Introduction

The Illinois Basin – Decatur Project (IBDP) is a large-scale carbon capture and storage (CCS) demonstration which completed injection of one million metric tons of carbon dioxide (CO2) captured from an ethanol production facility, into a deep saline reservoir over a period of three years. An on-site Monitoring, Verification, and Accounting (MVA) program was developed to characterize and monitor near-surface and subsurface site conditions. Since March 2019, groundwater monitoring wells ranging in depth from 20 to 300 feet have been used to monitor groundwater levels and chemistry near the project site. Objectives of the shallow groundwater monitoring network included establishing pre-injection conditions and monitoring for anomalous geochemical signals that could indicate CO2-related changes. If leakage occurred, the concentration of O2 at the injection site will be lower than 4%, the groundwater near the injection site may be slightly acidified, and pH < 7.0. CO2 could potentially migrate into shallow groundwater aquifers, and lower the pH of the groundwater, which could mobilize trace metals that naturally occur in aquifer materials. In this work, batch experiments were conducted with sediment samples collected from the shallow Tiskilwa glacial outwash aquifer at the IBDP site to evaluate the potential impact of CO2 leakage on shallow groundwater quality. This study has helped determine which major and trace metal concentrations would potentially be increased in the presence of CO2, and how the subtle changes would be monitored. A better understanding as to which reactions are expected to control the shallow aquifer geochemistry.

Methods

Archived sediments from the well G104 borehole (Figure 1) were analyzed from the Tiskilwa sand and gravel aquifer (>2 mm grain size) by total digestion and X-ray Diffraction (XRD).

100 g of aquifer sediment was placed in two Erlenmeyer flasks (Figure 2) with 150 mL of deionized water to saturate each gas with water and prevent evaporation. Source water was added to each batch immediately following sampling to maintain a 1:1 water/sediment ratio.

5 mL of the diluted sample was used to determine pH and 5 mL was then filtered through a 0.45-µm syringe filter (Figure 3) and acidified with nitric acid for ICP-MS analysis.

"Zero point" chemistry and mineralogical data were used in Geochemical Workbench™ to model a major cations and cations reactions with the mineral phases.

Acknowledgements

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Results and Discussion

Table 1 shows the mineral composition of the Tiskilwa aquifer. Figure 4 predicts the change in mass (A) over the coarse of the batch experiments as a result of the increase expected to CO2-saturated natural groundwater. Sr, Co, Ni, and Cu are all relatively non-reactive, while Fe is only reactive in the presence of O2. The dissolution of Fe- and K-feldspar could potentially release calcium and potassium into solution while kaolinite mineralization is relatively insensitive to the geochemical environment because feldspar is less reactive and Si while kaolinite is precipitating both quadrivariant carbonate and silicate precipitates.

Table 2 shows the results will be further extended to improve the representativeness of the studied area. The results will be further extended to improve the representativeness of the studied area. The results will be further extended to improve the representativeness of the studied area. The results will be further extended to improve the representativeness of the studied area. The results will be further extended to improve the representativeness of the studied area.

Conclusions

The batch experiments performed in this study indicated CO2 interaction with shallower groundwater would decrease groundwater pH and increase both major and trace element concentrations.

Depletion of carbonate minerals in batch experiments, such as calcite/dolomite was rapid.

The concentrations of trace metals of environmental concern, including Fe, Co, Ni, and Cu all increased sharply during the first 48 hours, then stabilized along with pH. Uranium generally shows a slightly increasing trend throughout, while As decreases slightly. The control data for each plot except for As show either a very little change or a slightly decrease, likely due to N2 saturation stripping dissolved CO2 out of solution to create a slightly basic environment. Results from the As control are inconclusive due to higher variability. Table 2 shows the results from total digestion analysis of solids for six trace metals that are important either due to their potential toxicity (Fe, U, As, Ni) or their usefulness in understanding the geochemical environment (Sr, Co).