Evolution of Groundwater Quality and Source Tracking of Nitrate Contamination in the Seymour Aquifer of Texas

Caitlin Payblas - Environmental Science, School of Geology, Energy and the Environment
Faculty Advisors: Dr. Omar Harvey and Tamie Morgan, SGEE

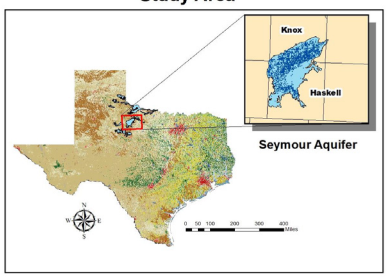
Introduction

- Nitrate nitrogen (NO_3-N) contamination of groundwater in the Seymour Aquifer has been documented since pre-1960.
- Concentrations as high as 35 mg/L NO_3-N have been reported (*3.5 times* the EPA allowable standard for drinking water).
- While most water from the Seymour Aquifer is used for agricultural irrigation, a portion is still used for domestic purposes and poses potential risk to human health.
- The specific source of NO_3-N contamination is still debated

Research Approach

- Three possible sources of NO_3-N contamination were considered in this study
  - geology of the aquifer (natural salt accumulation from water confined in patches of Quaternary-age alluvium)
  - contribution of nitrate from sewage and agricultural fertilizers (cotton, wheat, peanuts)
  - historical land use change of the area above the aquifer (leguminous nitrogen-fixing mesquite cleared in the 1930's for agriculture)

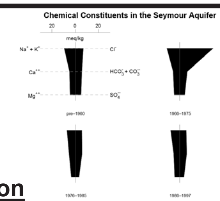
Study Area



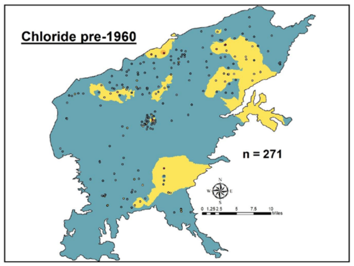
- My research combined chemical and geospatial analysis with specific objectives:
  1) Assessing the evolution of groundwater in the Seymour Aquifer since pre-1960 and after
     - Groundwater quality data from the Texas Water Development Board was used in conjunction with geospatial and chemical analysis to identify changes in the groundwater quality over time.
     - Empirical Bayesian kriging (EBK) analysis was used to interpolate chloride (Cl^-) and NO_3-N across the study area pre-1960 (pre-heavy fertilizer use) and thereafter.
  2) Determining the most likely source(s) of NO_3-N in sampled wells.
     - 14 groundwater samples were collected in Spring 2017 (3/18/17) and Fall 2017 (9/14/17) from selected domestic and irrigation wells
     - $\delta^{15}N$ and $\delta^{18}O$ stable isotopic signatures of the samples were evaluated as a means of isolating NO_3-N source as fertilizer/rain, soil or septic/manure in origin.

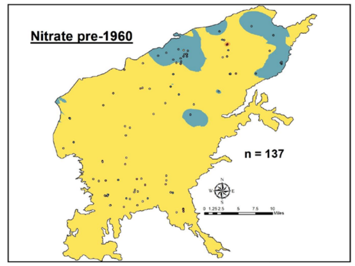
Research Findings

- Stiff diagrams represent average groundwater composition across the aquifer
- Averaged groundwater composition was graphed over the past six decades to determine which component (if any) drove overall chemical change
- From stiff diagrams, chloride was the main component driving overall changes in groundwater

