Beaches and Tributaries: The Role They Have in Barnegat Bay's Water Quality

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Abstract

The Toms River subwatershed is 124 square miles making it the largest drainage area of any river in the Barnegat Bay watershed. Dozens of small tributaries drain into the Toms River from across Ocean County, widening the reach of the Toms River subwatershed. Because of the high volume of people that the Toms River subwatershed includes, it is imperative to monitor the health and efficiency of the Toms River in order to understand Barnegat Bay. In this study, the Toms River was tested and monitored at various sites in Beachwood, Pine Beach, and Island Heights. Water quality parameters tested included temperature, salinity, chlorophyll-a, pathogenic and non-pathogenic bacteria colonies, optical brightening agents, nitrates, and phosphates. The results showed that Beachwood had a strong relationship between bacteria colonies and optical brightening agents. The Island Heights sites, located on Dillon's Creek, showed relationships between bacteria and optical brightening agents along with high levels of phosphates and nitrates, especially after rainfall events. Because of the strong correlation between optical brightening agents and bacteria colonies at various locations, it is necessary to investigate the quality of the storm drain pipes and sewage pipes throughout the Barnegat Bay watershed. The findings suggest that there may be some old pipes or illegal connections. Further investigation may be warranted by the Ocean County Health Department or municipal utilities authorities specifically at Beachwood Beach and along Dillon's Creek.

Introduction

The Toms River subwatershed is 124 square miles making it the largest drainage area of any river in the Barnegat Bay system. The subwatershed is made up of Toms River Township, which hosts 91,837 people, along with surrounding Ocean County townships including but not limited to Manchester, Berkeley, Jackson, and Pine Beach ("Toms River Watershed"). Dozens of small tributaries drain into the Toms River from across Ocean County, widening the reach of the Toms River subwatershed. Because of the high volume of people and waste that the Toms River subwatershed includes, it is imperative to monitor the health and efficiency of the Toms River in order to understand the Barnegat Bay. In this study, the Toms River was tested and monitored at various sites in Beachwood, Pine Beach, and Island Heights. Some water quality parameters, including temperature, salinity, and conductivity, were measured in order to make sure the system was balanced and generally similar week to week. Other water quality parameters,

including bacteria, optical brightening agents, phosphates, and nitrates, were tested for their questionable nature and potential danger to the Toms River and Barnegat Bay. Specifically, optical brightening agents, a man-made chemical used mainly in toilet papers and detergents, was tested in order to detect the presence of wastewater that could be responsible for bacteria colonies (Tavares, 2008). In past years, Beachwood Beach has struggled with E. coli, a fecal coliform. The beach has had many closings; thus, it is important to assess whether the bacteria is from animals and runoff, or from another source such as storm drain pipes or septic systems. Additionally, there have been reports about a strange foam on the surface of Dillon's Creek in Island Heights. We questioned whether this foam could be a detergent, detectable with optical brightening agents. In this study, we will investigate these locations along with others in order to make a conclusion about the types of threats these areas pose to the Barnegat Bay.

Methods

Study Sites (Figure 1)

- Pine Beach - storm drain (Figure 2)
- Beachwood – Beach (Figure 3) and Beachwood Municipal Marina
- Island Heights – Roadside (Figure 4) along Dillon's Creek , Park (Figure 5), Creekside, and Dillon's Creek Marina (Figure 6)

Procedure

All samples were taken on Tuesdays between 8am and 12pm. The YSI-85 Multimeter (Figure 7) was used to test salinity (ppt), temperature (C), and conductivity (mS/cm). A 3 meter sampling pole was used to collect water (Figure 8). Sampling bottles, 250 mL, were filled and collected water was used to test for phosphates (ppm), nitrates (ppm), and pH. Whirl-Pak bags

were used to collect water samples for bacterial analysis and to measure relative chlorophyll-a and optical brightener agents (OBA) (Figure 9). Both chlorophyll-a and OBA was measured using a handheld Aquafluor Fluorometer by Turner Designs (Figure 10). To measure pH an EcoTestr pH2 probe handheld meter was used after calibration (Figure 11). Phosphates were measured using the LaMotte Smart3 Colorimeter (Figure 12). Nitrates were measured using the LaMotte Smart2 Colorimeter. Bacteria was tested by using the Coliscan Easygel method with samples being incubated at 37°C for 24 hours. A control was used (distilled water) to ensure that testing protocol was conducted under sterile conditions. All water quality testing was conducted at the Save Barnegat Bay EcoCenter .

