Sources and Evolution of Nitrate-Nitrogen in Urban Stormwater Runoff

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OUTLINE

1. Population Growth: Urbanization, Algal Blooms
2. Policy driven: Fertilizer Bans in Urban Areas
3. Nitrogen Transport in Urban Neighborhoods
   - High-frequency Stormwater Runoff Data
4. Conclusions

① Urban Population Explosion: World

- 1850: 2% people lived in cities
- 1900: 6% people lived in cities
- 1950: 29% people lived in urban areas (cities + suburbs)
- 2010: 50% people lived in urban areas (cities + suburbs)
- 2050: 70% people will live in urban areas (cities + suburbs)

Urban Population (%): US

Land Use Changes in Florida: Human modification of natural landscape

Population Growth
- 1900: 0.53 million
- 2015: ~20 million
- 2036: 36 million

Impacts of Urbanization: Increase in Runoff

When it rains, a large amount of water........
**Impact of Nutrients**
- Excessive plant growth in streams/lakes
- Scum and algae near lake shores
- Unpleasant odors

**History of Regulations to Control Urban Nutrient Pollution in Florida**
- 1999 – Watershed Restoration Act passed
- 2007 – Fertilizer ordinances begin to appear
- 2007 – Urban Turf Rule passed
- 2009 – Fertilizer ordinances mandated in some areas
- 2010 – State model ordinance developed

**Florida Fertilizer Bans/Ordinances**
- 08/2015 – Florida counties (28) and municipalities (76) now have some kind of fertilizer ordinance
- Range from recommendations on application timing to complete rainy season “blackouts” (8 counties, 33 municipalities)

**Most controversial**
- Blackout period (June-Sept)
- Ban on retail fertilizer sales during blackout (effective in Pinellas county, Tampa)

**RATIONALE**
- Higher rainfall causes more runoff, so the rationale is that by banning fertilizer applications, loss of nutrients in runoff from lawns will be reduced.

**Rainfall Distribution in Florida**
- Average annual rainfall: ~137 cm or 1370 mm
- 50-70% rainfall during wet season (June to September) in short-duration, high-intensity storms

**Nitrogen Transport from Residential Neighborhoods**
- High-frequency Stormwater Runoff Data (5 minute intervals)
**Study Unit: Residential Neighborhood**

- Area: 13.4 ha (33 ac)
- 31 homes: average lot size is 0.24 ha (0.63 acres).
- Average home size: 4,400 ft² (408 m²)
- 0.5 to 1 million USD

**Residential Neighborhood: GIS Mapping**

- Dominant vegetation: live oak and turfgrass

**Installed stormwater autosampler, pH, flow meter, rain gauge**
- Collect runoff samples (every 5 minutes, up to 14 samples) from the outlet pipe draining the neighborhood
- Captured 25 stormwater events during 2014 wet season

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**What is the source of water in residential stormwater runoff?**

**2014 Wet Season**

- Urban stormwater runoff = originated from rainfall. Slight evaporation during transport of water.
- No other source of water (e.g., irrigation water, sanitary sewer leaks, septic systems).
- Stormwater runoff transported N present in different sources.

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**What are the sources of nitrate-nitrogen in residential stormwater runoff?**

**Bayesian Mixing Model:**

- Rainfall was the main source of NO₃⁻N in stormwater runoff in 56% of samples.
- Fertilizer containing NH₄⁻N: 34% of samples.
- Fertilizer containing NO₃⁻N: 8% of samples
- Mixed sources: 2% of samples.

**Yang and Toor. 2016. ES&T.**
Change in nitrate-N sources in stormwater runoff events

Of stormwater events:

- 15 events dominated by atmospheric deposition (mean credible interval: 33 to 72%)
- 9 events were dominated by NH₄ fertilizer (mean: 38 to 63%)
- 4 events were dominated by NO₃ fertilizer (mean: 35 to 56%)  

Conclusions

1. Capturing storm-events led to identifying dominant NO₃-N sources in urban stormwater runoff:
   - Atmospheric deposition (56%), Chemical fertilizers (42%), Soil/waste (2%)

2. No denitrification during transport of NO₃-N in stormwater runoff
   - Mixing of different sources

Source dominance during wet season

- Atmospheric deposition contributed more NO₃-N in the beginning of wet season:
  - July (55-88%)
  - August (32-65%)
  - September (18-55%)
- Chemical fertilizer (NH₄ fertilizer and NO₃ fertilizer) showed an increasing contribution from:
  - July (1-32%)
  - August (1-57%)
  - September (<1-49%)
- No change in soil and waste sources

Questions?

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