A GID-Based Spatial Analysis of Groundwater Vulnerability for Major Aquifers in Oklahoma, US

Method

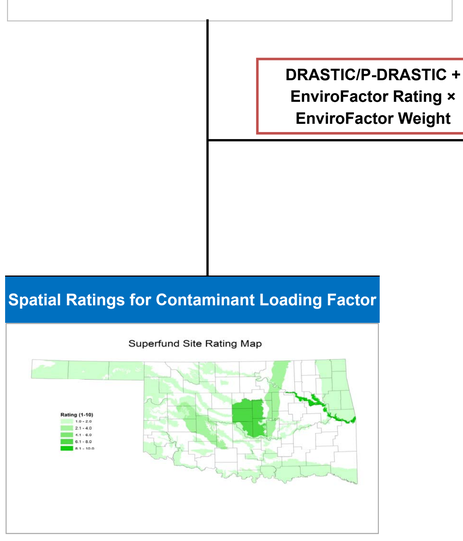
►The DRASTIC model was developed by the EPA to be a standardized system for evaluating groundwater vulnerability to pollution. Specifically, DRASTIC involves using of seven geologic and hydrogeologic factors, which are Depth to water (*D*), net Recharge (*R*), Aquifer media (*A*), soil media (*S*), Topography (*T*), Impact of the vadose zone (*I*), and hydraulic Conductivity (*C*). Each of the factors will be rated by assigning a numerical value based on its magnitude. The ratings will be multiplied by a relative weight which is decided by the importance of the factor. The sum of all the weighted ratings will be the score for groundwater vulnerability. The equation for DRASTIC index can be written as,

Hydrogeologic Factor	DRASTIC Weight	Pesticide DRASTIC Weight
D- Depth to water	5	5
R- Net Recharge	4	4
A- Aquifer media	3	3
S- Soil Media	2	5
T- Topography	1	3
I- Impact of the Vadose Zone	5	4
C- Aquifer Hydraulic Conductivity	3	2

$$Groundwater\ Vulnerability\ Index = D_r D_w + R_r R_w + A_r A_w + S_r S_w + T_r T_w + I_r I_w + C_r C_w$$

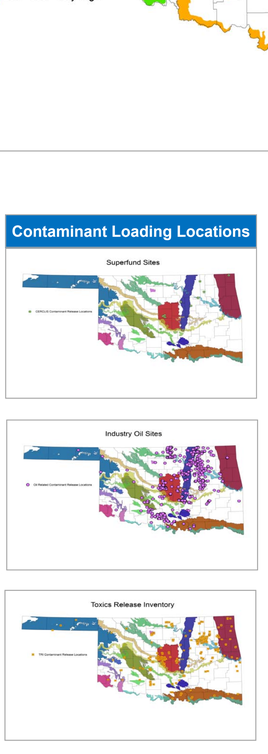
Where, r is the rating, w is the weight for each of the 7 factors.. The aquifers vulnerability were classified into 5 groups based on their indices: very low (0-80), low (81-120), moderate (121– 160), high (161-200), and very high (201-300).

Summing Up Weighted Ratings for DRASTIC factors



DRASTIC/P-DRASTIC + EnviroFactor Rating × EnviroFactor Weight

- V=Number of Loading Facilities Within Each Basin Normalized by Basin Area
- Scaling V Using $V1=(V-V_{min}) / (V_{max}-V_{min})$
- Convert V1 into a 1– 10 Scale
- The weight used for contaminant loading was rescaled from Secunda et al., 1998.



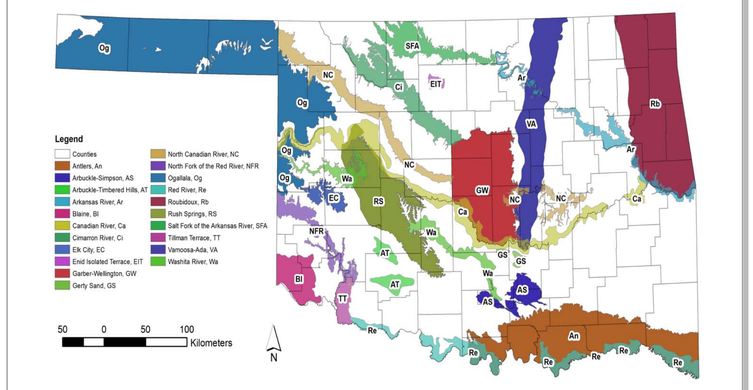
Introduction

► **Groundwater Contamination** Groundwater serves as a major source of water for municipal, agricultural, industrial and domestic use. Particularly, groundwater is depended on as a principle source of drinking water. It is essential to plan sustainable groundwater supplies in quantity and quality. Groundwater vulnerability mapping is one of the evaluation tools that can help identify the locations that pose a high risk to contamination (NRC, 1993).

►**Groundwater Vulnerability Modeling** Groundwater vulnerability defines as the sensitivity of groundwater quality to a contaminant load on the land surface, which is determined by the intrinsic characteristics of the aquifer (Vrba and Zaporozec, 1994). A variety of methods have been developed to evaluate groundwater vulnerability : overlay and index methods (Gogu and Dassargues, 2000), process-based simulation model (Carsel, 2011), and statistical-based data processing (McLay, 2001) . The overlay and index methods are widely used due to the accessibility of spatial data, the flexibility of incorporating other factors, and the simplicity of calculation. One of the overlay and index models is “DRASTIC” (Aller, 1987), which has been frequently used in groundwater vulnerability study.