Data Analysis

Optical brightening agents were compared to total bacteria colony levels at Beachwood site 1, Beachwood site 2, and Island Heights site 2. A regression test was run to assess the relationship between the two variables.a. Optical brightening agents were compared to E. Coli colony levels at Island Heights site 2. A regression test was run to assess the relationship between the two variables. An alpha value of 0.05 was used to determine significance for all tests conducted. Total nitrogen-nitrate, phosphate, chlorophyll, and pH was assessed over time at all locations.

Results

Pine Beach

- Total nitrogen - nitrate levels ranged from 0.00 ppm to 4.00 ppm, while phosphate levels ranged from 0.00 ppm to 2.71 ppm
- Chlorophyll and pH did not show much fluctuation over the time period (Tables 1 and 2).

Beachwood 1

- Optical brightening agent values ranged from 76.77 relative fluorescence units (RFU) to 130.2 RFU.
- The optical brightening agent values were compared to the total bacteria levels, and the resulting p-value was 0.3895 showing that the data was not statistically significant
    - However, as optical brighter values rose throughout the time period, total bacteria colony values saw an increase.
- Total nitrogen-nitrate levels ranged from 0.00 ppm to 3.00 ppm, while phosphate levels ranged from 0.00 ppm to 2.29 ppm.
- Chlorophyll and pH did not show much fluctuation over the time period.

Beachwood 2

- Optical brightening agent values ranged from 77.49 RFU to 161.10 RFU.
- The optical brightening agent values were compared to the total bacteria levels. The resulting p-value was 0.0500 showing that the data was statistically significant, and the r-squared value was 0.9024 showing a strong correlation (Figure 13).
- Total nitrogen-nitrate levels ranged from 0.00 ppm to 4.00 ppm, while phosphate levels ranged from 0.00 ppm to 4.08 ppm.
- Chlorophyll and pH did not show much fluctuation over the time period.

Island Heights 1

- Total nitrogen- Nitrate levels ranged from 1.00 ppm to 30.00 ppm, while phosphate levels ranged from 0.44 ppm to 3.73 ppm (Figure 14).
- Chlorophyll and pH did not show much fluctuation over the time period (Table 1).

Island Heights 2

- Optical brightening agent values ranged from 122.20 RFU to 202.3 RFU.
- The optical brightening agent values were compared to the total bacteria levels. The resulting p-value was 0.1348 showing that the data was not statistically significant, but the r-squared value was 0.5797 showing a strong correlation (Figure 15).
- The optical brightening agent values were compared to the *E. coli* colony levels. The resulting p-value was 0.0241 showing that the data was statistically significant, and the r-squared value was 0.8566 showing a strong correlation (Figure 16).
- Total nitrogen-nitrate levels ranged from 0.00 ppm to 11.00 ppm (which is high) while phosphate levels ranged from 0.00 ppm to 2.30 ppm.
- Chlorophyll and pH did not show much fluctuation over the time period.

Island Heights 3

- Total nitrogen-nitrate levels ranged from 0.00 ppm to 4.00 ppm, while phosphate levels ranged from 0.00 ppm to 1.58 ppm.
- Chlorophyll and pH did not show much fluctuation over the time period.

Island Heights 4

- Total nitrogen-nitrate levels ranged from 0.00 ppm to 3.00 ppm, while phosphate levels ranged from 0.00 ppm to 2.98 ppm.
- Chlorophyll and pH did not show much fluctuation over the time period.

