Corrosion in Produced Water Desalination and Treatment Facilities

Jacob Furrh, Amin Kiaghadi, Hanadi S. Rifai

Department of Civil and Environmental Engineering

UNIVERSITY of HOUSTON

Background

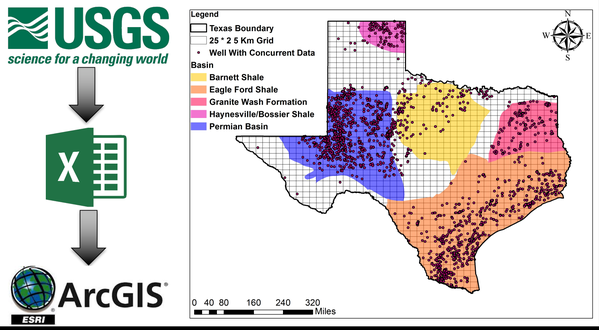
- Produced Water to Oil Ratio up to 9.5 [1,2]
- Variable ionic concentrations, TDS, and pH can intensify both scaling and corrosion[2]
- Pipeline corrosion in Oil and Gas costs nearly 7 billion USD per year[3]
- Corrosion Agents such as Cl^-, H_2S, and SO_4^{-2} are analyzed in literature[4]
- Langelier Saturation Index (LSI) & Ryznar Stability Index (RSI)[5]

http://www.rkconsult.nl/pipeline-integrity/

Methodology

Corrosion Agents: Spatial Analysis

- Produced water quality data from USGS
- TDS, pH, Cl^-, HCO_3^- , H_2S were chosen as water quality parameters that affect the corrosion the most
- 25 km x 25 km grid of Texas



LSI & RSI Calculations

$$LSI = pH_s - pH$$

$$RSI = 2pH_s - pH$$

$$pH_s = (9.3 + A + B) - (C + D)$$

$$A = \frac{\log TDS - 1}{10},\ B = -13.12 * \log(Temperature) + 34.55,$$

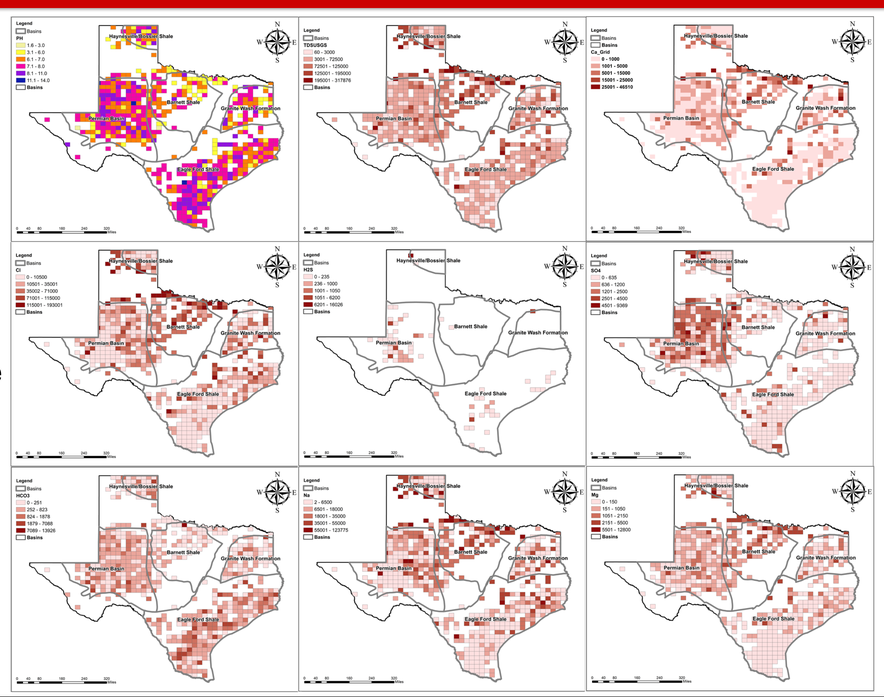
$$C = \log(Ca\ hardness\ as\ CaCO_3) - 0.4,\ D = \log(Total\ Alkalinity)$$

$$Total\ Alkalinity = f(HCO_3^-, CO_3^{2-}, pH)$$

- Wells with concurrent ions were chosen for consistency (a total of 3,284 wells)
- Due to high concentrations, activity coefficients play a critical role
- For ion-strength (I) < 0.8 the Davies equation was used and for I > 0.8 a simplified version of Pitzer Model was applied[6]
- Temperature was assumed to be 298 K

