FIU
FLORIDA INTERNATIONAL UNIVERSITY
Institute of Environment

Sucralose: Validation of a Water Quality Tracer

UNESCO-IWRA ONLINE CONFERENCE
17-19 JANUARY 2023
3RD IN THE IWRA ONLINE CONFERENCE SERIES

Theme 1: Emerging Pollutants in Aquatic Ecosystems

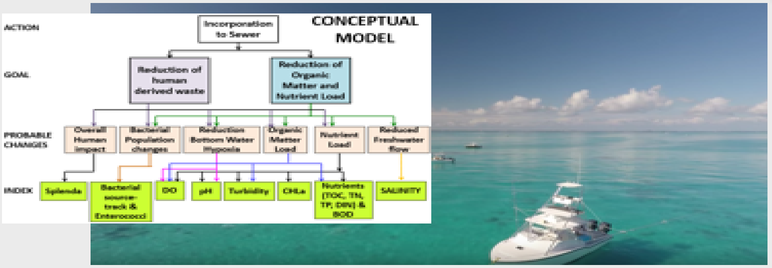
Background

From septic to sewer:

- Internal nutrient loading and urban runoff has significant effects on the physical, chemical, and biological composition of waters within waterways in South Florida, especially in canal and coastal waters.
- Elevated nutrient concentrations, hypoxia, algal blooms, fish kills, macroalgal growth, seagrass die-offs and coral diseases are becoming more frequent.
- Urban canals and rivers do not meet the State's minimum water quality criteria and are a potential source of nutrients and other contaminants to near shore waters designated as Outstanding Florida Waters.
- Cities are incorporating communities to central sewer systems to improve canal and coastal water quality, and some improvement has occurred as consequence of the elimination of septic tanks and cesspits, but still many of them remain leaking pollutants to nearby waterbodies.

Research

- Many chemical species, that are unique to human consumption have been proposed as tracers to follow the intrusion of human derived wastewater into aquatic ecosystems, among them, sucralose. For a tracer to become an indicator a relationship to traditional water quality parameters must be identified so a potential link to common impacts such as eutrophication can be elucidated.
- Our previous work in the City of Islamorada and Miami Beach, Florida (1), consisted of a comprehensive water quality monitoring conducted in a system of canals in the Florida Keys that have been subject to a conversion from traditional septic systems to municipal sewage collection. Time series of traditional water quality parameters, such as nutrients, pH, and dissolved oxygen display significant shifts at specific sucralose levels (thresholds) and cluster analysis indicated that samples with sucralose levels below the threshold did not show evidence of water quality issues while sites with above threshold concentrations were affected by eutrophication.
- Results indicated that sucralose was in fact a reliable indicator with well-developed relationships to traditional water quality parameters. Furthermore, we defined specific sucralose thresholds at about 57 ng/L and 150 ng/L separating background from human-influenced and human-impacted waters respectively.
- The hypothesis that these empirical thresholds apply in different estuarine and coastal water bodies had to be validated. Therefore, we analyzed water samples from waterways in the Great Miami Area to test for nutrients and sucralose.
- This study presents the second application of sucralose as an effective human-derived wastewater "indicator" rather than just a tracer.



Research Question

Is Sucralose an adequate water quality indicator for all coastal waterbodies in South Florida?

Objectives

The Objectives of this work were:
1- To validate quantitative relationships between Sucralose and water quality parameters in diverse waterbodies in the Greater Miami Area; and

2- Validate the sucralose thresholds previously obtained for canals in the Florida Keys

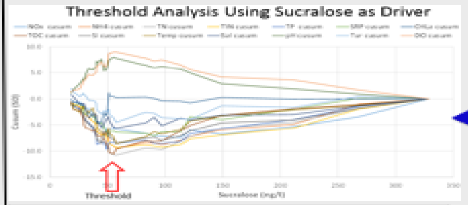
Materials and Methods

Fieldwork: Profile measurements (YSI-EXO2 cast)
Temp, DO, %DO Saturation, depth, Cond, Sal, pH, Turbidity

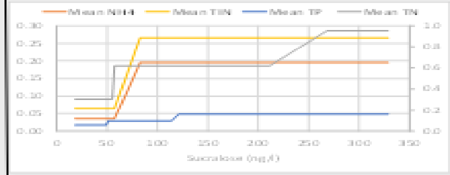
Labwork:

- Samples were analyzed for ammonium (NH4+), nitrate+nitrite (N+N), nitrite (NO2-), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total organic carbon (TOC), silicate (SiO2), chlorophyll a (CHLA), and turbidity using standard laboratory methods.
- NH4+ was analyzed by the indophenol method[1]. NO2- was analyzed using the diazo method and N+N was measured as nitrite after cadmium reduction[2]. The ascorbic acid/molybdate method was used to determine SRP[3]. High temperature combustion and high temperature digestion[4, 5] were used to measure TN and TP[6], respectively. TOC was determined using the high temperature combustion method[7]. Silicate was measured using the heteropoly blue method[8]. Samples were analyzed for CHLA content by spectrofluorometry of acetone extracts[9]. Sucralose in canal waters was determined by online solid phase extraction liquid chromatography in tandem with mass spectrometry (SPE-LC-MS/MS) method[10]

