An Examination of the Fecal Matter Origin in South Eastern Florida Coastal Waterways by Studying the Sucralose Levels in Selected Waterways.

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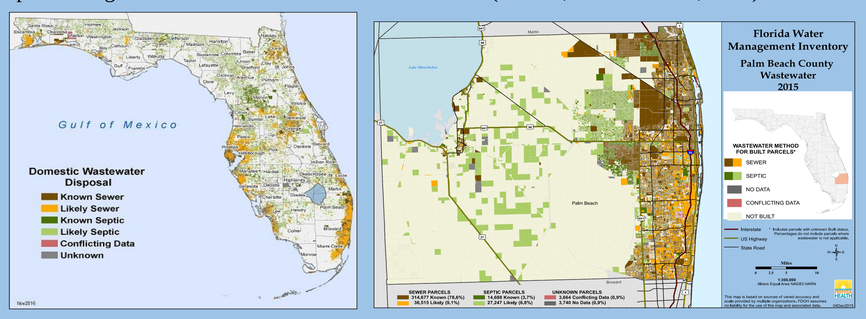
Abstract: Biological bacteria from feces has been recorded in Palm Beach County waterways. Exposure to this fecal matter has been known to cause gastrointestinal and severe respiratory diseases (Abdelzaher, et al., 2009). Although the exact source is presently unknown, it may be due to improper care and leaching of coastal septic systems, boats that dump untreated sewage, or urban runoff from fertilizers. In order to better identify the source of the E. coli that has led to beach closures throughout Palm Beach County, water samples were taken from beaches, inlets, and the intercostal waterways where septic systems are prevalent. Samples were analyzed for nitrates using a selective ion electrode and sucralose, a known marker for human feces, using high-performance liquid chromatography (HPLC). Prospective results indicate that areas in South Florida have bacterial markers affected by human waste (FDOH, 2016). Although some municipalities are aware and are working towards remediation of this problem, the general public is still ignorant. The Florida Department of Health results show that feces appear in the tested regions, through sampling of sucralose will conclude whether the feces in the waterways of Palm Beach County, Florida, are of human origin. While the public may be aware of fecal matter in the water, they may be unaware that the problem originates with their sewage and that they can directly encourage effective change in controlling the feces levels.

Introduction

Throughout Palm Beach County, beach closures prompted by Florida Department of Health's Palm Beach County Healthy Beaches Program tests for enterococci levels, in which the results frequently show high levels of enterococci, indicating the presence of feces. This is very disconcerting since much of the population of Palm Beach County, Florida and tourists in the area spend a considerable amount of time in the water or at the beach. Fecal matter in the water hinders the public from performing water related activities: watersports, fishing, swimming, and boating activities, due to beach and waterway closures. The high fecal matter levels effect the general health of tourists and residents, as well as contaminate waterway systems, which is a detriment to the markets that depend on steady annual tourism and watersports. Nowhere has this been more documented in South Florida then the St. Lucie River Estuary where fecal matter has induced mega toxic algae blooms that have killed thousands of life forms, destructed the natural ecosystem, and caused significant economic damages. In 2007 alone, the St. Lucie Estuary totaled approximately $840 million in tourism and marine use (FOS, 2013). The human and animal fecal matter present in the waterways of South Florida cause bacterial infections, gastrointestinal illness, and severe respiratory problems, that in severe cases may lead to death (CDC, 2017). The Florida Department of Environmental Protection (FDEP), Florida Department of Health (FDOH), and Florida Fish and Wildlife Conservation Commission (FWC) endeavor to monitor and educate the public regarding clean beach management. The fecal matter within the water may be a function of antiquated or poorly monitored septic systems as well as run off from fertilized residential lawns (DEP, 2016). The presence of feces in waterways can significantly impact costal habitats, the health of residents and tourists, and the economy. In order to validate a source, nitrate levels and sucralose, a chemical marker for human feces, were quantified in surface and benthic grab from samples collected from Palm Beach County beaches, intercostal waterways, and inlets, where both septic systems and human waste are prevalent.

