The Effect of Artificial Sweeteners on Water Quality

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SECTION 24, TEAM 5

FALL 2017

Overview

I. Describe the recent use of artificial sweeteners
II. Discuss how artificial sweeteners may impact water quality
III. Outline the conducted water quality studies
IV. Discuss results and potential implications

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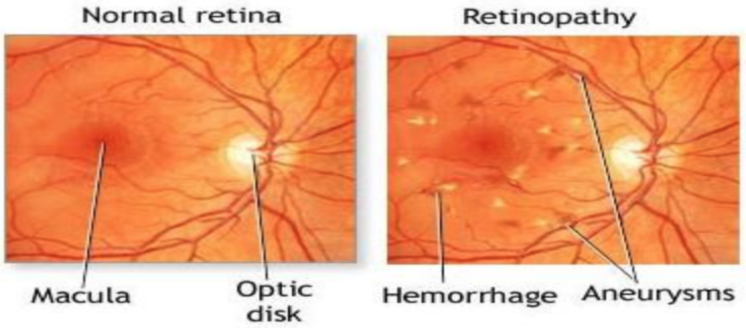
Recent Use of Artificial Sweeteners

Diabetes Mellitus: persistent high blood glucose levels lead to various deficits throughout the body (Capozzi et al., 2017)

- 592 million people by 2035
- $250 billion current annual healthcare costs



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- 592 million people by 2035
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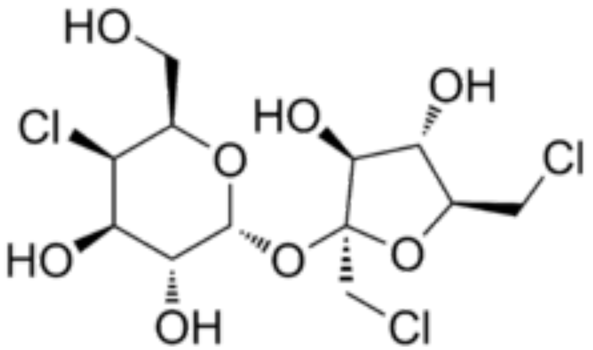
Health-conscious individuals (Grotz & Munro, 2009)

- Preference for sweet taste ubiquitous in cuisines across the globe
- Maintain sweet flavor and eliminate high-calorie consumption

Synthesis of Artificial Sweeteners

Major components: sucralose



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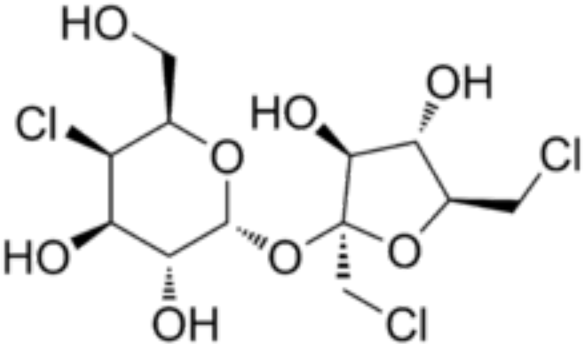
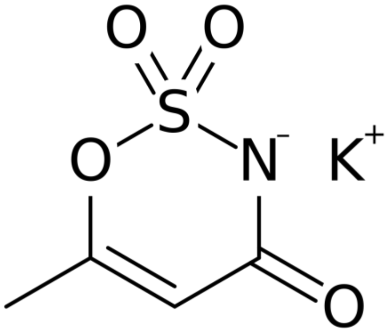
Major components: sucralose, acesulfame





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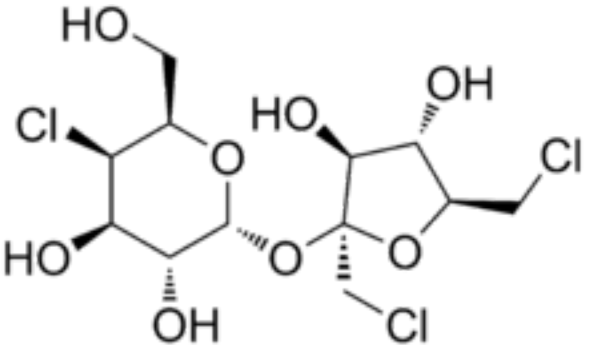

