

MICROPLASTICS AND PPCPS OCCURRENCE IN KARST GROUNDWATERS OF ILLINOIS

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Introduction

- ▣ Plastic debris is widespread within surface-water environments.
- ▣ About 25% of all drinking water, worldwide, comes from karst aquifers.
- ▣ Karst aquifers have enlarged secondary porosity due to dissolution by recharge (rainwater and snow melt) along fractures.
- ▣ Groundwater in karst areas is often contaminated.

What are Microplastics?

- ❑ Fragments of plastic < 5 mm in length.
- ❑ 5 categories: fiber, fragment, bead, foam, or film
- ❑ Microfibers derived from synthetic clothing materials
 - Average of 1.7 g of microfibers released from washing a jacket made from synthetic materials
- ❑ Microbeads originate from plastic debris and polyethylene added to health and beauty products (banned 2015).
- ❑ Polyethylene (polyester) most dominant polymer found in treated wastewater



What is Karst?

- ▣ Karst (n.) is a geologically and hydrologically integrated or interconnected and self-organizing network of landforms and subsurface large-scale, secondary porosity created by a combination of fractured carbonate bedrock, the movement of water into and through the rock body as part of the hydrologic cycle, and physical and chemical weathering.



Karst and Groundwater Contamination

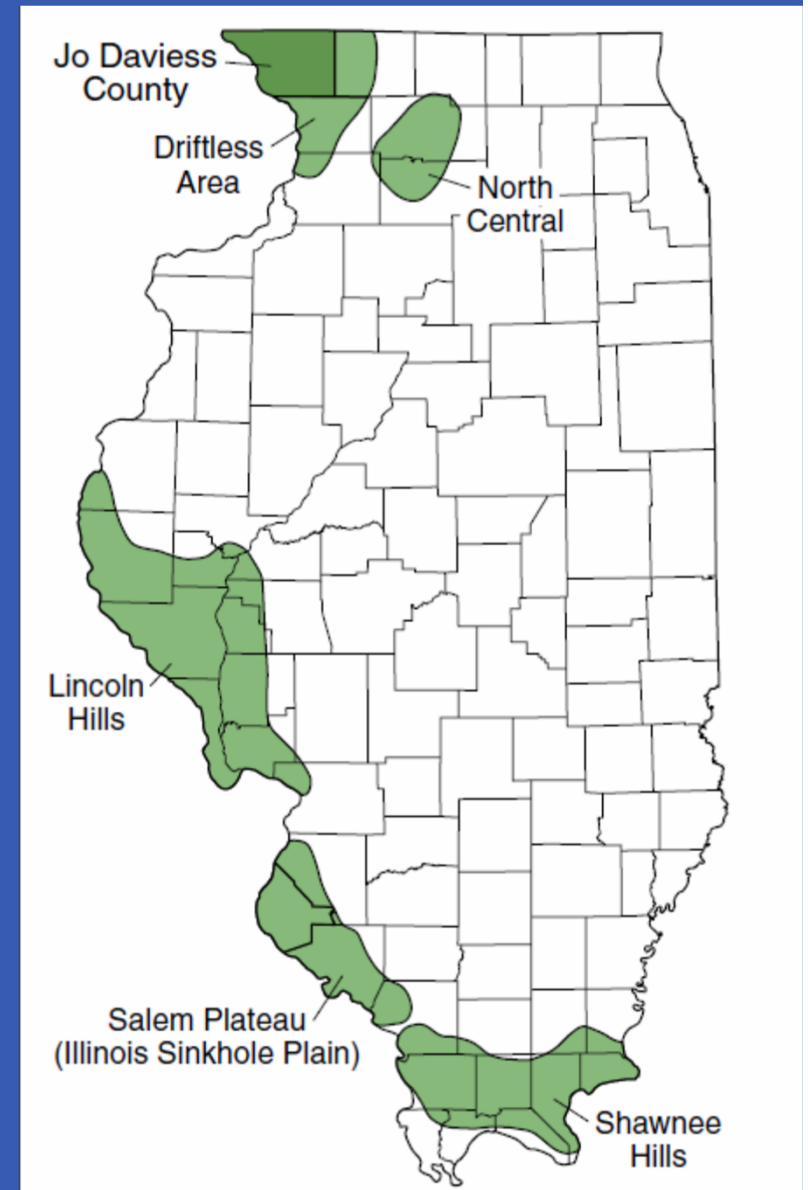
- ▣ Karst aquifers have enlarged secondary porosity due to dissolution along fractures and bedding planes by recharge.
- ▣ Karst aquifers are open to infiltration from surface-borne contaminants (both dissolved and particulate) via sinkholes and exposed bedrock.
- ▣ Because of open nature of karst, we hypothesized karst aquifers should contain microplastics.
- ▣ Even though karst systems can differ significantly in scale and flow dynamics, particulate matter, including microplastics, should be able to travel within groundwater along karst features.

