Using Geochemical Analysis to Compare Cave Hollow Spring and Big Sinking Creek

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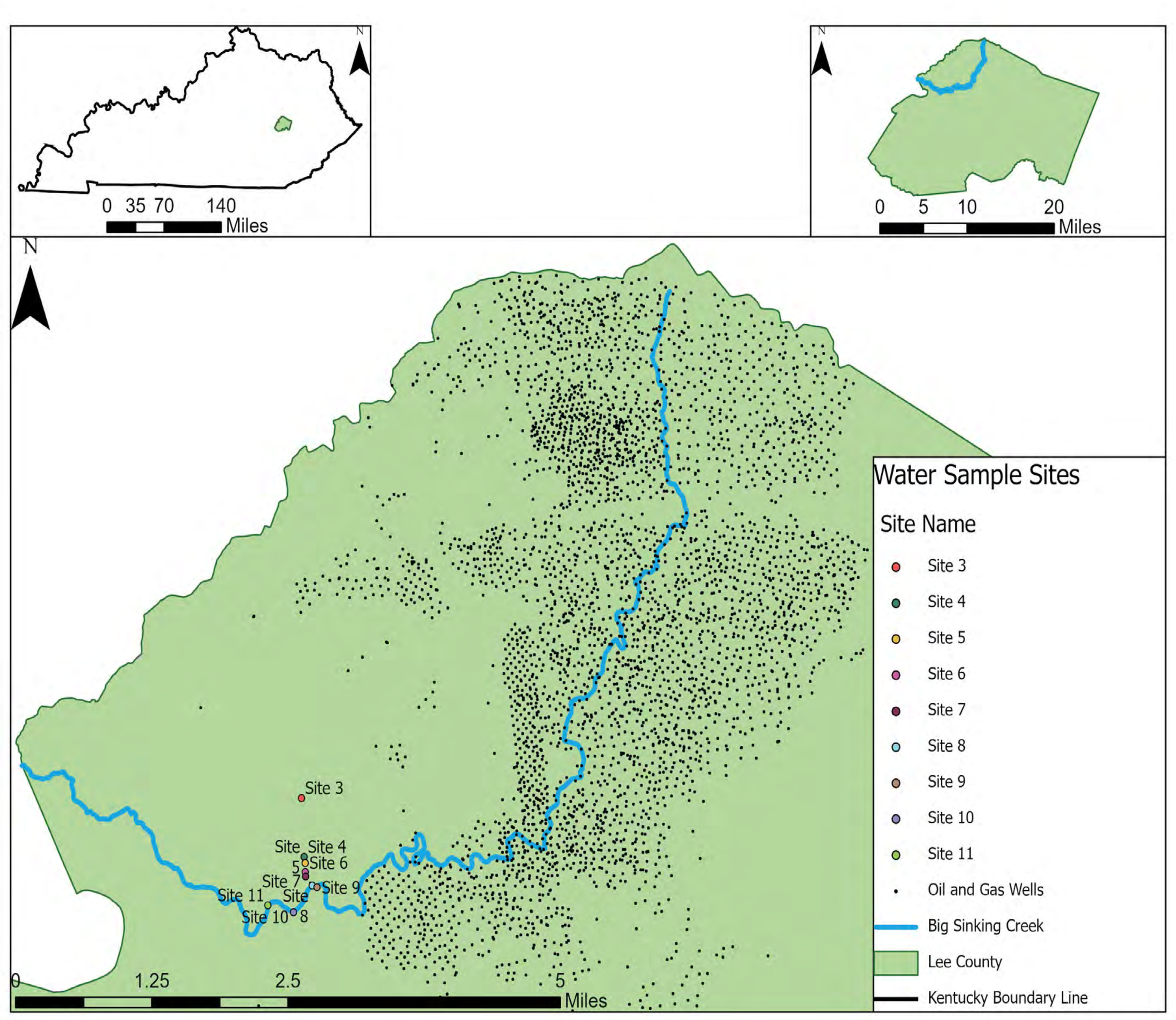
Kentucky Geological Survey