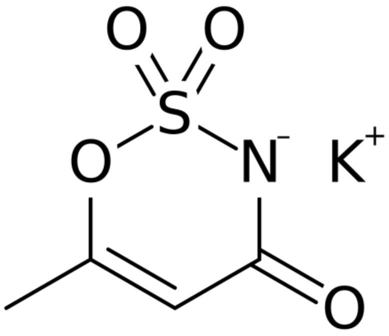

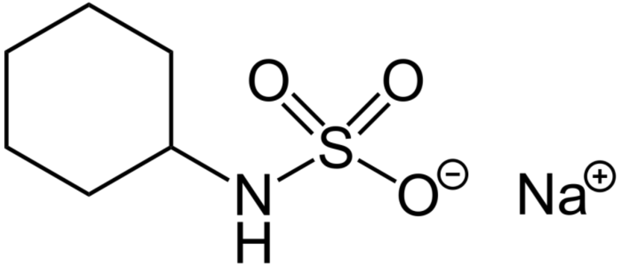

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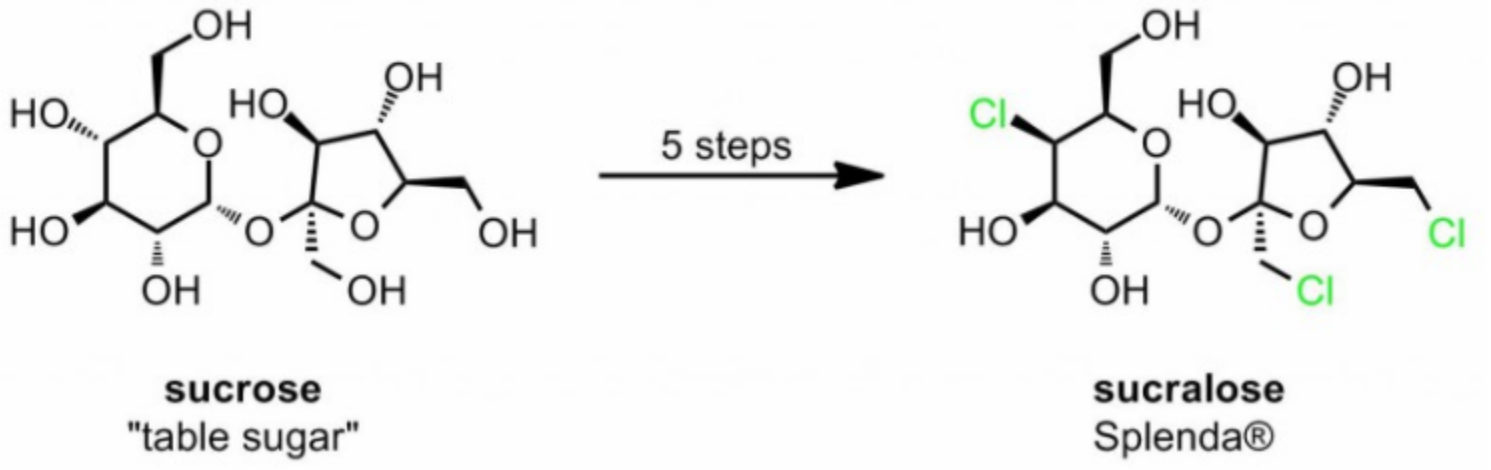
Synthesis of Artificial Sweeteners

Series of selective chlorination to convert from glucose-analog to galactose analog, rendering them unable to be metabolized



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Potential Impact on Water Quality

Artificial sweeteners can be beneficial for detection

- Spoelstra et al. (2013) & Zirlewagen et al. (2016)

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Artificial sweeteners are potentially hazardous to aquatic life

- Pal et al. (2014)

Artificial Sweeteners as Helpful Detectors

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- Artificial sweeteners are able to pass through water treatment plants and are found in potable water supplies

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- Artificial sweeteners are able to pass through water treatment plants and are found in potable water supplies
- With AS being mobile in groundwater, it is suitable to trace wastewater
- A study was conducted on The Grand River Watershed flowing into Lake Erie
    - After taking samples of water from different parts of the river, elevated levels of AS was found.
    - AS has a high concentration and resistance to breakdown in water proved that is it an ideal tracer of wastewater

