Climate Change Influence on Coastal Onsite Wastewater Infrastructure

Tropical Storm Eta, Nags Head, NC (Nov.13, 2020)

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Climate Change is Coming for Coastal Septic Systems

- Groundwater levels & extreme precipitation events are increasing in many coastal communities (Cox et al. 2019, Paerl et al. 2019, Kunkel et al. 2020).

- Changes pose a threat to onsite wastewater (ww) treatment, impacts to public health, and ecosystems.

- How can coastal communities that use onsite wastewater treatment protect water quality as climate changes?
Changing conditions in coastal regions can cause unique WW management challenges (nuisance flooding, extreme precip., sl rise)

How can coastal communities cost effectively and legally implement climate adaptation plans for decentralized wastewater infrastructure?

Interdisciplinary Perspectives
- Groundwater dynamics
- Expert interviews (operators/installer, health officials)
- Legal analysis
NC Reliance on Onsite Wastewater Treatment & Disposal

- NC has ~2 million systems in total; ~1 million systems in watersheds draining to the coast (modified from Pradhan et al. 2007).
- NC has the highest percentage (48.5%) of state residents using onsite wastewater systems in the Southeast U.S., and the 4th highest in the U.S. (EPA 2002).

### Onsite Wastewater Treatment

- **Septic Systems**
- **Package Plants/Advanced Systems**

### Approximate Distribution of Systems in NC Coastal Counties

- **Number of Systems**
- **Majority-decentralized**
- **Centralized**
- **Decentralized**
- **Municipal**
- **Package and Advanced**
- **Septic**
Vertical Separation Distance (VSD)

- Depth of unsaturated soil between the drainfield and the water table.
- Adequate VSD needed for degradation of organics, bacteria/virus removal, nitrification.
- Field & column studies* suggest VSD > 60 cm needed for adequate soil treatment of wastewater.

*(Karathanasis et al. 2006a, b; Humphrey et al. 2011; Stall et al. 2014; Humphrey et al. 2015a; O’Driscoll et al. 2014; Humphrey et al. 2015b; Cooper et al. 2016; Humphrey et al. 2017).
Climate Change Threats to OWTS – Storms & Flooding (Acute)

- Flooding and storm-related erosion can reduce treatment capacity of coastal onsite wastewater treatment systems (OWTS).

Flooded drain lines (Hurricane Florence, Sept. 2018)

GW depth in 3 wells near a Pitt Co., NC OWTS

Humphrey et al. 2020 (in review)
Climate Change Threats to OWTS: Groundwater Inundation (Chronic)

- Rising gw levels due to sea level rise and coastal storms can reduce the VSD.

- NC requires 30-45 cm VSD between the drainfield and the groundwater.

- Chronic failure can occur as gw rises and reduces the thickness of unsat. soils and compromises their ability to treat wastewater.
Groundwater and Sea Level Monitoring Sites – Dare Co. NC

- 8 well clusters (NC DEQ) ~ 1983-1984
- ~ monthly data collection, mid- 1980s
- daily data collection at most sites by 2008
- Duck, NC –NOAA Tidal Gauge; 1977
- additional project wells (since 2019)
- For this talk- focus on longer-term DEQ data
Groundwater levels have been rising in the surficial aquifer over period of record (1983-2019).

Sea level rise at Duck, NC (NOAA, 2020): 4.77 cm (1.9 in)/decade (1978-2019).
Groundwater Level Trends (Surficial Aquifer; 1983-2019)

- Mean annual gw levels rose significantly from 1983-2019 (except Stumpy Pt)
- Median gw level rise trend-12.8 cm/decade (~5 in/decade)
- GW level rise ranged from 29 cm/decade (Wanchese) – 6cm/decade (Skyco Rd.)
Groundwater Level Rise ➞ Reduction in GW Depth

- Greatest GW level increase (depth decrease) at Wanchese Community Building
- GW depth < 1 m (~0.4-.6 m depth to drainlines/trench & 0.45 m VSD), unsuitable for conventional septic
- VSD decline over time - reduced suitability for conventional septic systems
Effects of Sea Level Rise on GW Depth and VSD

- Majority of sites - gw < 1 m depth
- These areas would not be viable for conventional OWTS (VSD > 0.45 m)
- Only 2 areas had gw depth > 1 m for 30% of year (viable for OWTS)
Coastal Storms and GW Response: Reductions in VSD

- GW Level Response to Rainfall @ Wanchese
- Extreme rain event (18 cm, 7 in.)
- 1.2m (3.9 ft.) GW rise
- ~100 days to return to pre-event GW levels
- At this site for > 5cm (2 in.) rain events, weeks to months for gw to return to pre-storm levels
Why are the GW Levels Rising in the Surficial Aquifer?