Introduction

Oil has been extracted in Kentucky since 1818, with approximately 190,000 wells drilled over the years. Our study area lies in the Red River Gorge Geological Area. This area is characterized by its karst landscape and is prone to the formation of caves and sinkholes. The Big Sinking oil field, Kentucky's only giant oil field, lies just 1.5 km East of our study area. Discovered in 1916, the Big Sinking oil field produced over 100 million barrels of oil from 1918 to 2000, with peak production occurring in 1919 (Nuttall 2001). Contamination by material from the oil field could lead to increased salinity, which would lead to issues for agriculture, water quality, wildlife, and aquatic ecosystems. Due to the proximity of the Big Sinking oil field to our study area, we aimed to determine if local water resources were affected by contamination from the oil field through geochemical analyses. We hypothesize that there will be a difference when comparing the sites along Big Sinking Creek to the sites in Cave Hollow Spring.

Study Area



Methods and Results

Site Name	Calcium, Dissolved by ICP (mg/L)	Chloride (mg/L)	Sodium, Dissolved by ICP (mg/L)	Magnesium (mg/L)	TOC (mg/L) 6/4/24	TOC (mg/L) 6/25/24
Site 3	30.7	1.08	0.71	2.94	0.52	1.3
Site 4	25.7	1.52	1.34	2.23	1	1.6
Site 5	26.4	1.65	1.35	2.27	0.79	1.5
Site 6	26.7	1.57	1.28	2.28	0.7	1.4
Site 7	27.4	2.47	1.86	2.42	0.71	1.3
Site 8	28.5	2.16	1.8	2.57	0.66	1.2
Site 9	41.9	84	40.9	5.62	2.68	3.8
Site 10	41.8	89.8	38.5	5.43	2.81	3.7
Site 11	42.2	86.8	39	5.51	2.69	3.8

Figure 1. The results shown come from tests conducted in the Kentucky Geological Survey Water Lab using water samples collected in the field. Water samples were collected using a syringe with a 0.45 micron filter on the end. Each container was rinsed 3 times with the filtered water and then filled with the filtered water. Samples were stored in a refrigerator upon returning to KGS. The tests ran include Total Nitrogen (TOTN), Total Phosphorus (TOTP), Total Organic Carbon (TOC), cations, anions, and heavy metals.