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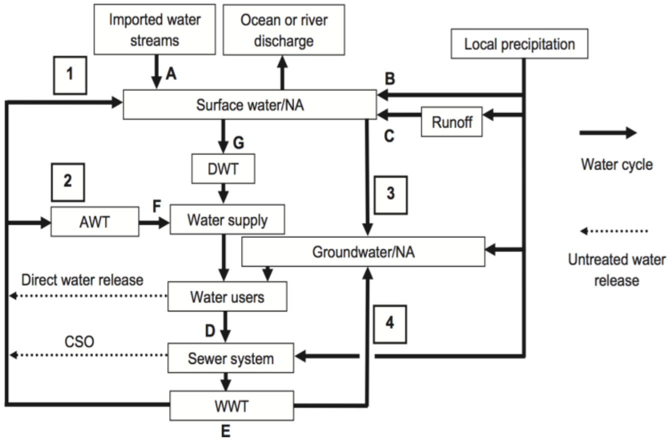
- Cyclamate and acesulfame: two artificial sweeteners
  - Used as indicators for pollution of both treated and non-treated wastewater
  - Compared concentrations of sweeteners to each other and other indicators
- Conclusion
  - Acesulfame and cyclamate as indicators? = success (the latter more)
  - Able to name and quantify other contaminants water
  - So can be very useful for future water quality analyses

Artificial Sweeteners as Toxins

Pal et al. (2014)

- Reviewed the presence of *emerging organic compounds* (including sucralose) in the *urban water cycle (UWC)*



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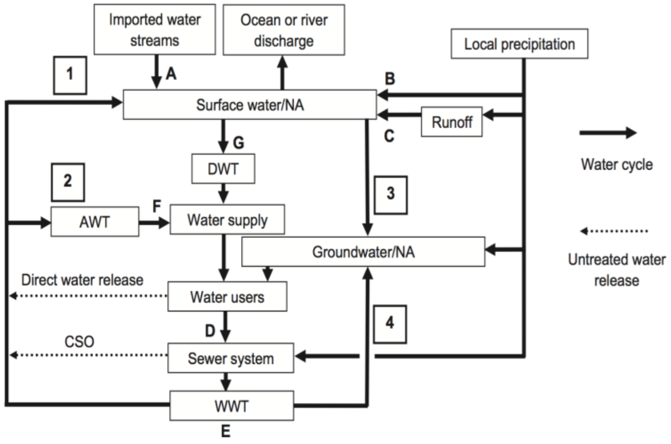

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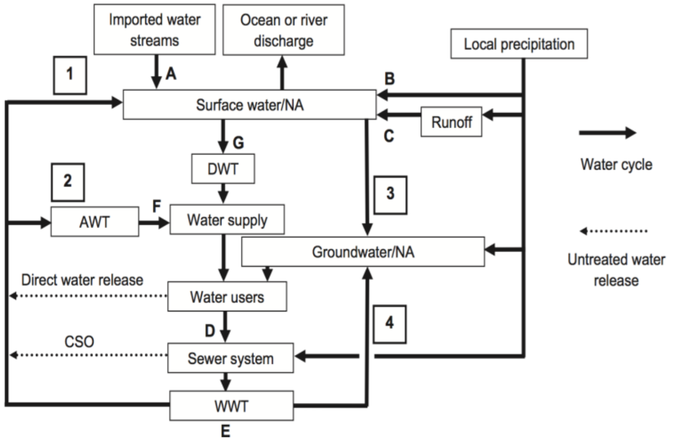
- Reviewed the presence of *emerging organic compounds* (including sucralose) in the *urban water cycle (UWC)*
- UWC is particularly susceptible to contamination
- 1123 mg/L sucralose leads to
  - Decreased locomotion in crustaceans
  - Build-up of sucralose in mussels, fish, and algae



Current Study

Aim to determine the effect of artificial sweeteners on water quality

We hypothesized that an excess of artificial sweeteners will decrease water quality on the following parameters:

- Temperature
- Turbidity
- Total solids
- CFU assay

Predictions

In excess of 1123 mg/L, we predicted:

- **Temperature: the sucralose will cause a significant increase in temperature in the experimental groups compared to the controls**
- Turbidity: the experimental groups will have higher turbidity values compared to the controls
- Total solids: the total solids value will be higher for the experimental groups than the controls
- CFU: the experimental groups will have a greater amount than the control groups

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Water source: lotic site on Douglass Campus

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Experimental group: lotic water + 1200mg Kirkland No Calorie Sweetener