Discussion

While the findings of this study may not directly indicate the source of inputs into the locations tested, it did determine correlations between water quality parameters and trends in the

parameters over time to perform further research and analysis. Optical brighteners are "a fluorescent substance added to detergents in order to produce a whitening effect on laundry", and when found in the presence of water indicates "untreated or inadequately treated water reaching the water body" (Pitterele, 2009). When elevated optical brightener levels and elevated bacteria levels, especially *E. coli,* are found in the same water body it can indicate the presence of human sewage (Tavares, 2008). The p-value and r-squared value at Beachwood site 2 shows that the comparison of optical brighteners and total bacterial colonies was statistically significant and had a strong correlation. Findings in this data analysis show that there is a probable direct source of human pollution leading into this waterbody. While Beachwood site 1 did not show statistical significance between optical brighteners and total bacterial colonies, increases in optical brighteners were typically followed by increases in total bacteria colonies. With further collection and analysis, this site can also be pinpointed as probable sites for direct human inputs. Island Heights site 2 did not show statistical significance between optical brighteners and total bacterial colonies; however, it was the only site that consistently showed elevated *E. coli* levels in relation to elevated optical brightener levels. The p-value and r-squared value at Beachwood site 2 shows that the comparison of optical brighteners and *E. coli* colonies was statistically significant and had a strong correlation. Findings in this data analysis show that there is a probable direct source of human pollution leading into this waterbody. Certain weeks, sites such as Island Heights site 4 experienced elevated bacteria levels without the presence of elevated optical brighteners. This can be due to the presence of waterfowl or other animals. Total nitrogen-nitrate and phosphates were found consistently elevated at each location; however, Beachwood site 2 saw the highest levels of phosphates, and Island Heights site 1 consistently

saw the highest levels of nitrogen-nitrates. Beachwood site 2 is found at a municipal marina, and the elevated phosphate levels may be a result of the washing of boats or construction off the side of the road. Island Heights site 1 is found directly off the side of the road with homes directly to one side. Due to its location, this site seems to be affected by runoff from nonpoint source inputs.

Conclusion

We recommend the monitoring of Beachwood site 1, Beachwood site 2, and Island Heights site 2 for bacteria levels and optical brightening agents weekly, and if possible directly following precipitation. It is also recommended that nitrate and phosphate levels be monitored at each site on a weekly basis. We also recommend that direct inputs into Dillon's Creek and Beachwood be investigated in terms of storm drain infrastructure and possible bad connections from sanitary sewer pipes that are producing runoff into the systems, especially after precipitation events.

Acknowledgements

We would like to sincerely thank everyone at Save Barnegat Bay for providing us with this wonderful opportunity. We would like to thank Britta Wenzel and GraceAnne Taylor in particular for helping us set up our lab, giving us help, and always having snacks. Finally, special thanks to our wonderful advisor, Dr. Wnek, for helping us reach our potential.

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Table 1. Chlorophyll data was collected every Tuesday from June 12, 2018 until July 31, 2018 at various sites along the Toms River utilizing an Aquafluor Fluorometer. Three samples were run and averaged to receive an accurate measurement.

