E. Coli Fate and Transport below Subsurface Septic Tanks in Lake Granbury Area

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Introduction

Onsite/decentralized wastewater treatment systems serve approximately 25% of U.S. households and almost 40% of new developments. The most common Onsite Wastewater Treatment System (OWTS) involves a septic tank unit followed by dispersal to a subsurface soil infiltration unit. Water contamination with *Escherichia coli (E. coli)* through onsite systems is becoming an issue in rural areas of the US.

E. coli transport is site specific and the flow regime has significant effects on bacterial transport. Seasonal rise of the water table into the infiltrative field can also move bacteria into ground water zones. Once it reaches the ground water, the bacteria can survive and travel to considerable lengths.

Lake Granbury in the upper part of the Brazos River in North Central Texas is an important source of water supply, providing water for over 250,000 people. Brazos River Authority (BRA) has detected that some of the lake's coves are contaminated with *E. coli.*

In the area OWTS is used to treat household effluents. We hypothesize that a possible source of contamination in the lake is due to large number of septic tanks, and their poor management. In response to concerns regarding potential risks associated with the *E. coli* contamination of the lake and subsequent involvement of resources and money, it is important to address the concerns.

The objectives of this research are:

- To mimic possible seasonal variability and topographic features through different scenarios involving the variation in groundwater table and lake level.
- To model the scenarios with the available data to investigate and uniquely characterize the impact on flow paths and *E. coli* transport in the vadose zone.
- To conduct a sensitivity analysis on the transport parameters.

Study Area

Lake Granbury is located in the Middle Brazos-Palo Pinto watershed (USGS Cataloging Unit-12060201). The site selected for modeling was a 100 m length across Pecan Valley Ct. in the Granbury area. The most common texture was silty clay loam followed by silt loam, clay loam, sandy clay loam and silt clay.

http://earth.google.com/

Areal view of the study area

A view across Lake Granbury

A view along the canal

Methodology

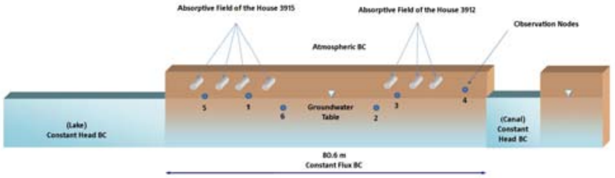
Two houses (3912 and 3915 on Pecan Valley Ct) were considered and it was assumed that they have OWTS as per Texas Administrative Code (Chapter 285 On-Site Sewage Facilities).

The house at 3915 is located near the lake, and the one at 3912 is located near the canal. The canal is constructed on the lake via an interconnected waterway.

This case allows us to investigate the likely effects of different scenarios on hydrologic behavior and the transport of *E. coli* in the vadose zone. Four different scenarios were investigated. Boundary conditions (BC) with respect to water level in the lake, in the canal, and in the groundwater system were incorporated in HYDRUS 3D as follows:

1. The canal level is higher than the lake level (if embankment or levy are present).
2. The lake level is higher than the canal level.
3. The lake and the canal are at the same level and the GW level is lower.
4. The lake and the canal are at the same level and the GW level is higher.

The first two scenarios represent topographic features while the third and fourth mimic possible seasonal variability.



We used the attachment/detachment model for *E. coli* movement in variably saturated soils [*Šimůnek et al.*, 2006].

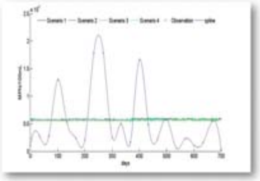
$$\frac{\partial \theta c}{\partial t}+\rho\frac{\partial s_e}{\partial t}+\rho\frac{\partial s_1}{\partial t}+\rho\frac{\partial s_2}{\partial t}=\frac{\partial}{\partial x_i}\left(\theta D_{ij}^{w}\frac{\partial c_1}{\partial x_i}\right)-\frac{\partial q_i c}{\partial x_i}-\mu_w\theta c-\mu_s\rho\left(s_e+s_1+s_2\right)$$

Where c and s are the *E. coli* concentrations *[cfu/100mL]* in the aqueous phase and solid phase, subscripts e, 1, and 2 represent equilibrium and two kinetic sorption sites, and μ_w and μ_s represent inactivation and degradation processes in the liquid and solid phases, respectively.

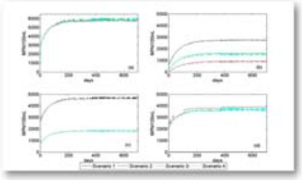
Results and Discussions

E. coli concentration in the canal and simulated daily *E. coli* concentrations for four scenarios at the interface of canal and subsurface are correlated with a dilution factor of order two. The dilution factor was calculated with number of sources per square unit area and total area of the modeling domain.

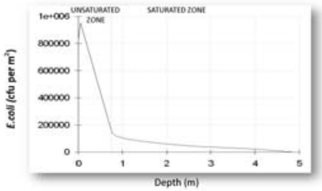
Majority of *E. coli* treatment occurred within the first meter. This may be because the top layer is unsaturated, thus removal rate is higher; and in the saturated zone, it is smaller.



The observed monthly *E. coli* concentration in canal and simulated daily *E. coli* concentration at the interface of the canal and subsurface (Jan 2006- Nov 2007)



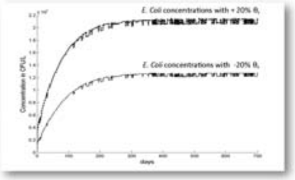
Concentration of *E. coli* at observation nodes (a) near canal; (b) near lake; (c) below the septic tank (canal side); and (d) below the septic tank (lake side)



***E. coli* concentration profile with depth from the drain field for scenario 3**

E. coli transport depends on different hydrological scenarios. It is mostly regulated by advective flux. Lateral advective flux is more prominent in the first two scenarios whereas, vertical advective flux in other two.

E. coli transport is found to be most sensitive to changes in values of saturated water content, followed by the decay coefficient and dispersivity parameters.



Change in *E. coli* concentration with change in saturated water content at observation node below the septic tank (lake side,

Conclusions

- This study demonstrates that one of the possible sources of contamination in the lake and the canal is due to the large number of septic tanks.
- Simulated bacteria concentrations decrease with depth. Unsaturated media restricts *E. coli* transport.
- Saturated water content is the most sensitive parameter in this study. Decay coefficient and dispersivity also show sensitivity. Dispersivity has been reported as an insensitive parameter in the literature, but in our case, this parameter is sensitive.
- Prediction of *E. coli* concentrations should be done keeping seasonal variations in mind. The parameters or boundary conditions, representative of seasonal variations, should be changed in HYDRUS while simulating *E. coli* on a yearly basis.

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Partial funding by EPA 319(H) for Lake Granbury Water Quality Initiative and TWRI is acknowledged.