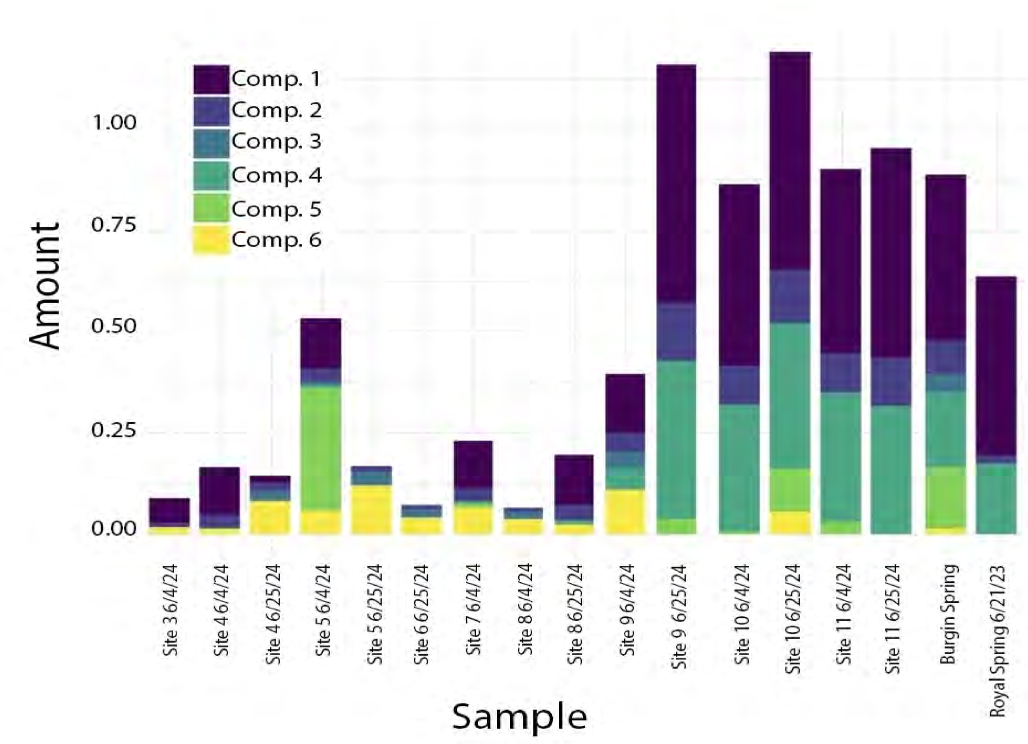


Figure 2. Component plot of water samples at each sample site generated during the PARAFAC analysis in R studio. The analysis uses EEM data to separate dissolved organic matter components.

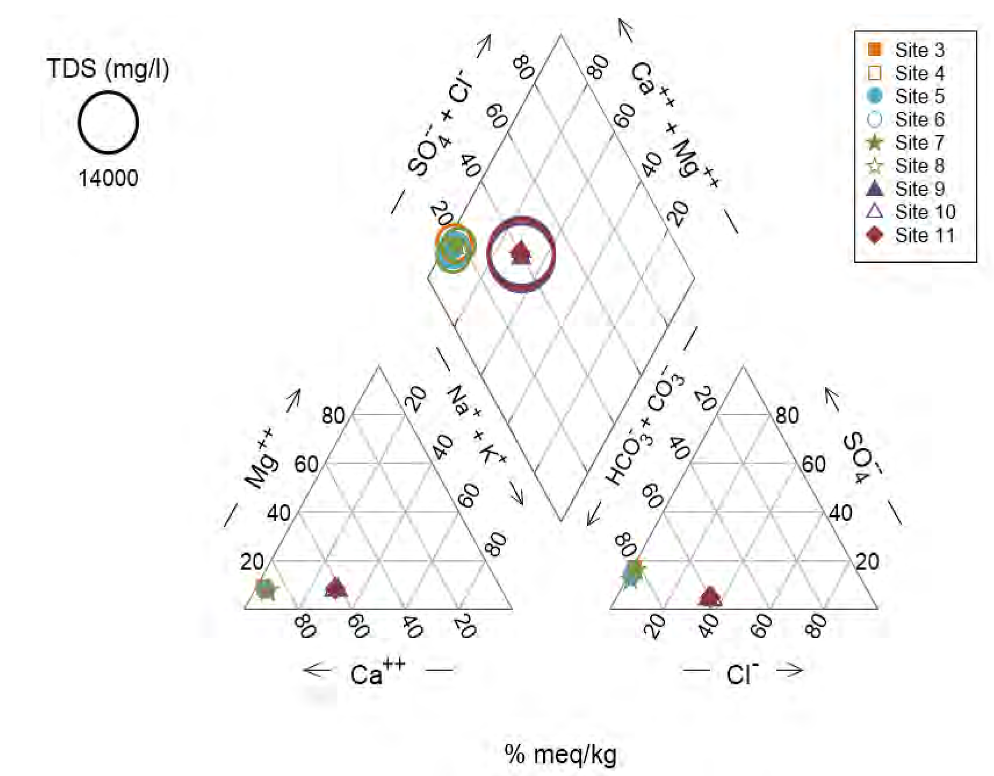


Figure 3. Ion Composition of Water Samples. Sites 9 to 11 plot in the same area away from sites 3 to 8 indicating a difference between the sites when comparing them to each other.