Collection Date	Pine Beach	Beachwood 1	Beachwood 2	Island Heights 1	Island Heights 2	Island Heights 3	Island Heights 4
6/12/2018	0.938, 0.955, 0.966	1.247	0.648	0.385, 0.416, 0.407	0.999, 0.954, 0.957	2.153, 2.446, 2.586	0.921, 1.026, 1.152
6/19/2018	0.876, 0.916, 0.887	1.015, 1.077, 1.011	0.801, 0.810, 0.798	0.179, 0.070, 0.178	3.047, 2.215, 1.520	2.368, 2.410, 2.406	1.107, 1.061, 1.104
6/26/2018	0.734, 0.717, 0.714	0.786, 0.801, 0.795	0.402, 0.402, 0.405	1.059, 0.645, 0.600	0.570, 0.555, 0.565	1.134, 1.081, 1.065	1.112, 1.037, 1.901
7/3/2018	1.194	2.282	0.66	0.375	0.729	2.339	2.736
7/10/2018	0.524	0.697	0.528	0.248	0.769	0.528	0.832
7/17/2018	2.544, 2.543, 2.456	1.902, 1.868, 1.859	1.396, 1.395, 1.350	0.596, 0.549, 0.575	1.780, 1.532, 1.572	1.188, 1.166, 1.156	1.057, 1.031, 1.008
7/24/2018	1.691, 1.638, 1.561	0.648, 0.607, 0.612	0.728, 0.692, 0.684	0.509, 0.457, 0.507	1.644, 1.511, 1.552	1.356, 1.338	1.335, 1.276, 1.276
7/31/2018	0.700, 0.697, 0.690	0.765, 0.760, 0.753	0.761, 0.766, 0.744	0.241, 0.236, 0.236	4.455, 4.615, 4.648	1.844, 1.701, 1.637	1.901, 1.793, 1.728

Table 2. pH data was collected every Tuesday from June 12, 2018 until July 31, 2018 at various sites along the Toms River utilizing an Oakton ecoTester pH2 probe.

Collection Date	Pine Beach	Beachwood 1	Beachwood 2	Island Heights 1	Island Heights 2	Island Heights 3	Island Heights 4
6/12/2018	6.8	6.9	7.5	6.9	7.0	6.6	6.7
6/19/2018	7.5	7.3	7.2	6.6	6.4	6.6	6.8
6/26/2018	-	-	-	-	-	-	-
7/3/2018	6.4	6.9	6.2	6.5	6.6	6.3	6.7
7/10/2018	6.7	6.9	6.9	7.0	6.6	6.9	7.1
7/17/2018	7.2	6.9	6.9	6.7	6.6	6.8	7.0
7/24/2018	6.5	6.9	6.9	6.9	6.1	6.4	6.8
7/31/2018	6.4	6.9	6.2	6.5	6.6	6.3	6.7