Objectives

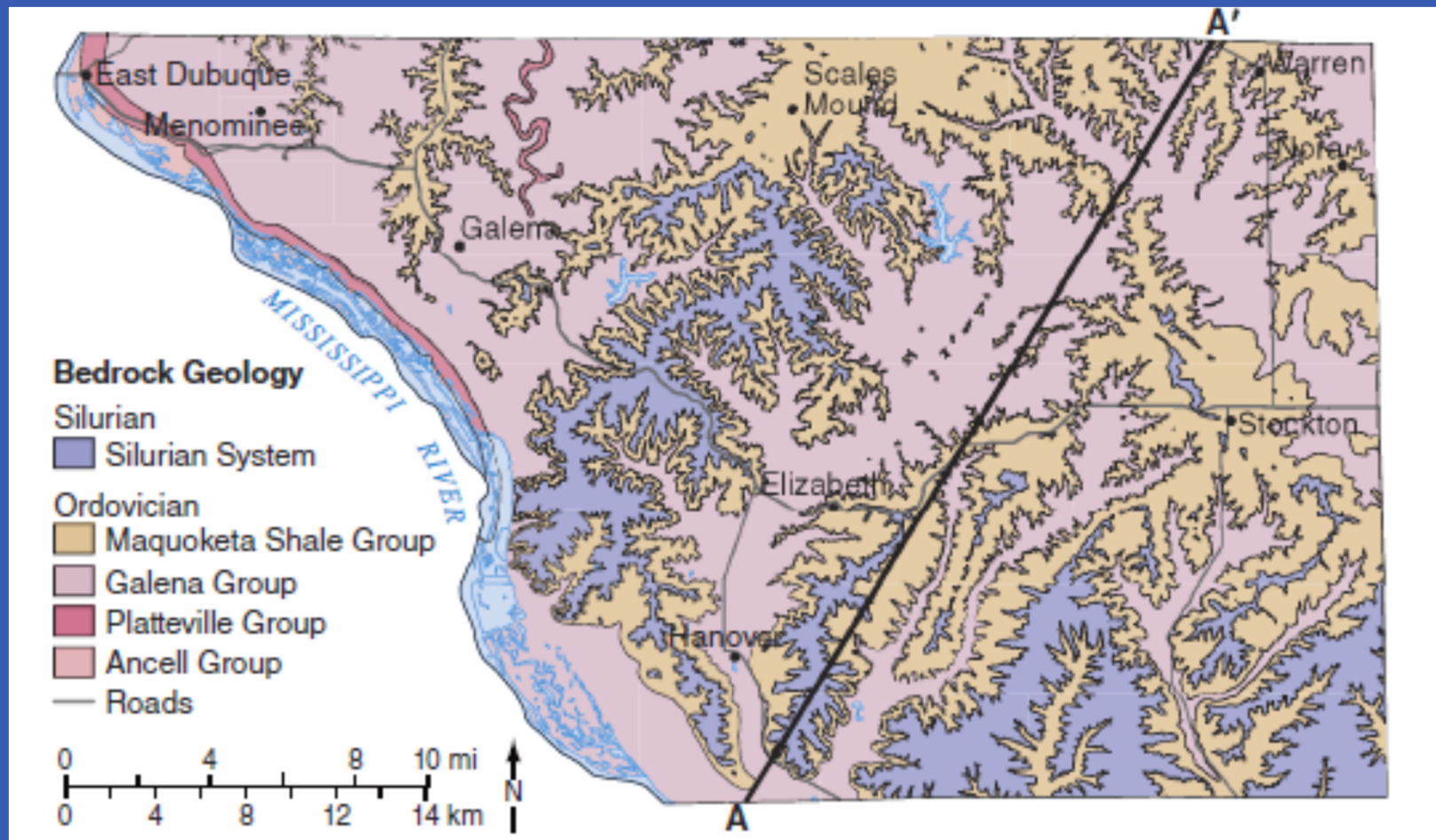
- ▣ Determine the presence or absence of PPCPs and microplastics in two different types of karst regions of Illinois.
- ▣ Compare any occurrences of these constituents with dissolved contaminants.
- ▣ Evaluate results based on karst characteristics of the study areas.

