s Twitter account had 1060 followers, gaining 246 followers throughout the year.

Facebook: IWC started the reporting period with 310 likes on Facebook and gained 47 likes during the year, ending at 357.
USGS Summer Intern Program

None.
## Student Support

<table>
<thead>
<tr>
<th>Category</th>
<th>Section 104 Base Grant</th>
<th>Section 104 NCGP Award</th>
<th>NIWR-USGS Internship</th>
<th>Supplemental Awards</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Masters</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Post-Doc.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>
Notable Awards and Achievements

Notable awards and achievements for Director Rick Cruse:


Positions:

2017 – present Soil Science DOGE 2017 – present Soil Science program coordinator

Notable awards and achievements for Associate Director Melissa Miller:


2017. Steering committee for Women for Water, a statewide organization to encourage a grassroots movement of women engaging in dialogue about water management.

Notable awards and achievements for Program Assistant Hanna Bates:

2017. Planning committee for Watershed Planning Advisory Council, a stakeholder group as established by the Iowa Legislature to provide recommendations to state and federal agencies to protect water resources in Iowa.