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Impact of Onsite Wastewater Treatment Systems on Stream Water Quality and Quantity in Urbanizing Watersheds of Georgia

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Introduction

- As widely as Onsite Wastewater Treatments Systems (OWTS) are used for wastewater treatment, their impact on water quality and quantity has not been elucidated to allow their inclusion in watershed management programs.
- Currently, OWTS are implicated (with little evidence) in widespread surface water pollution involving fecal pathogens and nutrients. Moreover, the contribution of OWTS to consumptive water use has not been widely explored to inform watershed management decisions.
- **Our overall goal** was to isolate the influence of OWTS on surface water quality and quantity and thereby identify any seasonal or temporal patterns.
- The study area is in the Southern Piedmont region and comprised 12 high density watersheds (HD: > 200 OWTS/mi²) and 12 low density watersheds (LD: <100 OWTS/mi²). We compared microbial water quality, nitrogen levels and baseflow in streams of HD to conditions in LD after 5 synoptic sampling events spanning Nov. 2011 – Apr. 2013.

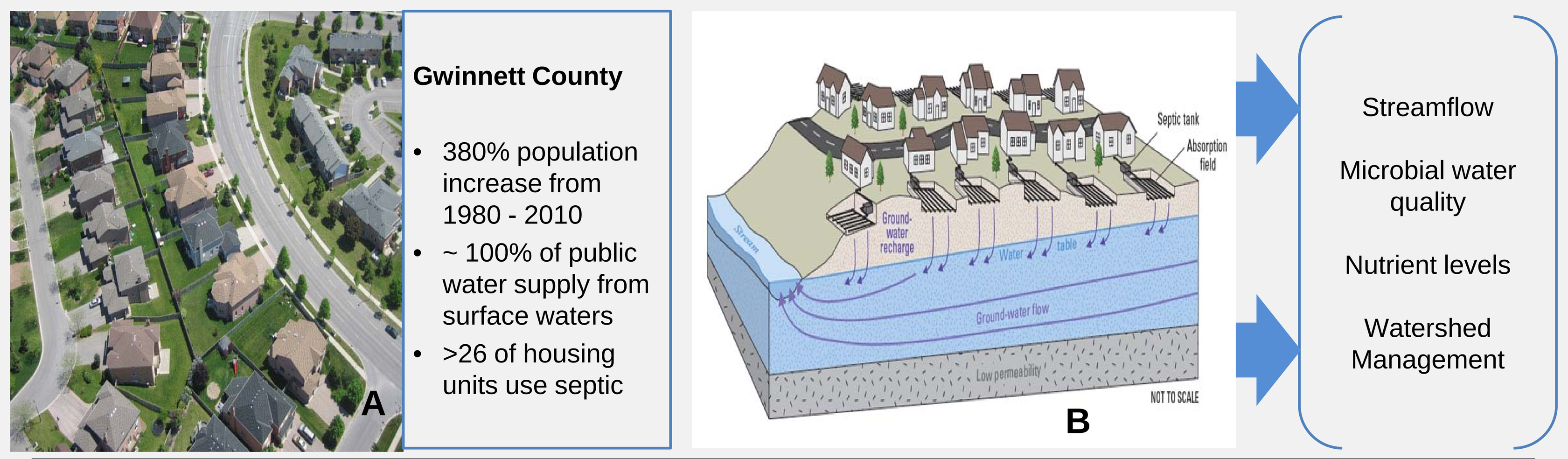

Figure 1. (A) Medium density residential land-use in study area (B) Conceptual diagram of OWTS influence on groundwater (Landers and Ankcorn, 2008)