Previous Work

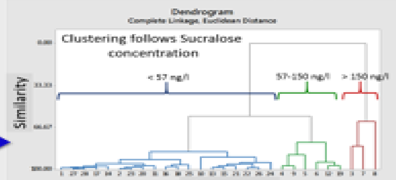


Cumulative Sum charts for all variables, plotted along the Sucralose gradient indicate a sharp concentration increase of all nutrients when Sucralose exceeds 57 ng/l. Likewise, DO and pH are high for Sucralose concentrations below 57 ng/l, and decline for concentrations above that threshold



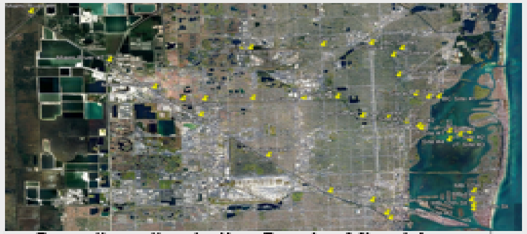
Sequential t-test Regime Shift Analysis[11] confirms nutrient threshold around 57 ng/l Sucralose

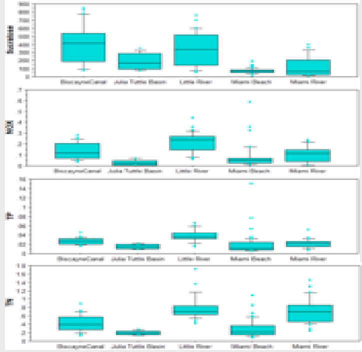
Cluster Analysis
NOx, NH4, TN, TIN, TP, SRP, CHLa, TOC, Si, Temp, Sal, pH, Tur and DO

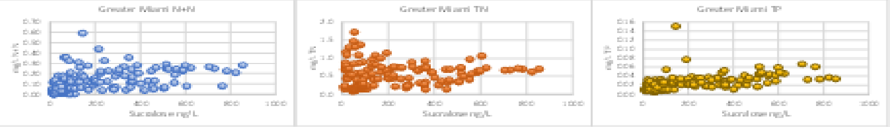


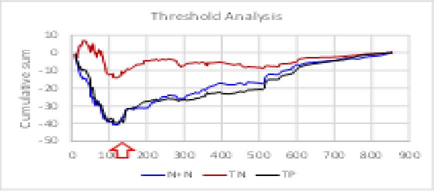
Cluster analysis indicated that samples with sucralose levels below the threshold did not show evidence of water quality issues while concentrations above 53 ng/L and above 150 ng/L grouped the sites progressively influenced and impacted by eutrophication, respectively.

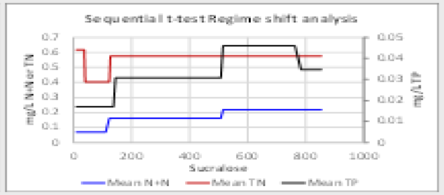
Results


Sampling sites in the Greater Miami Area









Conclusions

Sucralose concentration is directly correlated with nutrient concentrations.

All measured nutrients experience the onset of an elevated eutrophic state around 120 ng/l Sucralose, with a secondary uptick at about 500 ng/L sucralose (Figure above).

The 57 ng/L or 150 ng/L thresholds previously observed in samples for the Florida Keys canals are not present in the nutrient enriched Greater Miami Area.

Most samples in the Greater Miami Area are above background concentrations a those of the Keys, underscoring the already influenced and impacted pollution levels.

Acknowledgements
This study was funded by the City of Islamorada Village of Islands; USA-EPA (SF - 02D05321 - 1); and NASA (NNX17AH03G)

References

(1) Koroleff 1983. Methods of Seawater Analysis. Verlag Chemie, Germany
(2) Grassoff 1983. Methods of Seawater Analysis. Verlag Chemie, Germany
(3) Murphy and Riley 1962. Anal. Chim. Acta 27: 31-36.
(4) Frankovich and Jones 1998. Mar. Chem. 60:227-234.
(5) Walsh 1989. Mar. Chem. 26: 295-311.
(6) Solórzano and Sharp 1980. Limn. & Ocean. 25:754-758
(7) Sugimura and Suzuki 1988. Mar. Chem., 24, 105-131.
(8) APHA 1995. Standard Methods for the Examination of Water
(9) Yentsch and Menzel 1963. Deep Sea Res. 10: 221-231
(10) Batchu et al. An. Bioan.Chem. 2015, 407, 13:3717-3725
(11) Rodionov 2004. Geophys. Res. Lett., 31, L09204,
(12) Briceno et al 2016. SETAC NA 37th Annual Meeting

Henry O. Briceno, PhD, Florida International University

unesco
Programme hydrologique intergouvernemental
IWRA