Figures

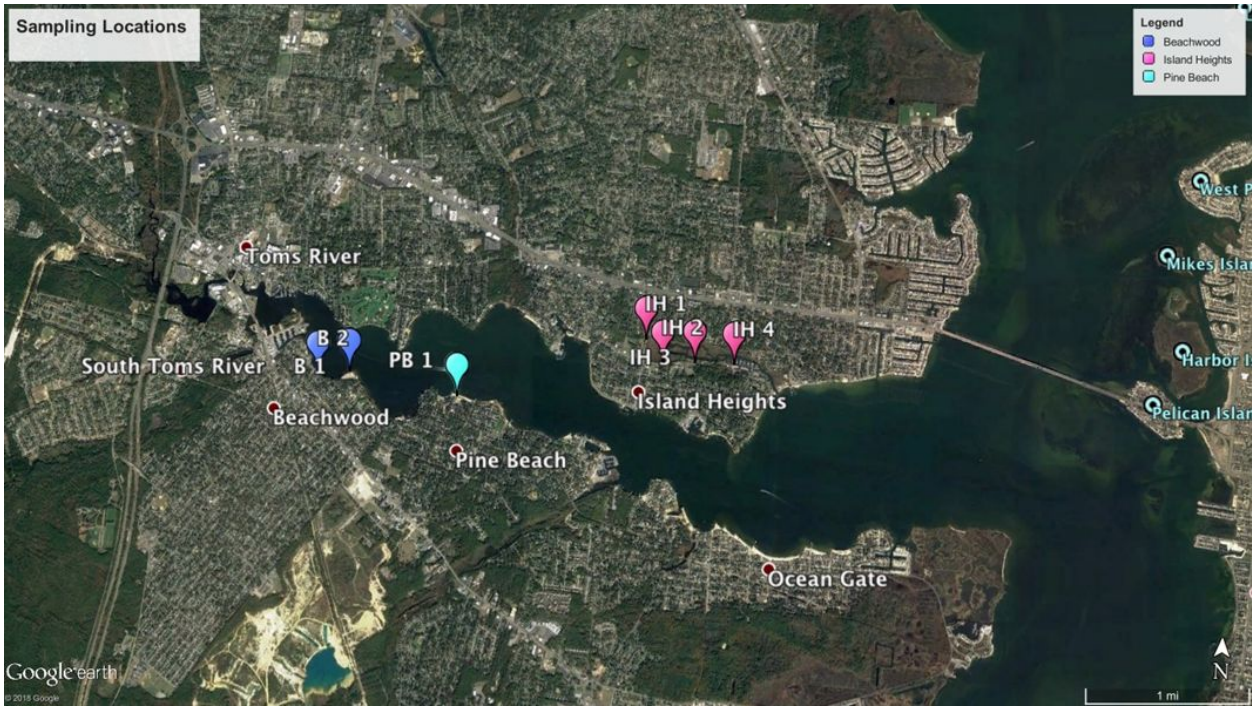

Figure 1. The seven locations sampled from June 12 through July 31, 2018. All samples were collected between 8am and 12pm. All locations are either tributaries or beaches of the Toms River, the largest subwatershed in the Barnegat Bay watershed.

Figure 2. The storm drain at Pine Beach is exposed at low tide. Storm drains are utilized to help carry water from flooding off the streets and back into water bodies. However, the water is often highly concentrated with litter and other contaminants.

Figure 3. The beach access in Beachwood. A storm drain is situated under the dock. Beachwood has had trouble in the past with pipe connections in their infrastructure. The state closed the beach this summer for high bacteria levels.

Figure 4. The end of Dillon's Creek in Island Heights is situated next to a house on a hill and a roadway. After rainfall events, the water flows into the creek. The water does not mix well.

Figure 5. Turtle Run, a small park on Dillon's Creek. The water flows more easily here than at IH1, but is still relatively inactive.

Figure 6. The Island Heights marina located toward the mouth of Dillon's Creek. The marina initially had high bacteria levels, but they were eventually accounted to geese. Samples were taken off the boat docks where the water flowed well.

Figure 7. The YSI-85 Multimeter used for testing temperature(°C), salinity(ppm), and conductivity (mS).

Figure 8. The sampling pole used to gather water samples for the bottles and Whirl-Paks.

Figure 9. The Nanco Whirl-Pak used to collect water samples. One-hundred ml samples were collected and kept on ice in the dark until samples were tested.

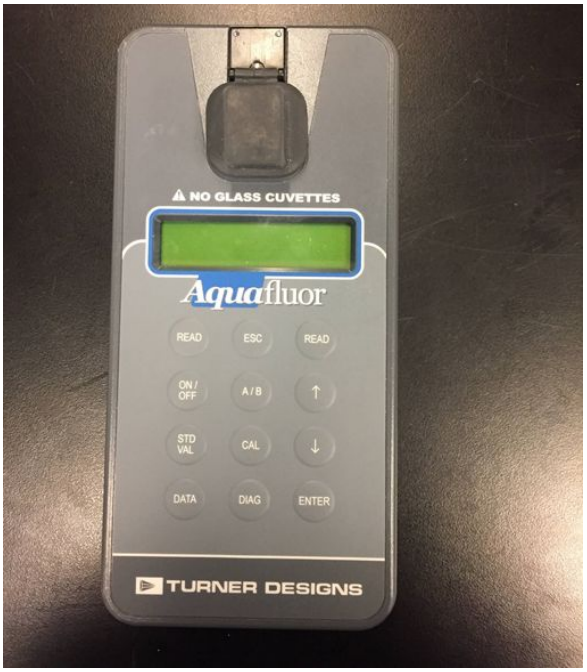

Figure 10. The Turner Designs Aquafluor Handheld Fluorometer. OBA's were returned in fluorescence units. Chlorophyll-a was returned in ppm. Turbidity was returned in NTU's.

Figure 11. The Oakton pH probe used to measure pH of water samples.