Study Area

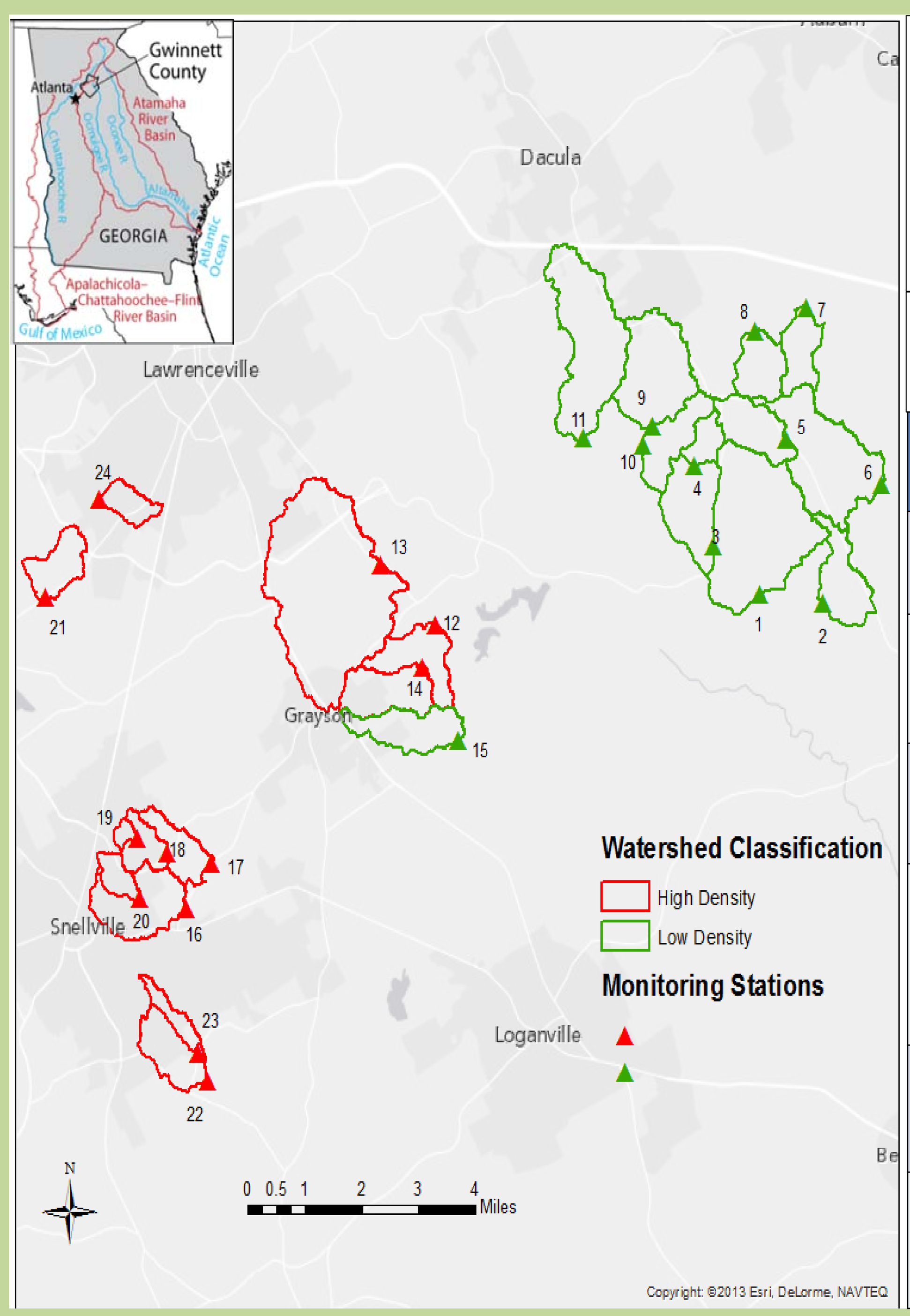

Figure 2. Location of the study site with 24 watershed boundaries and monitoring stations in Gwinnett County (Modified from Landers and Ankcorn, 2008).

Table 1. Some basic characteristics of watersheds in study area.

Watershed Characteristics		
OWTS Density	High	Low
Mean Drainage Area (mi²)	0.78	1.15
# OWTS/mi²	559	57
Watershed Imperviousness %	18.3	6.7
Median Distance to Stream (m)	95.7	128.3
River Basins	Oconee and Ocmulgee	

Sampling Regimes & Measured Parameters

- Synoptic sampling of watersheds (Figure 2) was conducted at baseflow 5 times between 2011 and 2013. Streamflow was also measured during synoptic sampling events (Figure 3).
- Storm samples collected with continuous stream gages at four sampling sites for later modeling work
- Samples were analyzed immediately for bacteria and within 48 hours for nitrogen.

