Evaluation of E. coli Concentrations in Groundwater Beneath Onsite Wastewater Systems in Eastern North Carolina

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ABSTRACT

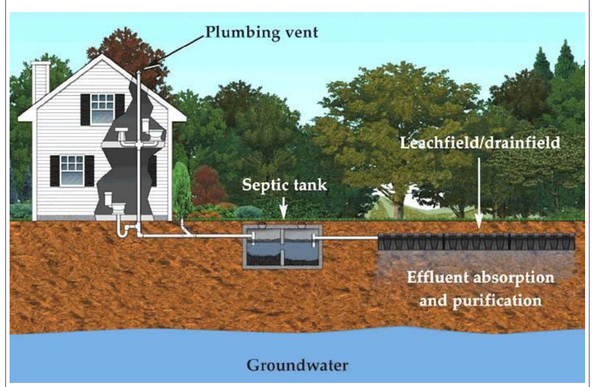
Wastewater contains pathogens including bacteria that may cause severe illness or death and thus untreated wastewater poses a risk to public and environmental health. Treatment wastewater (and pathogens) may occur in soil beneath septic system drainfield trenches if the systems are properly designed, installed, and maintained. However, monitoring groundwater near septic systems to assess treatment effectiveness is not required for most systems. The goal of this study was to assess the concentration of E. coli in groundwater beneath septic systems across a range of conditions in Eastern North Carolina. Groundwater samples collected from monitoring wells near 10 different septic systems were analyzed for *E. coli* concentrations between 5 and 10 times over an 18-month period. Results showed that septic systems with more than 1.0 ft of vertical separation distance to groundwater were effective at lowering the median concentration of *E. coli* to under 5 MPN 100 mL^{-1}. However, a septic system with less than 1 ft of separation had concentrations of *E. coli* that exceeded 1300 MPN 100 mL^{-1}. Ensuring that septic systems maintain 1 ft or more separation to groundwater is important for wastewater treatment.

INTRODUCTION

Excess bacteria concentrations are a common cause of water use impairment and often lead to closure of shellfish waters

Wastewater that is not effectively treated may be a source of pathogenic microorganisms

E. coli is an indicator bacteria that is often used to evaluate water quality with regards to pathogens and public health risks



Onsite wastewater systems are used by 50% of the population of NC for treatment and disposal of wastewater

Onsite systems include a septic tank to separate solids and liquids, drainfield trenches to store septic tank effluent, and soil beneath the trenches to help provide an environment for pollutant treatment

Bacteria cconcentrations can be lowered in soil via filtration, adsorption, die off, competition, predation, and dilution and dispersion

Soil properties including texture (percent sand, silt, and clay), structure, depth, and mineralogy influence water and air movement in the subsurface and thus influence wastewater treatment

Once onsite systems are permitted and installed, most are not required to be monitored to evaluate their treatment efficiency

More information is needed regarding the effectiveness of onsite wastewater system in lowering *E. coli* concentrations

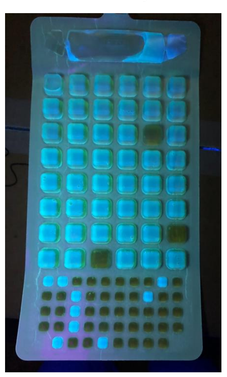
MATERIALS & METHODS



Monitoring wells were installed near the drainfield trenches of 10 different onsite wastewater systems in Eastern North Carolina The wells were installed using soil augers with extensions. Once the water table was reached, a few more borings were removed and then well screen was cemented to a solid cap on one end and coupled to PVC casing on the other end. The casing was cut just below the ground surface and encased in valve boxes. Soil profiles were laid onto tarps and the horizons were described.

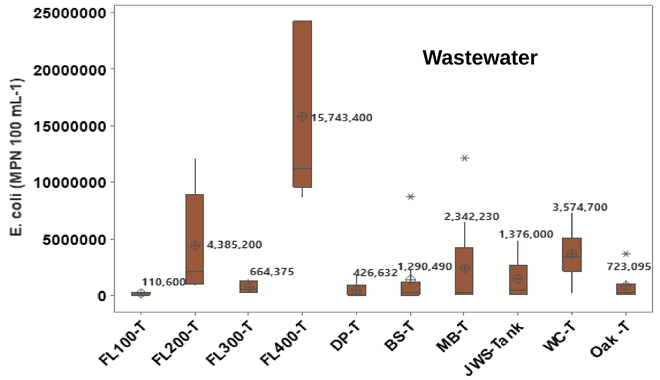

Wastewater samples were collected from septic tanks using disposable bailers. Wastewater was transferred from the bailer to sample bottle and multi-probe meter. The pH, oxidation reduction potential, and specific conductance of wastewater were determined in the field. Sample bottles with wastewater were placed in ice-filled coolers for transport to the lab for analyses.