Karst Regions of Illinois

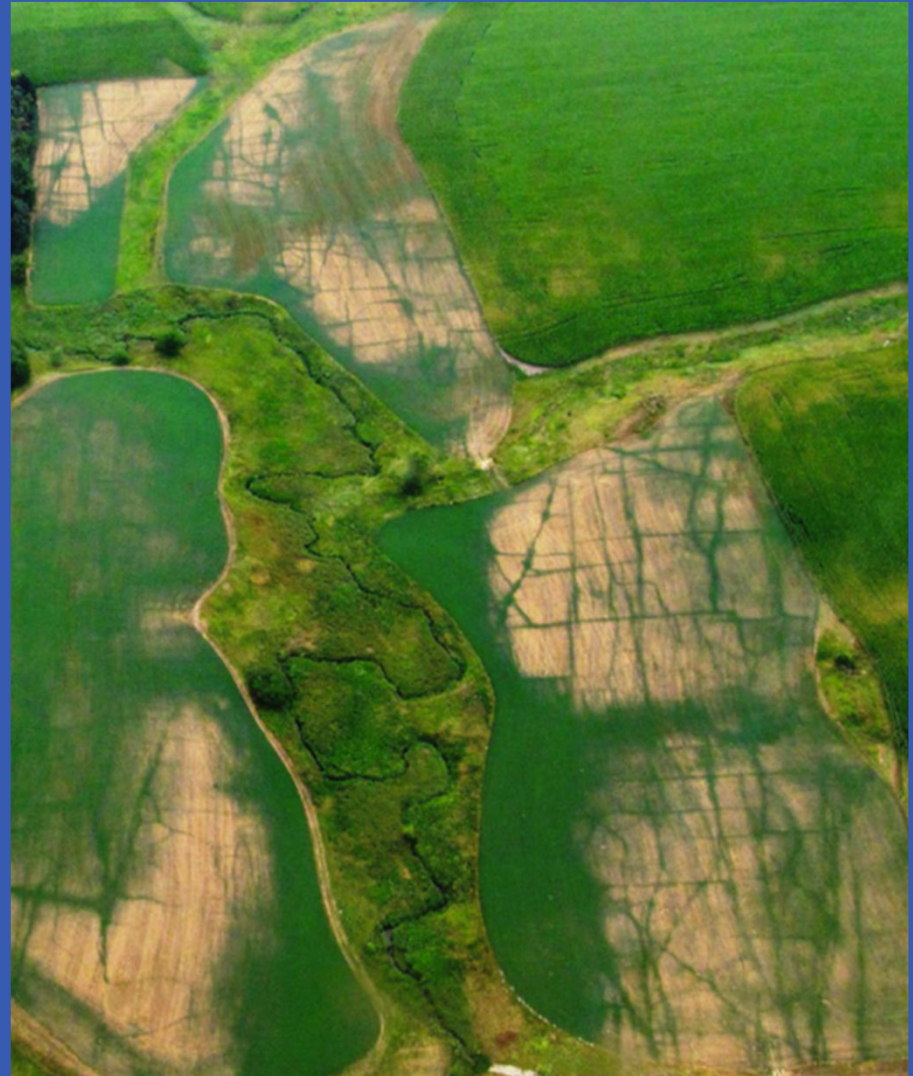
- ▣ Mississippian limestone of SW IL sinkhole plain contains sinkholes greater than 100 m in diameter and caves with passageways greater than 10 m in diameter that extend for many km.
- ▣ Ordovician dolomite of NW IL Driftless Area contains sinkholes on the order of 1 m in diameter, a few discontinuous crevice caves, and crevices typically < 0.5 m wide.



Northwestern Illinois' Driftless Area



Northwestern Illinois' Driftless Area



Crevice karst is dominant in NW IL.

Northwestern Illinois' Driftless Area



Cover-collapses sinkholes and caves are generally small

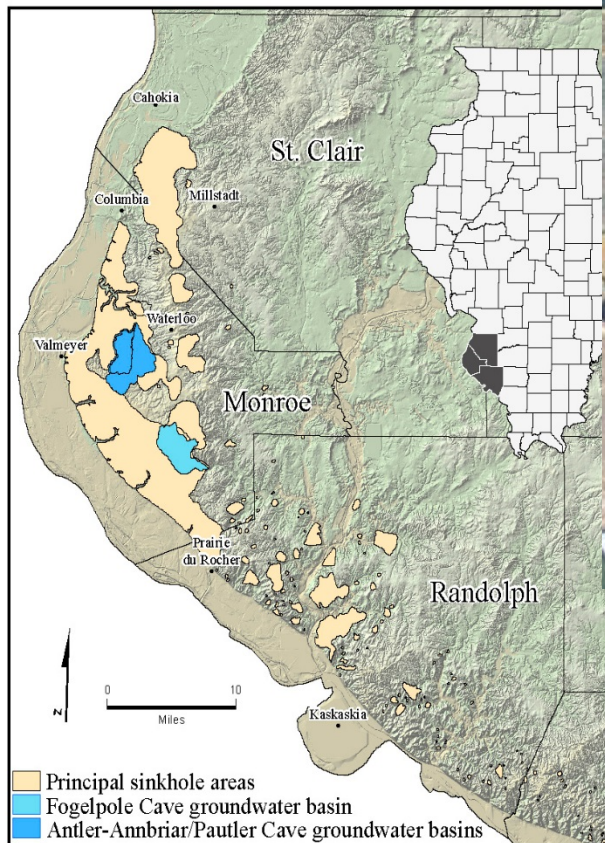
Northwestern Illinois' Driftless Area



Springs discharge from crevices and along bedding planes.

Southwestern Illinois' "Sinkhole Plain"

Salem Plateau



Southwestern Illinois' "Sinkhole Plain"



Sinkholes 30 to 100 m in diameter typically drain into crevices ranging from 15 cm up to 1 m in width.