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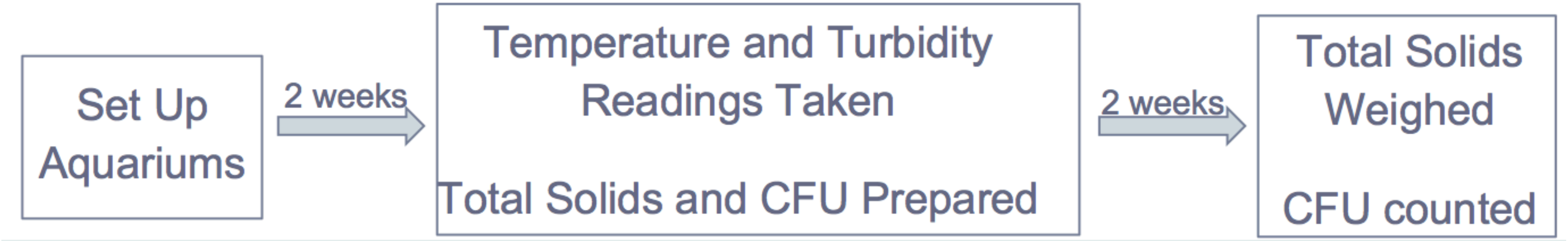
Timeline:



Methods

Temperature Differences: Temperature probe connected to LabQuest

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CFU Assay: Spot plated 3X serial dilution of sample water from each aquarium on lactose broth agar plates

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- Calculated independent samples t-tests & q-values

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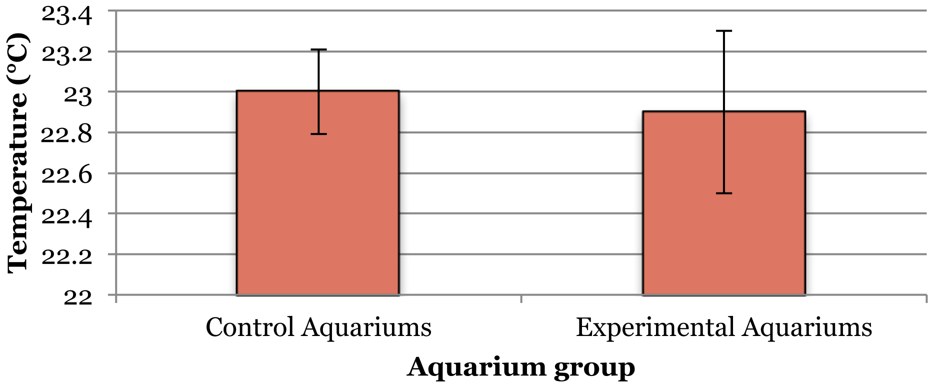
- Conditions: sucralose aquariums vs. water-only aquariums
- $p<0.05$ to determine significance
- Mean and standard deviation data noted for all parameters

Results

Temperature

- Mean temperatures not significantly different ($p=0.0644$)
  - Sucralose (M=22.9°C, SD=0.400)
  - Water-only (M=23.0°C, SD=0.208)
- Q-value: 92 (excellent)

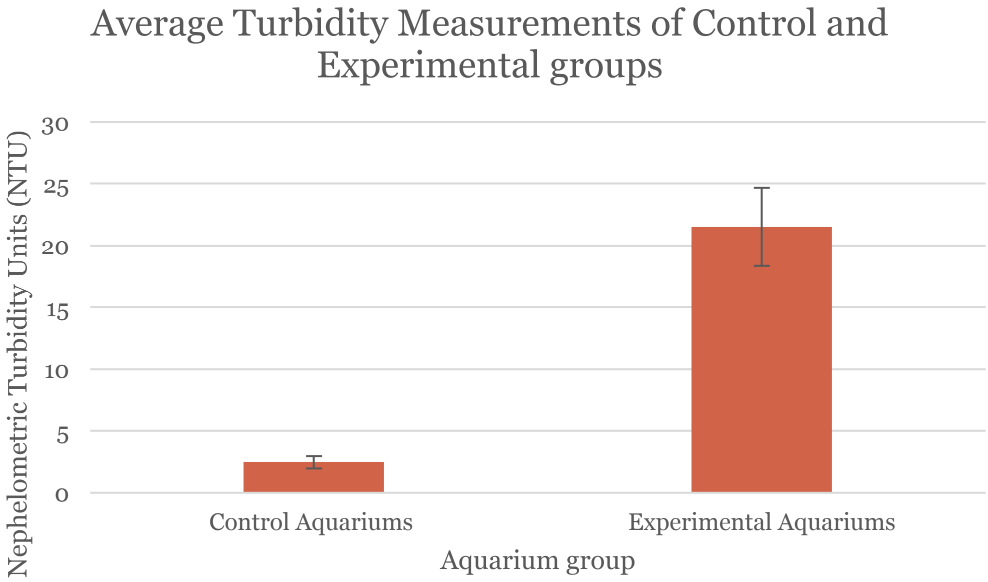
Average Temperature Measurements of Control and Experimental groups



