UNIVERSITY OF HAWAIʻI AT HILO MARINE OPTION PROGRAM STUDENT PROJECT REPORT

Analyzing Water Quality at Keaukaha, Hawaiʻi

Brooke Enright

Marine Science Department University of Hawaiʻi at Hilo

ADVISOR
Lisa Parr
UH Hilo Marine Option Program Site Coordinator
Marine Science Department
University of Hawaiʻi at Hilo

PROJECT SUPERVISOR
Tracy Wiegner, Ph.D.
Professor
Marine Science Department
University of Hawaiʻi at Hilo

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ABSTRACT

Poor coastal water quality due to sewage contamination is a concern for the community of Keaukaha, in East Hawai‘i. The Hilo WasteWater Treatment Plant (WWTP) and cesspools are expected to be the source of the contamination. My goal was to work with SHARP(Students in Hawaii Advanced Research Program) to assist with TCBES students' master thesis to determine the source of sewage pollution in Keaukaha and analyze if the WWTP was decreasing sewage in the water. Water quality sampling, Dye Tracer tests, statistical analysis, and a citizen science project were all conducted to measure sewage pollution in Keaukaha. Results from all the quality sampling, Dye Tracer tests, statistical analysis, and a citizen science project are reported to the WWTP and the Keaukaha community to contribute to the overall understanding of the wastewater issue.

INTRODUCTION

The Keaukaha, HI community is concerned about water quality levels at local beaches, expressing concern about water quality controls and potential sources of poor water quality along the coast. Poor water quality levels, such as high levels of sewage pollution, is damaging to the marine ecosystem and the coral reefs (Wear & Thurber 2015). Eutrophication can occur as a result of polluted waters, causing algal blooms that are driven by excess nitrogen input to overgrow and take over reefs, which limits light and nutrient levels to the corals and affects their growth and survival (Dailer 2012). Excess phosphate has been shown to decrease calcification of corals which can lead to an increase in coral mortality and the deconstruction of reefs (Dailer 2012). Additionally, Excess nutrients in waters can cause bacteria overgrowth which could potentially be hazardous to humans (US EPA 2021).

According to the US EPA, there has been a correlation between the concentration of sewage fecal indicators in recreational waters and disease incidence among swimmers (Fujioka 2001). People are more likely to be exposed to infectious diseases in higher levels of sewage polluted waters. There are an estimated 120 million cases of gastrointestinal disease and 50 million cases of respiratory diseases from humans being in water contaminated with sewage pollution (Shuval 2003). Polluted waters have also been linked to skin and urinary tract infection, hepatitis, and Staphylococcus infections (Abaya 2018). Ten percent of community members refuse to get in the water at Hilo Bay due to water quality concerns, despite it being one of the most accessible beaches in east Hawai'i. (Weigner 2009).

To maintain water quality, the state of Hawaii enforces State and Federal regulations. Wastewater standards were first established in 1972 in the Clean Water Act and are set and regulated by the United States Environmental Protection Agency (US EPA). Wastewater treatment plants (WWTP) adhere to state regulations by improving the physicochemical and microbiological properties of water and processing nutrients from sewage, chemicals, and other waste before returning it to the environment (Yasir 2021). The most common method the

US EPA uses for water quality testing is the measurement of the fecal indicator bacteria, Enterococcus (Fujioka 2001). The US EPA set standards for the state of Hawaii of 35 Enterococcus/100mL. While Enterococcus is a good fecal bacteria indicator, it is naturally present in tropical soils (Fujioka 2001), such as Hawaii, which may result in an inaccurate measurement of bacteria and skew water quality data. Hilo Bay has been failing to meet water quality federal regulations and has been listed as 1 of 7 troubled watersheds in the state of Hawaii by the HDOH (Weigner 2009).

The poor water quality levels in Hilo are associated with multiple sources including cesspools, decreased circulation due to structure and location of the breakwall, and failures at the Wastewater Treatment plant. The Wastewater Treatment Plant in Hilo has faulty equipment that is speculated to be contributing to the poor water quality levels in Keaukaha, HI. It is estimated that 86% of the equipment at the WWTP in Hilo needs to be replaced or repaired (Brestovansky 2021). The faulty equipment at the WWTP in Hilo may allow excess nutrients and contaminants into the water, decreasing the water quality severely. It is estimated that about 80% of wastewater flows back into the sea from not being treated properly at WWTP, which overall carries unwanted contaminants back into the marine ecosystem (Yasir 2021). Hawai'i county is under pressure to find solutions to its water quality issues, but the state currently can't afford the cost of repairing the equipment at the WWTP (Brestovansky 2021).

A major source contributing to sewage pollution in Hawaii is the use of cesspools (Abaya 2018). Cesspools dispose of wastewater deep in the ground where it can come into contact with groundwater, which flows into water sources and the ocean (HDOH 2021). Cesspools are still common in Hawaii due to the prevalence of older housing and plumbing. The use of cesspools in Hawaii is higher than in any other state (Abaya 2018). HDOH has developed a Cesspool Conversion Working Group to develop a plan to diminish usage of all cesspools in Hawaii by 2050 (HDOH 2021). The Regenerative Agriculture Water, Energy, and Environmental Management Committee is working to dismantle the cesspool system, but is not receiving enough funds to make sufficient progress (Brestovansky 2021).