Results

- pH was highest in the Barnett Shale region
- Highest SO_4^{-2} was observed in the Permian Basin
- Cl^- was higher in the Barnett Shale and north east of Permian Basin
- HCO_3^- was low in every region except for the Eagle Ford Shale
- H_2S data was extremely limited
- Na^+ and Mg^{+2} had significant effects in ionic strength calculation

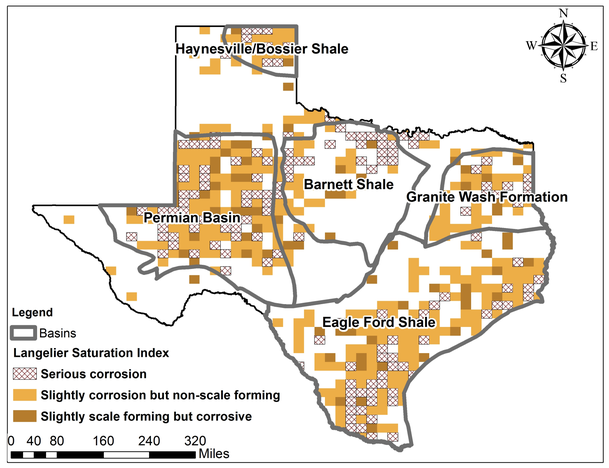


Results (Cont.)

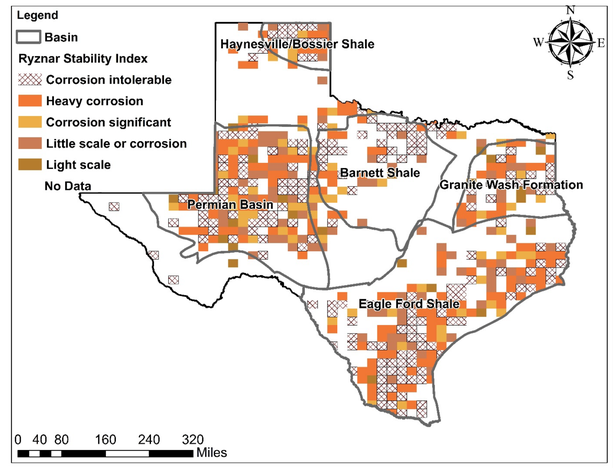
- Qualitatively, Texas produced water appears to be generally corrosive with large patches of extreme corrosion
- LSI and RSI indicate corrosion in the same areas
- Extreme corrosion is present in every region, but is concentrated in the northern Barnett Shale and southern Eagle Ford Shale, as well as clusters in the Permian Basin
- Scaling appears to occur less than corrosion and in less clustered areas
- Interactive online Decision Support System (DSS) tool to predict indices at locations:

http://truefurrh.wixsite.com/produced-water

LSI



RSI



Conclusions & Future Works

- Texas' produced water needs some treatment before pipeline transport
- Indices cannot provide a quantitative value for corrosion rate and future work is required to fully analyze corrosive potential
- Both quantitative and qualitative results can be validated using experimentation with real samples or synthetic produced water

Acknowledgements

- A special thanks to the entire Rifai lab for the mentorship and guidance
- This study was funded by the University of Houston Summer Undergraduate Research Fellowship (SURF)

References

1. Veil, J. and C. Clark "Produced Water Volume Estimates and Management Practices.
2. Veil, J. and J. Quinn (2008). Water issues associated with heavy oil production, Argonne National Laboratory (ANL).
3. Papavinasam, S. (2014). Chapter 1 - The Oil and Gas Industry. Corrosion Control in the Oil and Gas Industry. Boston, Gulf Professional Publishing: 1-39.
4. Smith, P., et al. (2011). "A model for the corrosion of steel subjected to synthetic produced water containing sulfate, chloride and hydrogen sulfide." Chemical Engineering Science **66**(23): 5775-5790.
5. Agatemor, C. and P. O. Okolo (2008). "Studies of corrosion tendency of drinking water in the distribution system at the University of Benin." The Environmentalist **28**(4): 379-384
6. Prausnitz, J. M., et al. (1998). Molecular Thermodynamics of Fluid-Phase Equilibria, Pearson Education.