Septic Systems

- Approximately sixty million Onsite Sewage Treatment and Disposal Systems (OSTDS) in the United States (DEP, 2017).
- According to the FDOH, thirty percent of Florida residents, approximately 2.6 million, use septic systems (FDOH, 2017).
- Over 80,000 septic systems in Palm Beach County alone, 65% of which were installed prior to 1983 and under the grandfathered in unregulated statute, meaning that the systems can sit only six inches above the high spring water levels (See Map 1) (FDOH, 2017).
- Due to the increased amount of precipitation during the months of July to September, and the porous sandy soil of South Florida, high water tables may result in flooded untreated sewage OSTDS penetrating the water table and coastal surface waters (Arnade, Linda Jenette., 1999).



Map 1: Private septic system and public sewage population map of Florida (left) and Palm Beach County (right)
(FLDOH, 2015)

Risk

- The fecal matter pathogens pose health risks to fisherman and swimmers in bodies of water. Bacteria may come from a myriad of sources: improperly functioning wastewater treatment plants, leaking or improperly functioning septic systems, storm water runoff, animal carcasses, and runoff from animal manure (EPA, 2015).
- Not only are the health of humans affected by fecal pollution, marine beaches may also be a large concern, according to studies by the United States Environmental Protection Agency (EPA), which show a correlation between marine beach illness and high enterococci levels (Abdelzaher, et al., 2009).
- The mega toxic algal blooms in the St. Lucie Estuary in St. Lucie County, Florida were the result of excessively high nutrient levels, one proponent being fecal pollution. The algal blooms caused the death and destruction of seagrass beds, oysters, fish, and many other marine species (FOS, 2013) (See Image 1)

Image 1: St. Lucie River marine life and estuary damage as a result of the toxic algal blooms
(FOS, 2013)

Sucralose

- Brand name Splenda ®, sucralose, is a polychlorinated chlorine containing synthetic artificial sweeter, with the chemical name: l,6-dichloro-l,6-dideoxy-p-D-fructofuranosyl- 4-chloro-deoxy-a-D-galactopyranoside (See Image 2) (Ho, Ho, & Hutchinson; Anja & Varoujan , 2009; Dye, et al., 2008).
- More than one hundred and seventy million Americans use low-calorie sweeteners such as Sucralose (Ho, Ho, & Hutchinson).

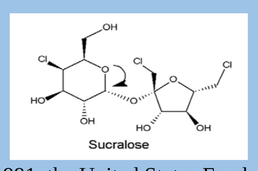


Image 2: The chemical composition of the compound sucralose.
(Rahn, Anja; Yaylayan, Varoujan A., 2009)

- The Canadian Food Inspection Agency (CFIA) since 1991, the United States Food and Drug Administration (FDA) since 1998, the European Union (EU) Scientific Committee of Food since 2004, and many other countries have accepted the culinary use of the sucralose (Abdelzaher, et al., 2009).
- Statistically sucralose is the most dependable product detected in known wastewater samples, while many other compounds resulted in false negative or false positive scenarios in the environment (Oppenheimer, Eaton, Haghani, Badruzzaman, & Jacangelo, 2011).
- Approximately 8% to 22% of the sucralose is absorbed into the human while the rest is excreted through urine or feces, therefore, sucralose being abundant in human waste (Dye, et al., 2008).
- Sucralose has been found to completely degrade in aqueous systems at temperatures of one hundred and eighty degrees at all pH levels (3, 7, 11) which is only a concern with a culinary application (Anja & Varoujan , 2009). However, at the temperature and pH levels in which the water was stored and sampled from the intercostal waterways, inlets, and beaches, the degradation of sucralose should be minimal.