Results

Turbidity

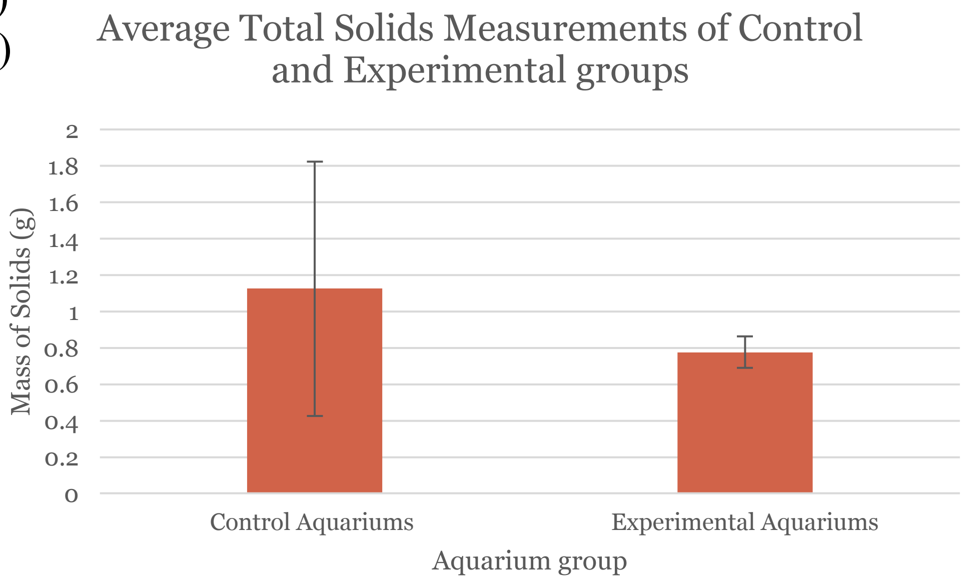
- Mean turbidity significantly different ($p=0.008$)
  - Sucralose aquariums: (M=21.5 NTU, SD=2.215)
  - Water only: (M=2.47 NTU, SD=0.503)
- Q-value
  - Sucralose: 60 (medium)
  - Water-only: 91 (excellent)



Results

Total Solids

- Mean total solids not significantly different (p=0.480)
    - Sucralose: (M=0.776g, SD=0.087)
    - Water-only: (M=1.12g, SD=0.699)
- Q-value (experimental and control)
    - Sucralose and water quality: 79 good quality



Results

CFU Assay

- Average CFU/ml for sucralose: 467 (SD=189)
- Average CFU/ml water only: no growth
- Unable to conduct t-test

Discussion

Hypothesis: sucralose will decrease water quality

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Predictions: the presence of sucralose will...

- Increase temperature differences
- Increase turbidity levels
- Increase total solids
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Only 1-2 of the 4 predictions were supported...reject the hypothesis

Discussion

Sucralose may lead to toxicity (Pal et al., 2014)

- Sucralose significantly increased turbidity levels
  - Increased turbidity, increased suspended particles
  - Sucralose may enter systems of crustaceans and impede locomotion

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  - Sucralose may enter systems of crustaceans and impede locomotion
- Sucralose did *not* significantly increase total solids
  - Fails to corroborate turbidity data
  - Limitations
    - Faulty scale
    - Potentially lost product from sugar burning

Discussion

Sucralose may detect fecal bacteria (Spoelstra et al., 2009; Zirlewagen et al., 2016)

- Sucralose facilitated growth of bacteria
  - CFU assay is presumptive, cannot determine which type
  - An excess of any bacteria could be detrimental

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- Ability for bacteria to thrive in sucralose-rich environment
  - Target bacteria to be eliminated
  - No strong evidence that sucralose decreases water quality
- Sucralose did *not* significantly increase temperature differences
  - Uniform temperature across a body of water with varying levels of sucralose
  - Limitation: sunlight exposure not varied

Discussion

Future studies

- Total solids analysis
  - Ensure use of accurate scale
  - Allow less time for water-evaporation stage

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  - Allow less time for water-evaporation stage
- Bacterial growth analysis
  - Fecal coliform test
- Temperature analysis
  - Manipulate sunlight exposure
- Full WQI analysis including all 9 parameters
  - Quantitative description of overall water quality

Literature Cited

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Thank you for your time

Questions?