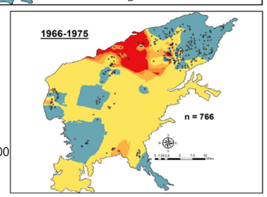


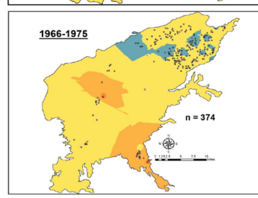
Cl^- and NO_3-N Evolution



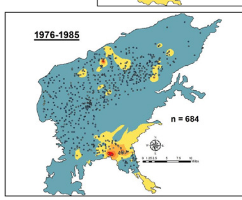


Chloride, Cl^-
mg/L
- <300
- 300 – 600
- 600 – 900
- 900 – 1,200
- >1,200

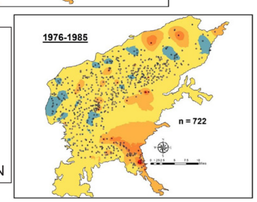


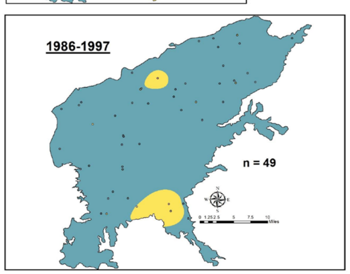


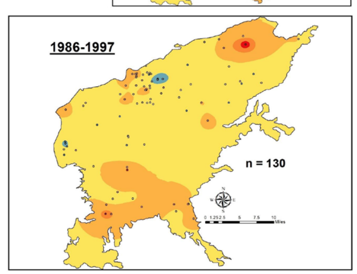
Nitrate, NO_3-N
mg/L
- <10
- 10 – 20
- 20 – 30
- 30 – 40
- >40



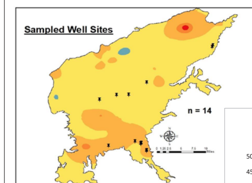
- Groundwater Cl^- and NO_3-N changed more in the northern and southern portions of the aquifer.
- Widespread NO_3-N contamination pre-1960 to 1997 with trends suggesting co-variation in Cl^- and NO_3-N



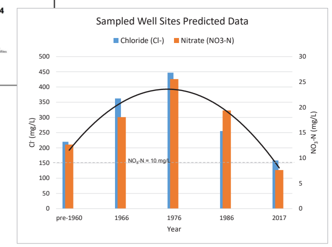




Research Findings (continued)

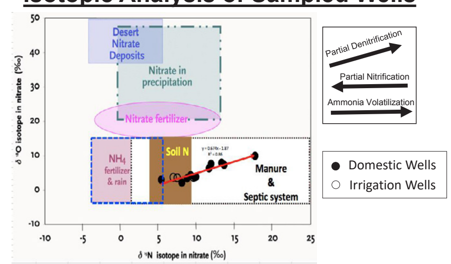


- Map on left shows the locations for the 14 wells sampled in 2017 - overlaid onto 1986-1997 groundwater composition map.



- The graph on the right shows extrapolated averaged Cl^- and NO_3-N at sampled locations
- Confirms covariation between Cl^- and NO_3-N in the aquifer.

Isotopic Analysis of Sampled Wells



- Based on isotopic signatures, two possible scenarios exists for NO_3-N in sampled wells:
  - NO_3-N existed as soil N and then transformed via partial denitrification into septic nitrogen or
  - There are two separate sources, septic and Soil N
    - decline of septic NO_3-N may have resulted from the 1972 Clean Water Act?
    - Fertilizer use didn't drop while NO_3-N did in decades post-1975—possibly due to better agricultural management?

Conclusions and Further Research

- Cl^- and NO_3-N behavior is concomitant and changes are likely being driven by the same phenomenon.
- NO_3-N is potentially coming from soil-N with partial denitrification and or a septic/manure source.
- Further research will include increasing sample size (from n=14 to n = 30) to provide a better view of present aquifer contamination and conducting more detailed isotopic analysis methods to differentiate between origins of NO_3-N as soil N and sewage N

References and Acknowledgements

"Groundwater Database (GWDB) Reports." *Groundwater Data | Texas Water Development Board*, Texas Water Development Board, www.twdb.texas.gov/groundwater/data/gwdbrpt.asp.
"Texas Natural Resources Information System." *TNRIS - Texas Natural Resources Information System*, tnris.org/.
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