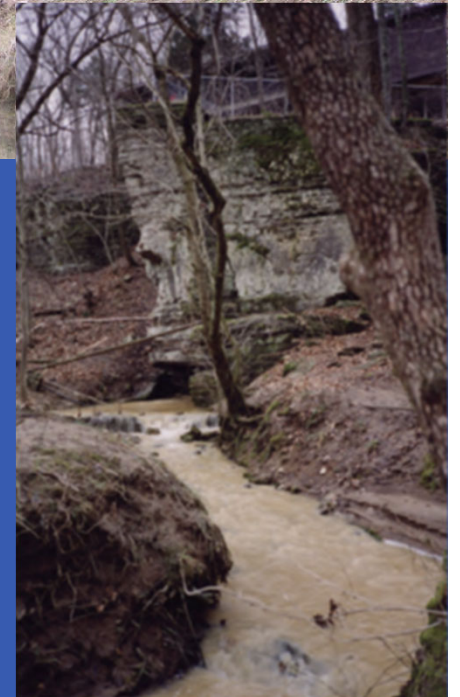
Farmers occasionally excavate these sinkholes and install stand pipes and back fill in order to use more ground for crops.



Southwestern Illinois' "Sinkhole Plain"



Springs discharge from
conduits and caves



Southwestern Illinois' "Sinkhole Plain"

A photograph of a person wearing a hard hat and a plaid shirt, standing in a cave. The person is illuminated by a flashlight, casting a bright beam of light on the surrounding rock walls. The cave walls are dark and textured, with some areas appearing to have stalactites or other rock formations. The overall atmosphere is dark and mysterious.