Figure 3. Some streams in the study area at baseflow conditions and streamflow measurement in collaboration with USGS

- Measured water quality indicators: pH, temperature, dissolved oxygen , specific conductance, chloride, *E. coli*, enterococci, nitrate, total kjeldhal nitrogen (TKN) and δ^{15}N
- Used Colilert and Enterolert kits from IDEXX Inc. for bacteria, in situ probe for common water quality parameters, standard methods for nutrients and velocity-area method for measuring streamflow
- Water samples filtered to collect DNA for later microbial source-tracking work

Results

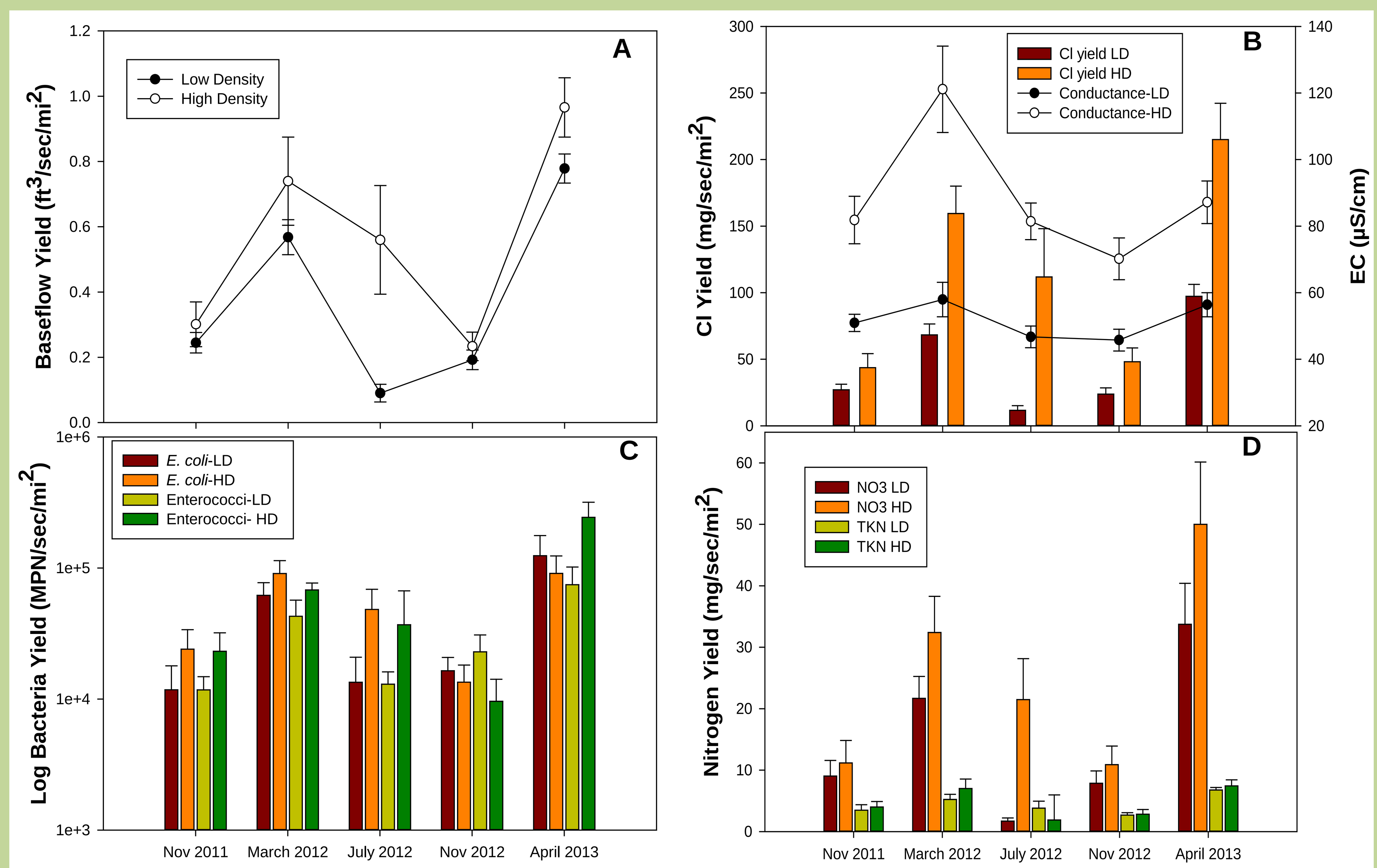

Figure 4. Baseflow (A), bacteria (C) and Nitrogen yield in streams of watersheds with low density (LD) or high density (HD) of OWTS. Fig. (B) Variations in chloride (Cl) yield and conductance in watersheds of LD or HD OWTS.