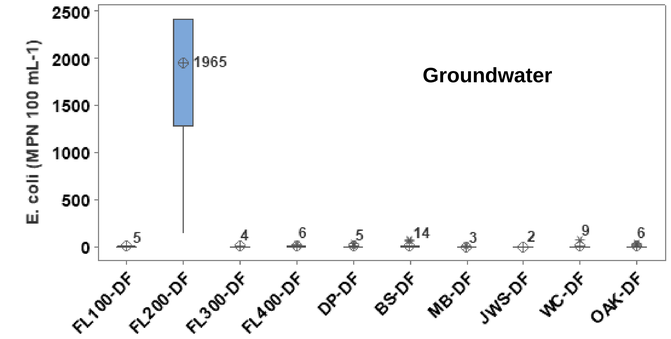


At each monitoring well, the depth to groundwater was determined using a Solinst TLC 107 Meter. Next, groundwater was purged 2 to 3 times using a bailer. Once the well recharged, groundwater was transferred to a sample bottle and placed in the ice filled cooler. Groundwater physicochemical properties including pH, oxidation reduction potential and specific conductance were determined in the field and recorded on data sheets. Back at the lab, *E. coli* were enumerated using the IDEXX Colilert substrate with Quantitray 2000. The trays were placed in an incubator for 24 hours and then the wells that illuminated were counted as positives. An MPN table was used to determine the concentration corresponding the illuminated "big" and "small" wells. Concentrations of *E. coli* were compared to recreational water quality standards.

RESULTS & DISCUSSION





Location	Depth to Water (ft)	Trench Depth (ft)	pH	ORP	SC (uS/cm)
BS-T			7.9 (0.5)	-151 (137)	2799 (863)
BS-DF	8.2 (0.8)	2.25	6.9 (0.5)	6 (75)	751 (511)
JWS-T			7.2 (0.2)	-135 (106)	1068 (425)
JWS-DF	16.7 (2.8)	2.6	6.3 (0.5)	80 (85)	719 (276)
OAK-T			6.9 (0.6)	-184 (75)	823 (241)
OAK-DF	5.8 (2.2)	2.1	3.7 (0.6)	126 (98)	270 (86)
DP-Tank			8.1 (0.5)	-194 (49)	2660 (1117)
DP-DF	4.8 (0.6)	1.8	6.2 (0.5)	49 (96)	782 (370)
MB-Tank			7.6 (0.4)	-181 (59)	1554 (447)
MB-DF	4.8 (0.4)	1.9	7.1 (0.5)	41 (139)	952 (439)
WC-Tank			7.2 (0.5)	-139 (93)	678 (306)
WC-DF	5.5 (1.1)	2.4	6.2 (0.4)	7 (78)	330 (255)
FL 100-T			6.94 (1.33)	-120 (118)	1604 (1064)
FL 100 DF	5.5 (1.68)	2.6	5.92 (1.0)	211 (191)	852 (482)
FL 200 -T			7.01 (0.2)	-196 (99)	1916 (429)
FL -200 DF	2.2 (.14)	2.3	6.3 (0.21)	5 (99)	604 (138)
FL 300-T			6.81 (0.2)	-200 (52)	2592 (570)
FL 300-DF	3.0 (0.6)	2	3.8 (0.3)	164 (68)	1100 (305)
FL 400 T			7.3 (0.10)	-220 (55)	1872 (419)
FL 400 DF	4.0 (0.7)	2.3	4.2 (0.3)	111 (101)	345 (118)

Concentrations of *E. coli* in wastewater (T) were elevated and variable. The mean concentrations ranged from 110,600 MPN 100 mL^{-1} at FL110-T to 15,743,400 MPN 100 mL^{-1} at FL400-T. Mean *E. coli* concentrations in groundwater near the drainfields (DF) were less than 15 MPN 100 mL^{-1} except for at FL200-DT where the mean concentration was 1965 MPN 100 mL^{-1} and there was no vertical separation to groundwater during most of the sampling dates.

CONCLUSIONS

Onsite wastewater systems that had 1 ft or greater vertical separation distance to groundwater were efficient at reducing *E. coli* concentrations. One system had less than 1 ft of separation to groundwater and exhibited *E. coli* concentrations that exceeded the recreational water quality standards and thus may have been a threat to surface water quality. The system was malfunctioning during the study but was repaired later.