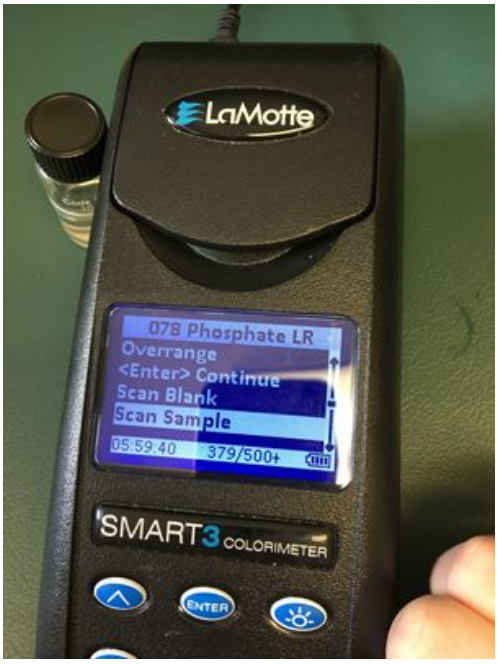

Figure 12. The colorimeter used to measure phosphates (ppm). It detects the hue of the sample- the bluer it is, the higher in nitrates.

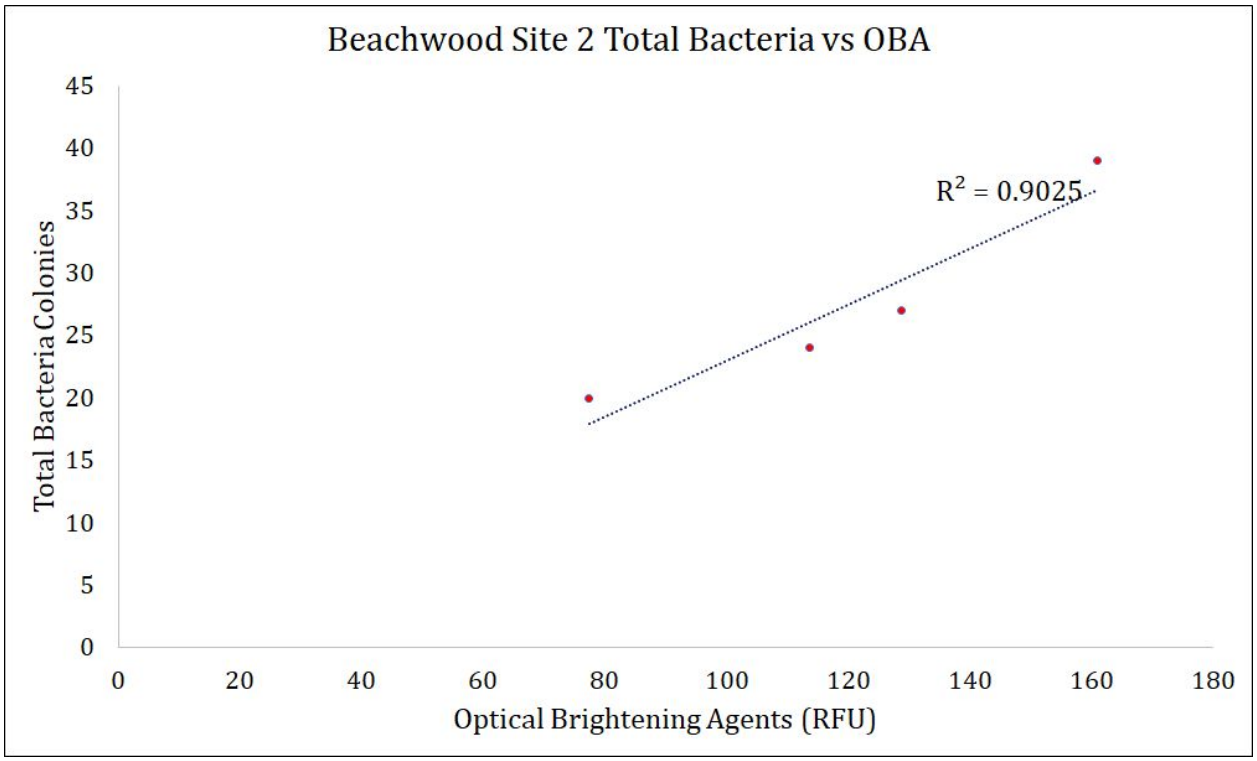

Figure 13. At Beachwood site 2 from 10 July 2018 to 31 July 2018 optical brightening agents (n =10) were compared to the total bacteria colonies (n = 4). The p-value was 0.0500 showing that the