Results

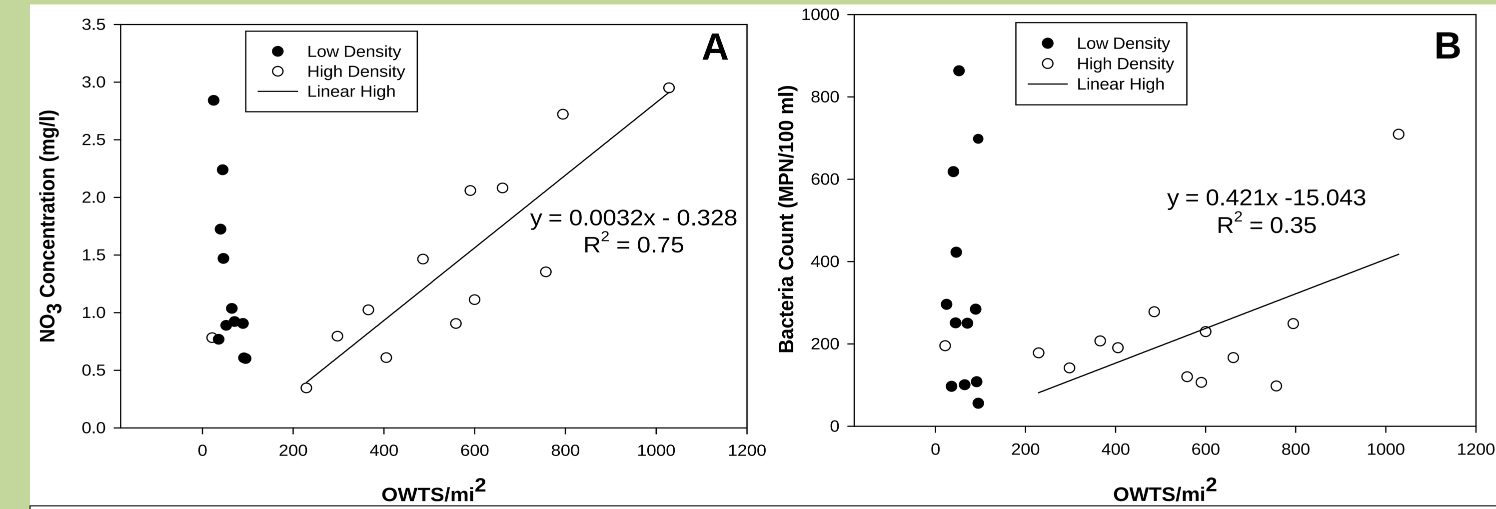

Figure 5. Relationship between nitrate concentration (A) and bacteria count (B) with OWTS density in high density or low density watersheds. All data between 2011 – 2013 were pooled.

- Water quality parameters such as temperature, pH and dissolved oxygen were comparable among streams in the two watershed groups (data not shown).
- Mean baseflow was significantly higher in high density watersheds vs. low density watersheds ($p = 0.046$) indicating the importance of OWTS to stream water recharge.
- Baseflow varied seasonally and over time in both high density and low density watersheds (Figure 4A) and showed significant difference ($p = 0.002$) between high and low density watershed groups during the dry summer period.
- Detection of Chloride in both watershed groups and the higher δ^{15}N (+7.6 - 25 ‰) signature in streams of HD watersheds suggest input from wastewater.
- Water quality parameters (*E. coli*, enterococci, nitrate, TKN, Cl and specific conductance) also varied seasonally in response to streamflow as impacted by OWTS density.
- There was a positive correlation between water quality indicators and OWTS density above 229 OWTS/mi² (Figure 5) suggesting that OWTS influence water quality at high density. Source tracking is needed to confirm this.

Conclusions

- Density of OWTS significantly influences stream water quality and quantity through contributions to baseflow resulting in higher fecal indicator bacteria counts and nutrient concentrations
- Seasonal variations in contaminant concentrations have to be considered in a broader context of watershed management to address specific watershed characteristics such as OWTS density, land-use and population density that influence water quality.
- OWTS contribution to stream water quantity under dry conditions could be critical to ecosystem processes and protection of ecological habitats.

Acknowledgment

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USDA

Reference

1. Landers, M.N. and Ankcorn, P.D. (2008). Methods to evaluate influence of OWTS on baseflow in selected watersheds in Gwinnett County, GA