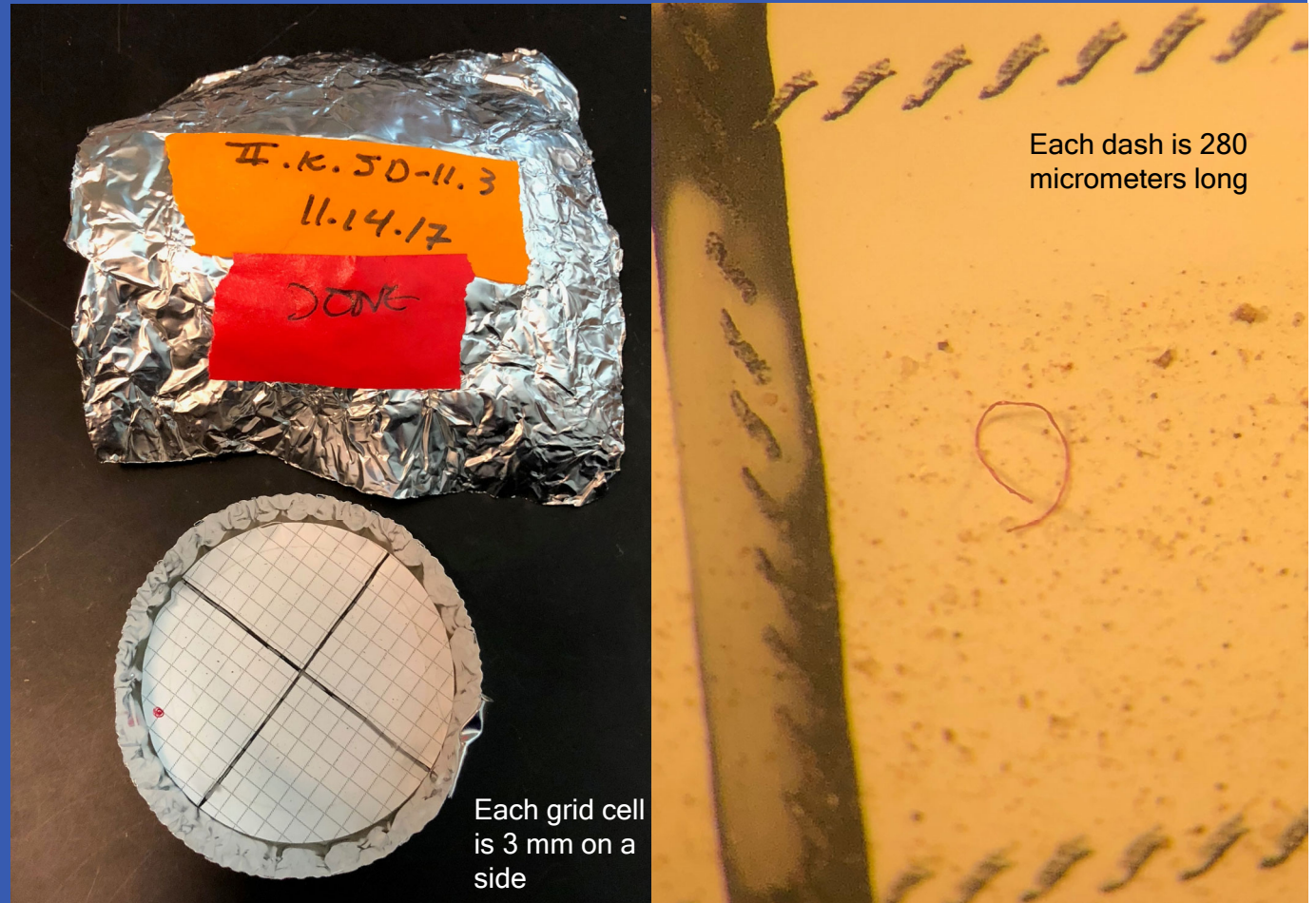
Caves are Branchwork-type

Methodology

- ▣ November 13-14, 2017, 8 springs and 3 shallow wells in Illinois' Driftless Area in NW IL were sampled for groundwater chemistry, PPCPs, and microplastics.
- ▣ November 17, 2017, 6 springs in Illinois' sinkhole plain in SW IL were sampled for microplastics only. Previously, these springs were sampled for chemistry and PPCPs (Dodgen et al. 2017).
- ▣ PPCP analyses conducted at ISTC
- ▣ Microplastic analyses conducted at Loyola University
- ▣ Chemical analyses conducted at ISWS
- ▣ Microbial indicators (total coliform and *E. coli*) measured at the City of Dubuque Environmental Monitoring Laboratory

Methodology

- ❑ Water samples passed through 0.45µm filters.
- ❑ Examinations conducted using a 25X dissecting microscope.
- ❑ Counts checked twice for consistency



PPCPs Analyzed



- ▣ **Caffeine**
- ▣ **Carbamazepine:** anticonvulsant and mood-stabilizing drug
- ▣ **Naproxen:** nonsteroidal anti-inflammatory drug (Aleve)
- ▣ **Ibuprofen:** nonsteroidal anti-inflammatory drug (Advil)
- ▣ **Gemfibrozil:** fibrate class, lowers lipid levels (Lopid)
- ▣ **Triclosan:** antibacterial and antifungal agent found in soaps, detergents
- ▣ **Sulfamethoxazole:** sulfonamide bacteriostatic antibiotic (Bactrim)
- ▣ **Trimethoprim:** bacteriostatic antibiotic used mainly in the prevention and treatment of urinary tract infections
- ▣ **Sulfamethazine:** sulfonamide antibacterial
- ▣ **Acetaminophen:** analgesic and antipyretic (fever reducer) (Tylenol)
- ▣ **Diphenhydramine:** antihistamine mainly used to treat allergies (Benadryl)
- ▣ **Erythromycin:** antibiotic of the macrolide class
- ▣ **Fluoxetine:** antidepressant (Prozac)
- ▣ **Triclocarban:** antibacterial agent common in soaps and lotions

Results: Chemistry and Microbial Indicators

- ▣ Most springs and both wells contained elevated (above background) concentrations of nitrate-N and chloride.
- ▣ Springs of SW IL contained elevated phosphate concentrations an order of magnitude greater than springs of NW IL.
- ▣ All springs contained coliform bacteria and *E coli* indicating enteric sources such as septic effluent
- ▣ Springs and wells in both areas contained contaminants from various sources, including road salt runoff, septic effluent, and N-fertilizers.