Study Area

►**Study Area** The study region is in the state of Oklahoma. More than 60 percent of the total water use in Oklahoma, including almost 90 percent of the state’s irrigation needs, is from groundwater. Groundwater provides municipal water for more than 300 Oklahoma cities and towns (Osborn, 1998). Oklahoma’s aquifers can be categorized into two types: bedrock and alluvium and terrace aquifers. Nitrate contamination was detected in many alluvial aquifers.

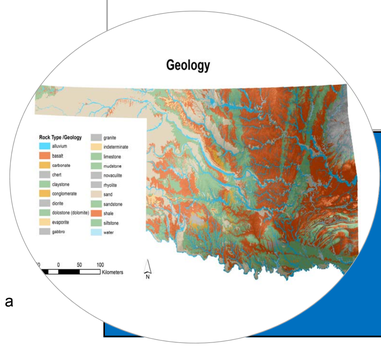


Objectives

► Mapping groundwater vulnerability for 21 major aquifers in Oklahoma using DRASTIC model and Pesticide DRASTIC model.

► Comparing the vulnerability maps generated by DRATIC and Pesticide DRASTIC models.

► Incorporating pollutant loading information into the DRASTIC map and the Pesticide DRASTIC map to gain a comprehensive view of contamination risk for hydrogeologic basins in Oklahoma.



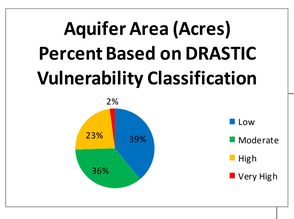
21 Hydrogeologic Basins in Oklahoma

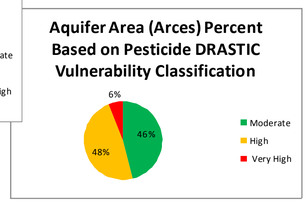
DRASTIC Based Vulnerability Map

Overall Groundwater Vulnerability Map

Result Discussion

1. The study confirmed the conclusion from precious study that the alluvial aquifers were more vulnerable to contamination introduced from the surface. Most of them have high or very high vulnerability to contamination which are shown in yellow and red in the map.
2. In general, the index generated based on Pesticide DRASTIC weighting system is high than that generated by DRASTIC weighting . Pesticide DRASTIC model is developed to evaluate nitrate related groundwater vulnerability. The weight specified on each factor is slightly different from DRASTIC.
3. Pesticide DRASTIC is more effective in terms of identifying high or very high contaminated regions.
4. Pesticide DRASTIC and DRASTIC model have a good agreement on spatial simulation results in low and very low vulnerable regions.





References

Aller, L., Bennett, T., Lehr, J.H., & Petty, R.J. (1985). DRASTIC—a standardized system for evaluating ground water pollution potential using hydrogeologic settings. *U.S. Environmental Protection Agency,* U.S. Environmental Protection Agency report. EPA/600/2-85/018. Washington, D.C. Retrieved from http://www.epa.gov/nscep/index.html.

Carsel, R.F., Mulkey, A.L., Lorber, M.N., & Leland, B.B. (1985). The pesticide root zone model (PRZM): a procedure for evaluating pesticide leaching threats to groundwater. *Ecol Model*, 30, 49–69. Retrieved from http://www.sciencedirect.com/science/article/pii/0304380085900365.

Gogu, R.C., & Dassargues, A. (2000). Current trends and future challenges in groundwater vulnerability assessment using overlay and index methods. *Environ Geol*, 39, 549–559. Retrieved from http://link.springer.com/article/10.1007/s002540050466.

McLay, C.D.A., Dragten, R., Sparling, G., & Selvarajah, N. (2001). Predicting groundwater nitrate concentrations in a region of mixed agricultural land use: a comparison of three approaches. *Environ Pollut*, 115, 191–204. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11706792.

National Research Council (NRC). (1993). Groundwater vulnerability assessment: Contamination potential under conditions of uncertainty. *National Academy Press*, Washington, DC. Retrieved from http://www.nap.edu/openbook.php?record_id=2050.

Oklahoma Water Resources Board. (2012). Oklahoma Comprehensive Water Plan Executive Report. OWRB, OK. Retrieved from http://www.owrb.ok.gov/supply/ocwp/ocwp.php.

Osborn, N.I., Eckenstein, E., & Koon, K.Q. (1998). Vulnerability assessment of twelve major aquifers in Oklahoma. *Oklahoma Water Resources Board*, technical report. Retrieved from http://www.owrb.ok.gov/studies/reports/aq-vuln/tr98_5.php.

Vrba J., & Zaporozec, A. (1994). Guidbook on mapping groundwater vulnerability. *IAH International contribution for Hydrogeology*. Herise, Hannover, Germany. Retrieved from http://webworld.unesco.org/water/ihp/publications/waterway/wat4/new.htm#Heading71.

Data Sources: Oklahoma Water Resources Board. 2011. OWRB Groundwater Aquifers. Retrieved from http://www.owrb.ok.gov/maps/pmg/owrbdata_GW.html.
U.S. Environmental Protection Agency. 2013. Retrieved from http://www.epa.gov/enviro/geo_data.html.
U.S. Department of Agriculture (USDA) Natural Resources Conservation Services, National Cartography & Geospatial Center. 2001. Retrived from http://datagateway.nrcs.usda.gov/

Projection System: NAD 1983 UTM Zone 14N

Lurong Yang ♦ Dec. 6th, 2013 ♦ CEE 187

Tufts UNIVERSITY