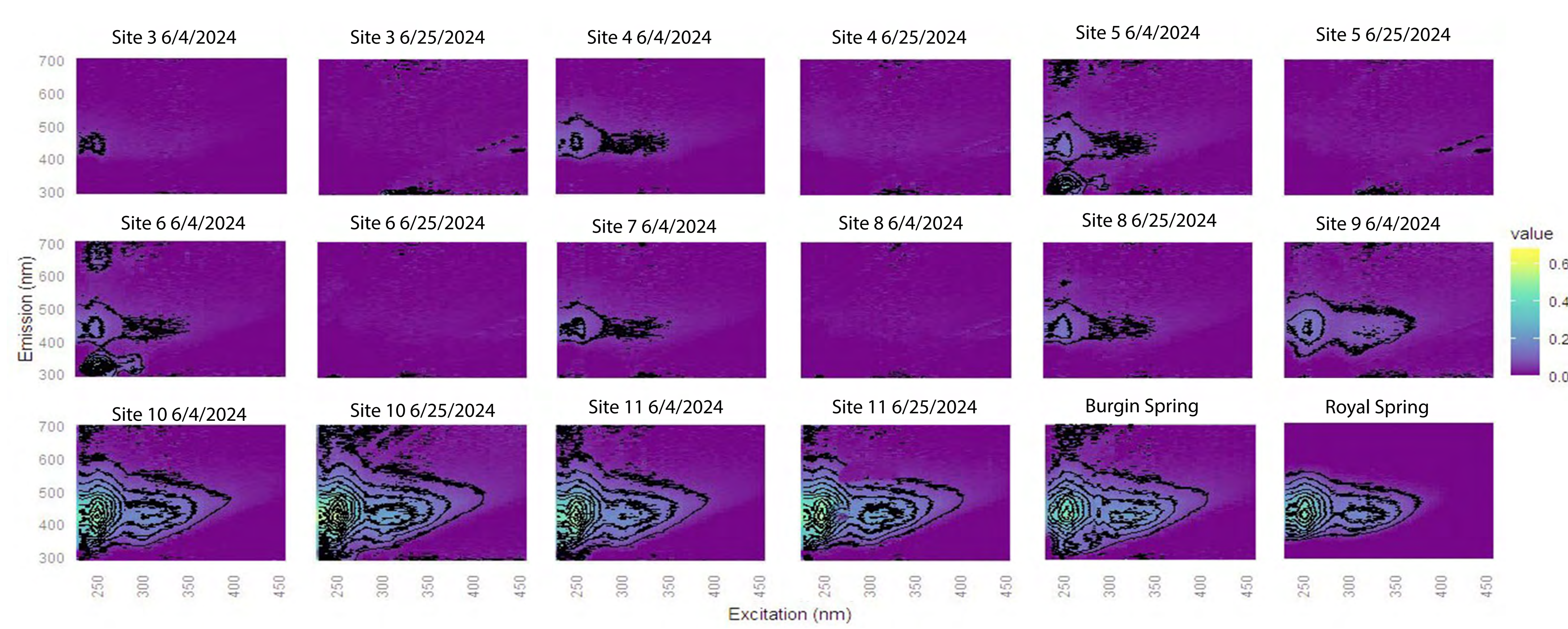


Figure 4. Fluorescence graphs showing how each sample plots according to their excitation and emission. These plots are able to show the amount of dissolved organic material that is present in each sample. The more color the graphs have, the more dissolved organic material that is present.

Key Points

1. Sites in Big Sinking Creek have higher concentrations of calcium, chloride, sodium, magnesium, and total organic carbon (TOC) in comparison to the sites in Cave Hollow Spring which supports the hypothesis.

2. Contamination is occuring and will need to be stopped to prevent any further contamination. We think that the contamination is coming from the oil field but it would need to be confirmed through further testing.

Figure 5. Pipe a few feet downstream of Site 8.

Conclusion/Future Work

There is a difference between the sites in Cave Hollow Spring and Big Sinking Creek when comparing them to one another. They also differ from each other when comparing the sites to the results of a brine analysis from the Big Sinking oil field. The total dissolved solids (TDS) analysis reported by Freeman (1941) concluded that the brine consists of sodium, calcium, and chloride. From our testing, the sites in Big Sinking Creek have a higher concentration of these elements than the sites in Cave Hollow Spring. Calcium is 11.1 to 16.5 mg/L higher, chloride is 81.53 to 88.72 mg/L higher, and sodium is 36.64 to 40.19 mg/L higher. The samples indicate that there is contamination, but further testing would be needed to confirm if the brine is causing the contamination. Further contamination could negatively impact the land by making it harder to use for agriculture, decreasing vegetation which would impact wildlife, degrading water quality which would affect those who use that water and aquatic ecosystems.

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