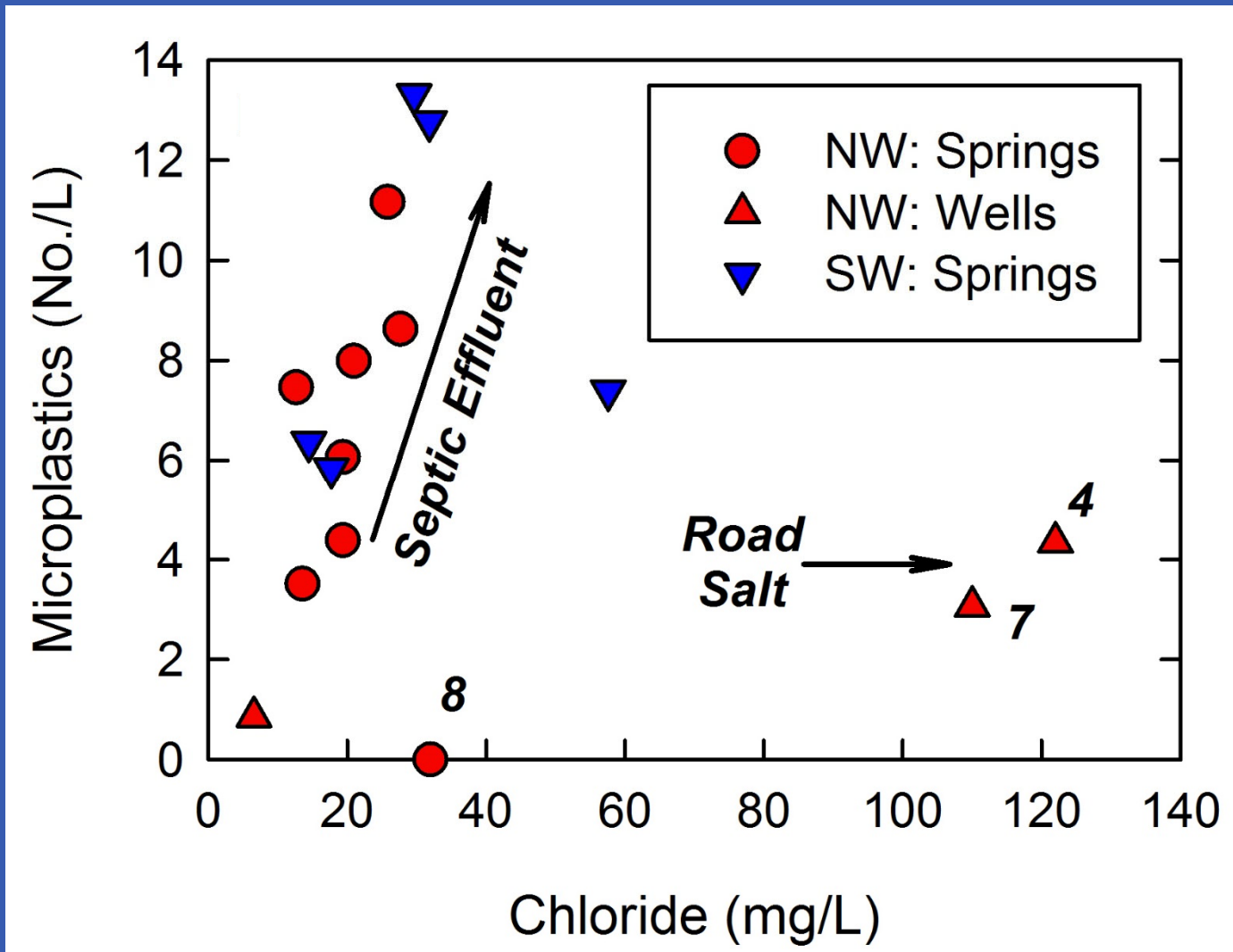
Results: Pharmaceuticals and Personal Care Products

- ▣ PPCPs were found in groundwater from 14 of 15 sites sampled that included caffeine, carbamazepine, sulfamethoxazole and triclosan.