data was statistically significant, and the r-squared value was 0.9024 showing a strong correlation.

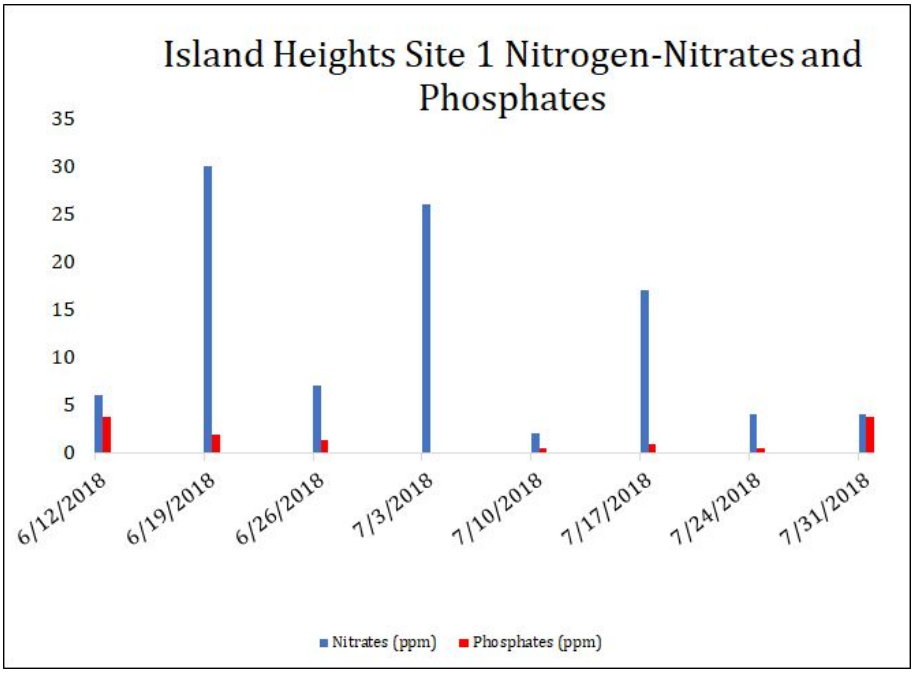

Figure 14. At Island Heights site 1 from 12 June 2018 to 31 July 2018 phosphate levels (n =17) and nitrogen-nitrate levels (n = 18) were assessed. This site consistently had the highest nitrate levels. The site is located next to a house and a main road of Island Heights.