Results

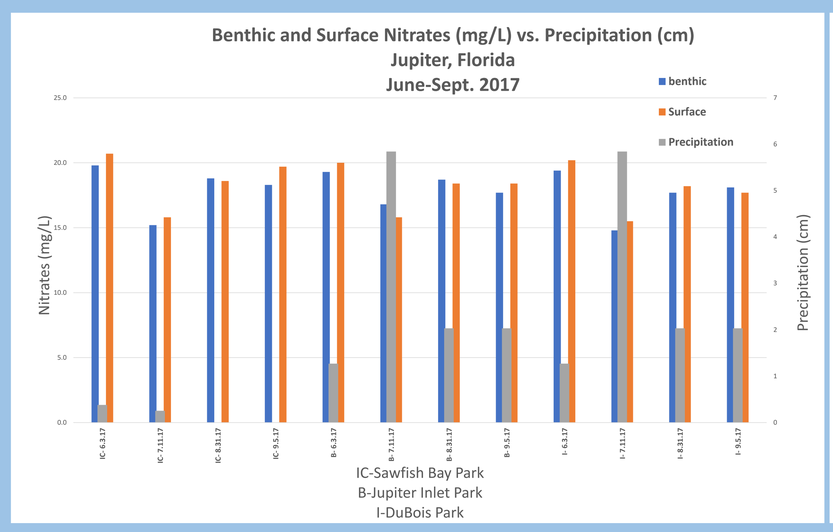


Figure 1: Nitrate Data for Jupiter, Florida

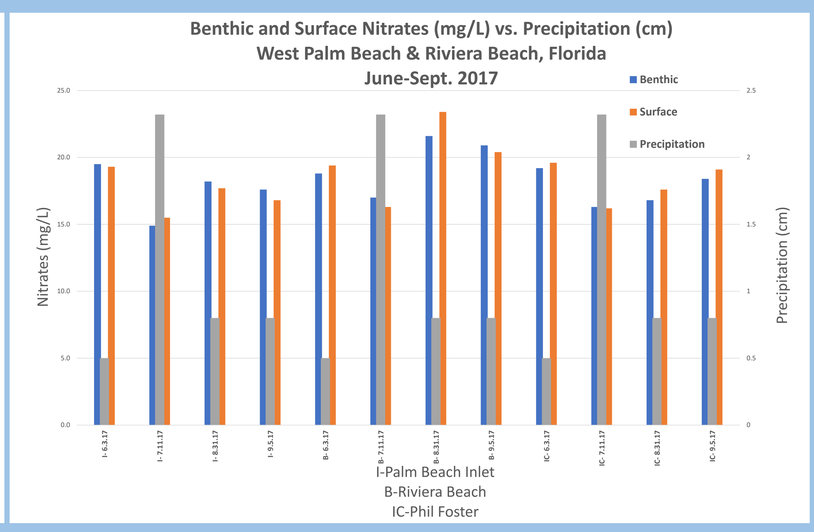


Figure 2: Nitrate Data for West Palm Beach and Riviera Beach, Florida

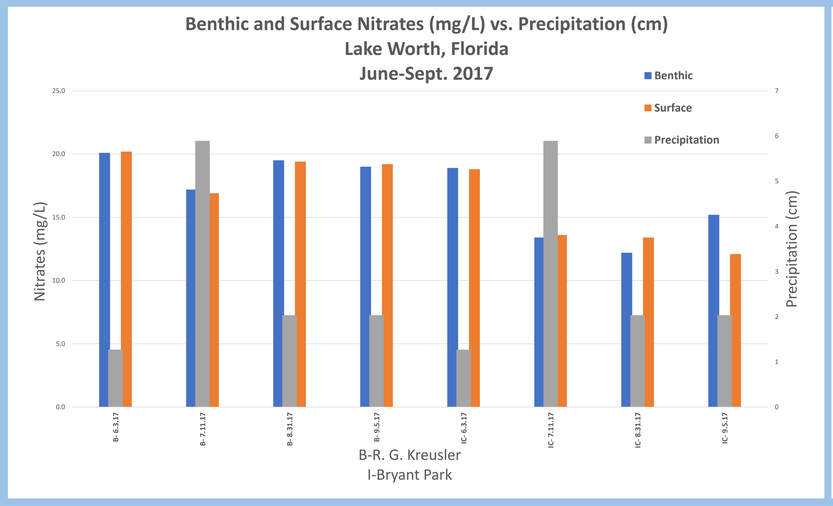


Figure 3: Nitrate Data for Lake Worth, Florida

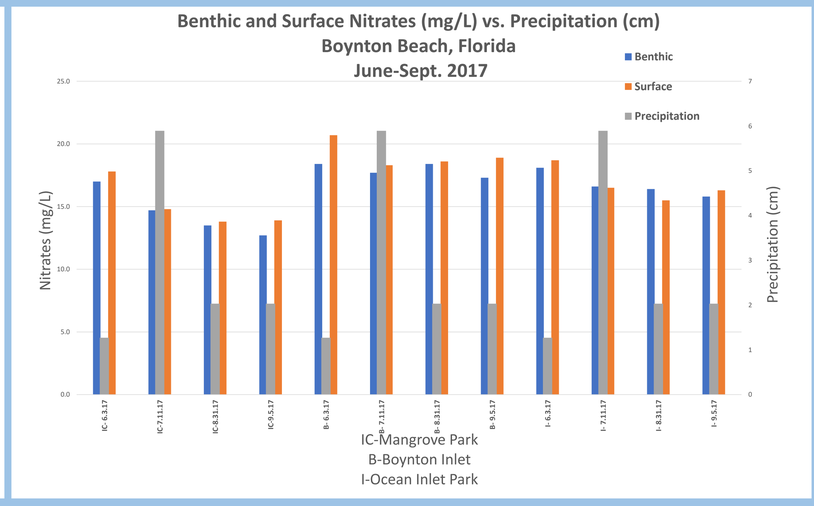


Figure 4: Nitrate Data for Boynton Beach, Florida

Map 2: Palm County Test Site Map

Land Use Concerns for Sites 1-5

- **Fertilizers from an abundance of golf courses in the coastal area**
- **Residential lawn fertilizer, pesticides, pet and human waste run off**
- **Public and private Septic Systems and public sewage system backups from high tides and rainfall**
- **Feces waste from coastal dog parks**
- **Potential agricultural area nutrient run off**
- **Urban and industrial pollution**
- **Feces from boats and harbor dumping**
- **Soil is limestone, sandstone, and fine to medium sand with good to moderate natural drainage**

(Environmental Health Statistics, 2017; USGS, 2013)

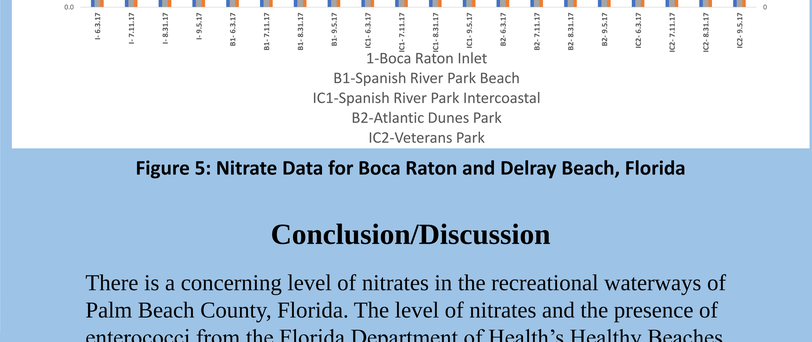


Figure 5: Nitrate Data for Boca Raton and Delray Beach, Florida

Methods

Throughout the waterways, intercostal waterways, and inlets of Palm Beach County, Florida, sixteen water samples were collected using both surface and benthic samples. The protocol for the grab samples of surface water were taken from the FDOH's Healthy Beaches Program, in which the samples were taken from a depth of 36 inches of water and the bottle was submersed to 18 inches of water before filling the sample container and capping the bottle. The benthic samples were collected from the benthic layer, also known as the sediment surface layer, of the ocean, inlet, or intercostal waterways and then the water was poured into the bottle. Samples were collected four times throughout the months of May to September. The samples were gathered and then transported to the lab for two phases of testing. The samples were stored in a dark room at 23°C until the time of nitrate testing using a selective ion electrode probe. Sucralose testing was then scheduled to be performed at Florida Atlantic University using a high-performance liquid chromatography (HPLC).