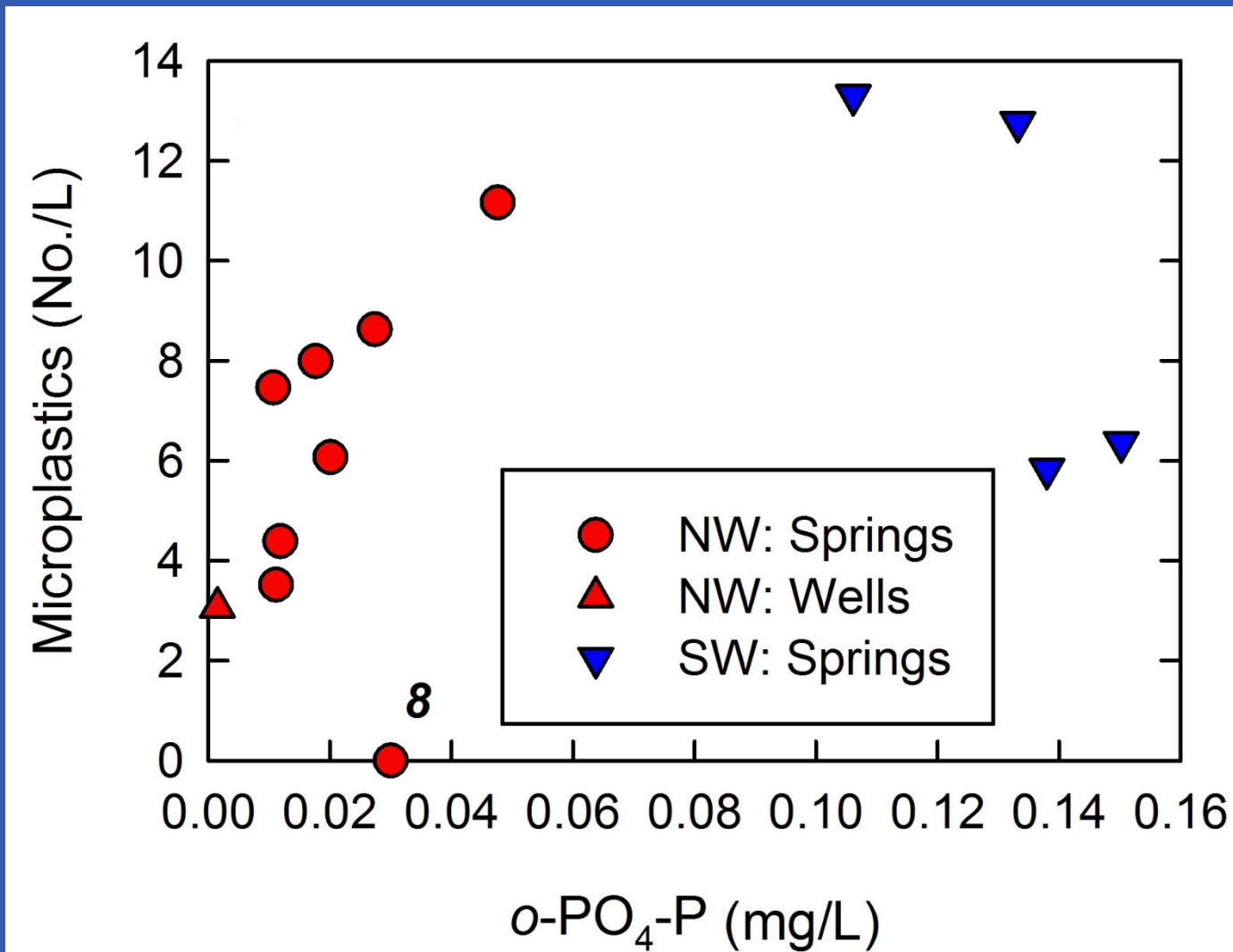
Microplastics

- ▣ 16 of 17 samples contained microplastics, in both regions
- ▣ Detections were all microfibers
 - > 70% were blue and/or clear in color
 - Red and gray accounted for 24%.
- ▣ Maximum concentration of 15.2 pieces per liter
- ▣ Based on this and previous investigations, the most likely source of PPCPs and microplastics in the karst aquifers is septic effluent
- ▣ This latter point is supported by an apparent relationship between microplastics and *E. coli*, albeit based on limited data, showing an increase in microplastics with an increase in *E. coli* counts.