- Sea Level Rise
- Precipitation
- Declining GW levels in the underlying Yorktown Aquifer
  - Potentially accelerating subsidence
  - Natural subsidence
- Withdrawals from the Yorktown typically discharged to the surficial aquifer via onsite systems
- Other factors (land-use change)
How are the rising GW levels affecting onsite wastewater treatment?
Interviews and surveys were conducted with coastal onsite wastewater treatment system operators and installers, as well as health officials.

Study conducted by:
Lauren Vorhees, NC Sea Grant
Jane Harrison, NC Sea Grant

Degler Waste Services, Ridgeland, South Carolina
Study Area & Participants

<table>
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Professional Experience of Wastewater O/Is

How many years of experience do you have working with OWTS in the coastal regions of North and South Carolina?

- 2-5 years: 1 participant
- 6-10 years: 2 participants
- 11-20 years: 7 participants
- 21+ years: 7 participants

Which coastal regions do you install, operate, or maintain onsite wastewater treatment systems?
- Outer Coastal Plain: 16 participants
- Inner Coastal Plain: 3 participants
- Sandhills: 1 participant

Do you work on barrier islands or sea islands?
- Yes: 7 participants
- No: 10 participants
Site variables that determine function in heavy rainfall

- Drainage (positive drainage)
- Soil type
- Elevation
- Groundwater height
- Slope
- Rainfall
- Infiltration
- Proper use and maintenance
- Proper installation
- Vegetation control
- Vehicle traffic over the site
- System age

Number of respondents
Dry conditions + heavy rain: will a conventional system malfunction?

- Yes: 2
- No: 17

Wet soils + heavy rain: will a conventional system malfunction?

- Yes: 8
- No: 11

Wet soils + King Tide: will a conventional system malfunction?

- Yes: 4
- No: 13
Adaptation measures to extreme weather events

• Raising septic tanks and drainfields
• Conservative installation measurements
• Greater tank capacity
• Advanced systems
  • Pretreatment
  • Drip irrigation
  • Modified e.g. chamber systems
  • Pressure systems
  • Curtain drains
Onsite Wastewater Adaptation – Potential Policy Options

- Land use planning/zoning
  - Necessary for future development
  - Possibly limited options for existing systems

- Stricter siting/installation rules
  - Necessary for future development
  - Focus is on new systems

- Maintenance requirements
  - Can extend working life of systems
  - Not a long-term remedy for SLR

- Advanced/alternative onsite systems
  - Option for some sites, regularly used
  - Cost, may require enhanced management

- Cluster/community systems
  - Flexible, utility option
  - Need suitable site, cost, local government management likely needed

- Centralized sewer
  - Advanced treatment, centralized management
  - High cost, permitting issues, local gov’t liabilities

- Retreat
  - Mitigates threats to human health, environment
  - Cost, political will, legal liabilities
Onsite Wastewater Adaptation – Legal Authority

• Local health agencies
  • Focus on imminent public health hazards
  • Existing rules don’t provide flexibility to respond to changing conditions

• Local governments
  • Critical land use planning and zoning authorities
  • Authority to directly regulate onsite systems is unclear (preemption?)

• South Carolina
  • Haphazard statutory scheme
  • “Abate obnoxious and offensive odors”
  • Permits may be revoked for major system malfunctions
  • Only 6 inches of separation from groundwater for many systems

• North Carolina
  • Comprehensive septic statute
  • Focus on public health
  • Permits can be valid without expiration
  • Local health agencies may petition for stricter standards
Conclusions & Future Work

- Sea level & gw are rising in the coastal Carolinas. Long-term & storm-related gw level rise can reduce the VSD & limit functionality of OWTS.

- Evaluate alternative systems that can work effectively in shallow water table conditions and during storm events.

- Economic analysis of wastewater infrastructure climate adaptation technologies.

- Future regulatory approaches in coastal communities should consider rising gw tables & their effects on VSD and OWTS effectiveness, and adjacent water quality.

Modified from Walter et al. 2016
Thanks for your attention!

Acknowledgments

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  - Maddy Roberts, Graduate Student (EH), East Carolina University
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