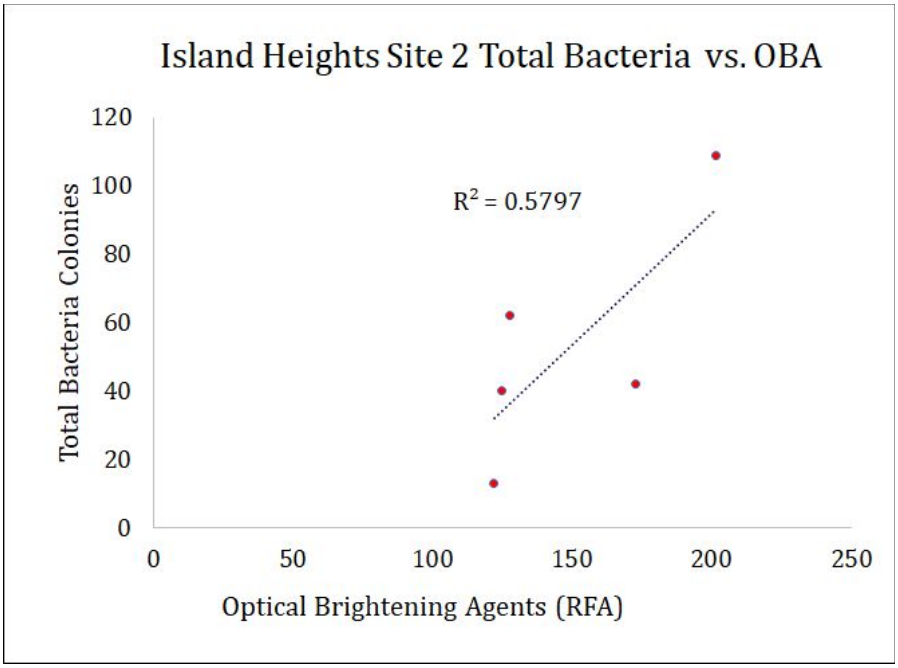

Figure 15. At Island Height site 2 from 3 July 2018 to 31 July 2018 optical brightening agents (n =11) were compared to the total bacteria colonies (n = 5). The p-value was 0.1348 showing that the data was not statistically significant, but the r-squared value was 0.5797 showing a strong correlation. However, further collection and analysis is required at this site.

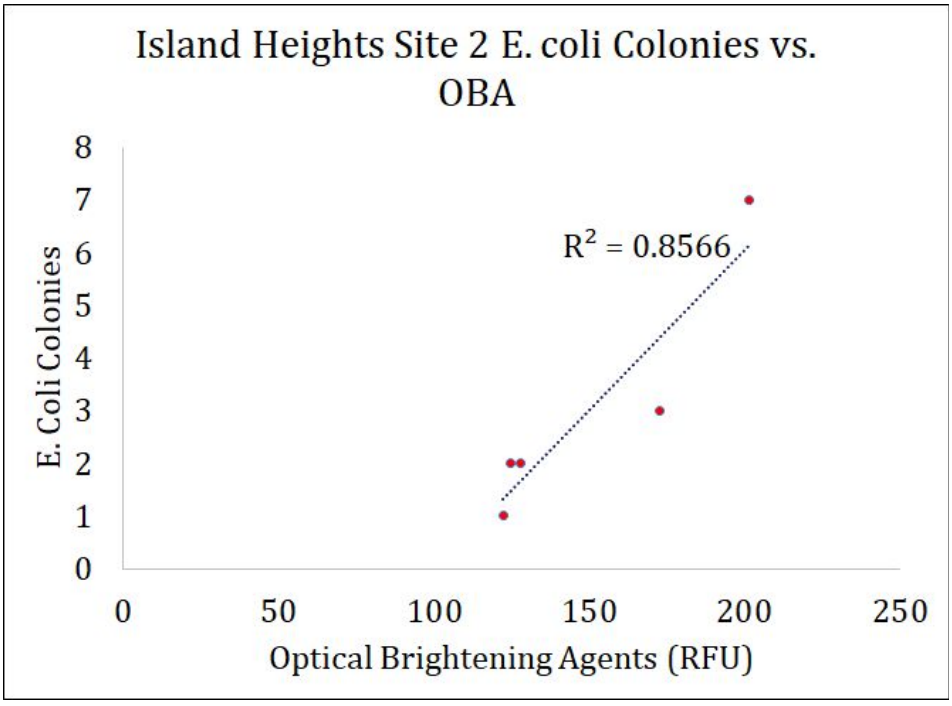

Figure 16. At Island Heights site 2 from 3 July 2018 to 31 July 2018 optical brightening agents (n =11) were compared to *E. coli colonies* (n = 5). The p-value was 0.0241 showing that the data was statistically significant, and the r-squared value was 0.8566 showing a strong correlation.