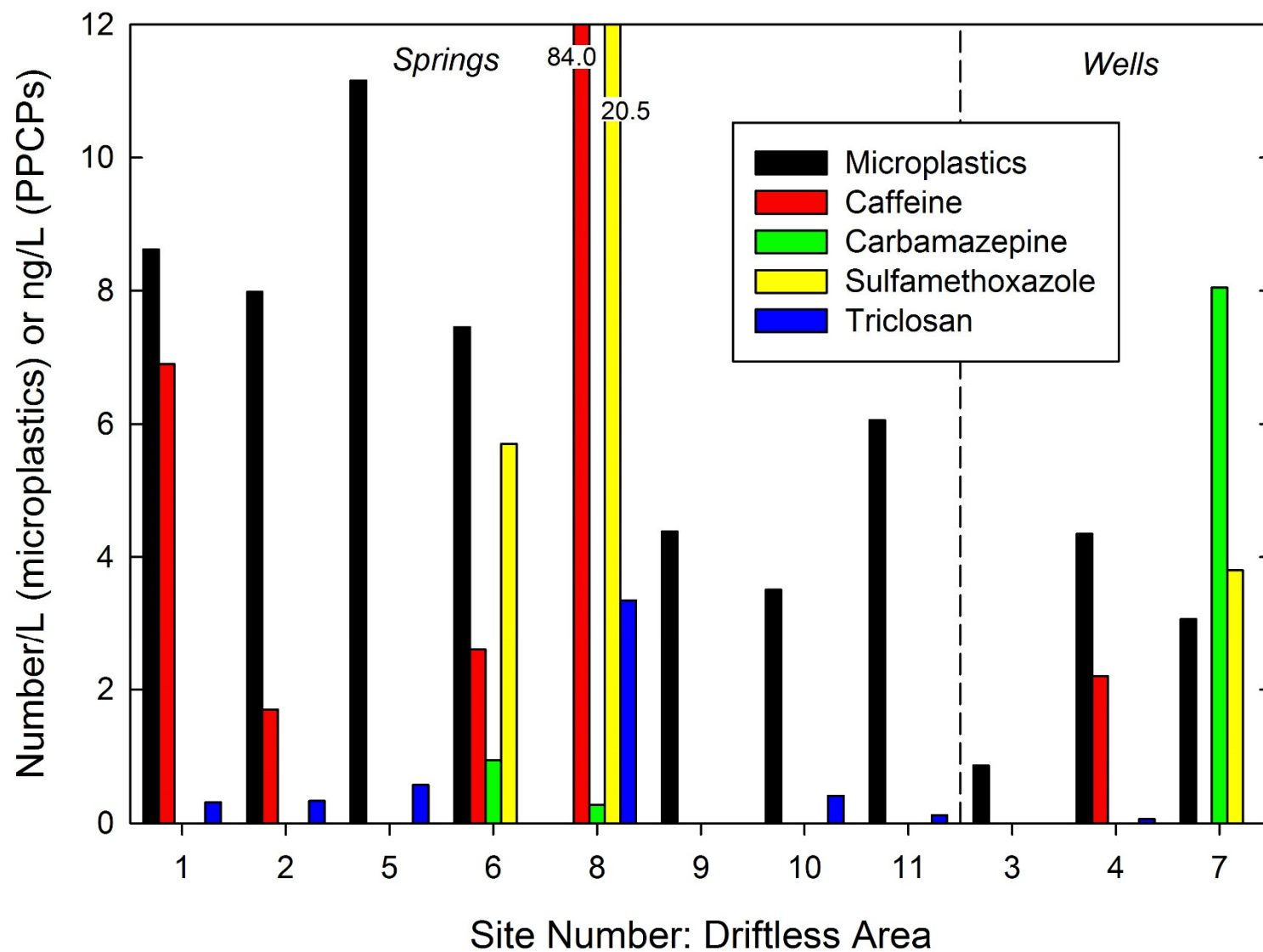
Microplastics vs. Chloride



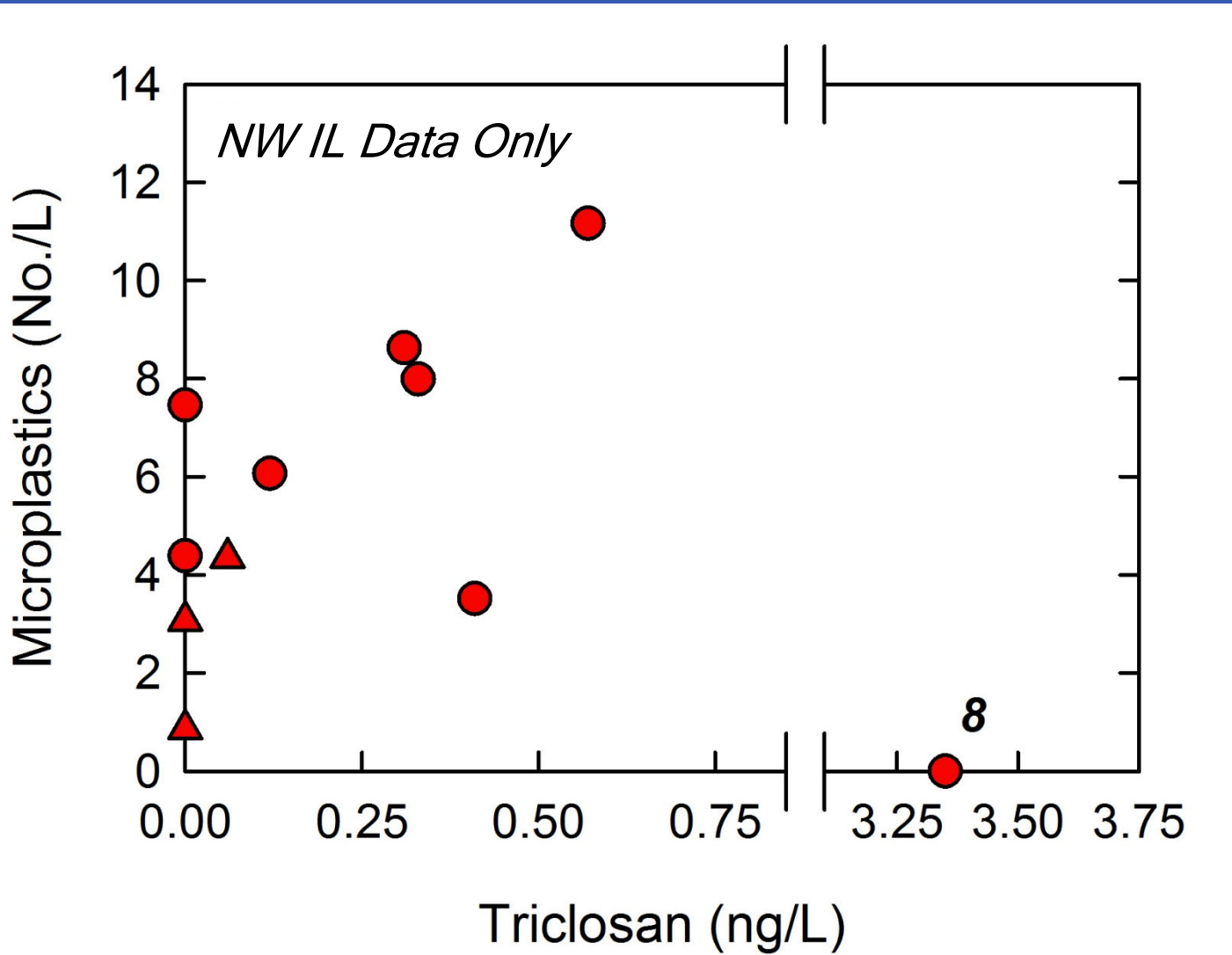
Microplastics vs. Phosphate



Microplastics and PPCPs: NW IL



Microplastics vs. Triclosan: NW IL



Conclusions

- ▣ We consistently found PPCPs and microplastics in springs and shallow wells within dolomite and limestone karst aquifers in IL
- ▣ Suggests that PPCPs and microplastics are present throughout shallow karst aquifers of IL
- ▣ Based on limited data, relationships between microplastics with chloride and phosphate are suggested
- ▣ Septic effluent is the likely source
- ▣ Because the presence of karst aquifers is not always obvious, microplastics could serve as indicators of the presence of a karst aquifer
- ▣ This is the first time (that we are aware of) microplastics have been detected in aquifers