Conclusion/Discussion

There is a concerning level of nitrates in the recreational waterways of Palm Beach County, Florida. The level of nitrates and the presence of enterococci from the Florida Department of Health's Healthy Beaches Program indicates that fecal matter is present. Determining if sucralose is present is imperative to determine if the feces are of human origin or of animal origin, which could be fertilizer runoff or animal feces runoff. Phase two of testing, sucralose testing, has yet to be completed. Sucralose testing should show whether the fecal matter is of human origin. There is a strong correlation between precipitation and nitrate levels (See graphs 1-5). The direct correlation between the level of precipitation and level of nitrates should carry over to the level of sucralose using the HPLC. Phosphorous levels should be tested and taken into consideration due to the possibility that the level of nitrates could be clouded by fertilizer runoff (See Map 1). There are many potential land use concerns to be considered as a result of the nitrate levels and should be clarified with the results and analysis of the sucralose levels in phase two (See Map 1).

Upon the completion of data collections, the results may indicate whether the fecal matter is of human, animal, or artificial fertilizer origin. Upon further data analysis, a positive correlation may be found between precipitation and nitrate. Additional possible impacts observed were time of day, weather conditions, surf conditions, water clarity, and cloud cover, however, no relationship was identified.

References: Anja, R., & Varoujan , Y. A. (2009, April 20). Thermal degradation of sucralose and its potential in generating chloropropanols in the presence of glycerol. *Food Chemistry, 118*.; Dye, C., Bjerke, A., Schlabach, M., Brorström-Lundén, E., Svenson, A., & Vikt, T. (2008, January). Measurements of Sucralose in the Swedish Screening. *Swedish Environmental Research Institute*.; Oppenheimer, J., Eaton, A., Haghani, A., Badruzzaman, M., & Jacangelo, J. G. (2011, May 12). Occurrence and Suitability of Sucralose as an Indicator Compound of Wastewater Loading to Surface Waters in Urbanized Regions. *ResearchGate, 45*.; Ho, G. S., Ho, C.-T., & Hutchinson, S. A. (n.d.). Stability and degradation of the high-intensity sweeteners: Aspartame, Alitame, and Sucralose.; Abdelzaher, A. M., Wright, M. E., Ortega, C., Solo-Gabriele, H. M., Miller, G., Elmir, S., . . . Fleming, L. E. (2009, December 4). Presence of Pathogens and Indicator Microbes at a Non-Point Source Subtropical Recreational Marine Beach. *Applied And Environmental Microbiology, 76*(3).; EPA. (2015, September). *E. coli and Enterococci.* Retrieved from United States Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-09/documents/ecoli.pdf; FOS. (2013, April 25). *The Everglades and the St. Lucie River: Flows & Current Issues.* Retrieved from Florida Oceanographic Society: https://www.floridaocean.org; FDOH. (2017). *Onsite Sewage*. (FDOH, Producer) Retrieved from Florida Depratment of Health: http://www.floridahealth.gov/Environmental-Health/onsite-sewage/index.html; FDOH. (2017). *OSTDS Statistics*. (FDOH, Producer) Retrieved from Florida Department of Health: http://www.floridahealth.gov/environmental-health/onsite-sewage/ostds-statistics.html; DEP. (2017, May 31). *Septic Systems*. (DEP, Producer) Retrieved from Florida Department of Environmental Protecion: http://www.dep.state.fl.us/water/wastewater/dom/septic.htm; Environmental Health Statistics. (2017). *Palm Beach County, FL Environmental Health Statistics*. (E. H. Statistics, Producer, & GraphIQ) Retrieved from Health Grove: http://environmental-health.healthgrove.com/l/424/Palm-Beach-County-FL; USGS. (2013, September 4). *South Florida Information Access (SOFIA)*. (USGS, Producer) Retrieved from U.S. Department of the Interior, U.S. Geological Survey: https://sofia.usgs.gov/publications/wri/78-107/biscayne.html; Arnade, L. J. (1999, November). Seasonal Correlation of Well Contamination and Septic Tank Distance. *National Ground Water Association (NGWA)*.