For my MOP project, I worked with the Students in Hawaii Advanced Research Program (SHARP) to assist Graduate Students in the Master of Science in Tropical Conservation Biology and Environmental Science (TCBES) program on their master thesis projects to determine major sources of sewage pollution in Keaukaha, on east Hawai 'i Island. I analyzed influent, effluent, and manhole samples of fecal indicator bacteria and nutrient samples across many locations in Keaukaha. In addition, I conducted a citizen science portion of the project in which I asked the Keaukaha community to rate the smell of sewage pollution based on a "Pilau-Meter" (Pilau: to stink, spoiled, rotten) in Puhi Bay. From the survey, I was able to analyze and track concerns of

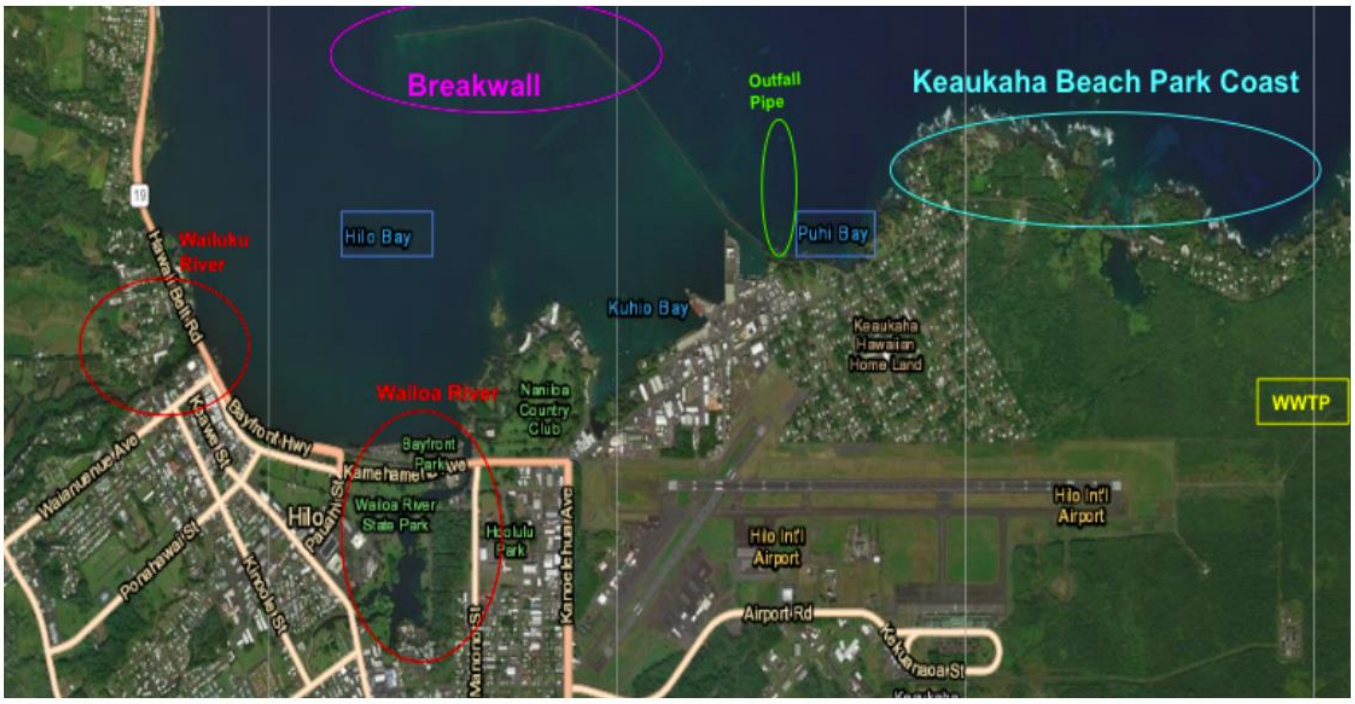
sewage pollution from community members and obtain data regarding sewage pollution conditions at specific dates and times to compare to water conditions that may affect the levels of water quality.

My objectives for my project were to 1) analyze bacteria and nutrients in water samples by helping in the field and lab ; 2) conduct a survey of the Keaukaha community about the stink of sewage pollution around Puhi Bay; and 3) report all data and results to the WWTP and the Keaukaha community.

MATERIALS AND METHODS

Study site

Figure 1: Map of Hilo, Hawai‘i
Map points out where surveying sites were conducted such as Keaukaha Beach Park, Puhi Bay, and Hilo Bay. It also points out some potential sewage impacts that were studied such as river impacts, the outfall pipe, and the WWTP.



Study site 1: Keaukaha Beach Park, HI sites 19°44’04”N 155°02’58”W

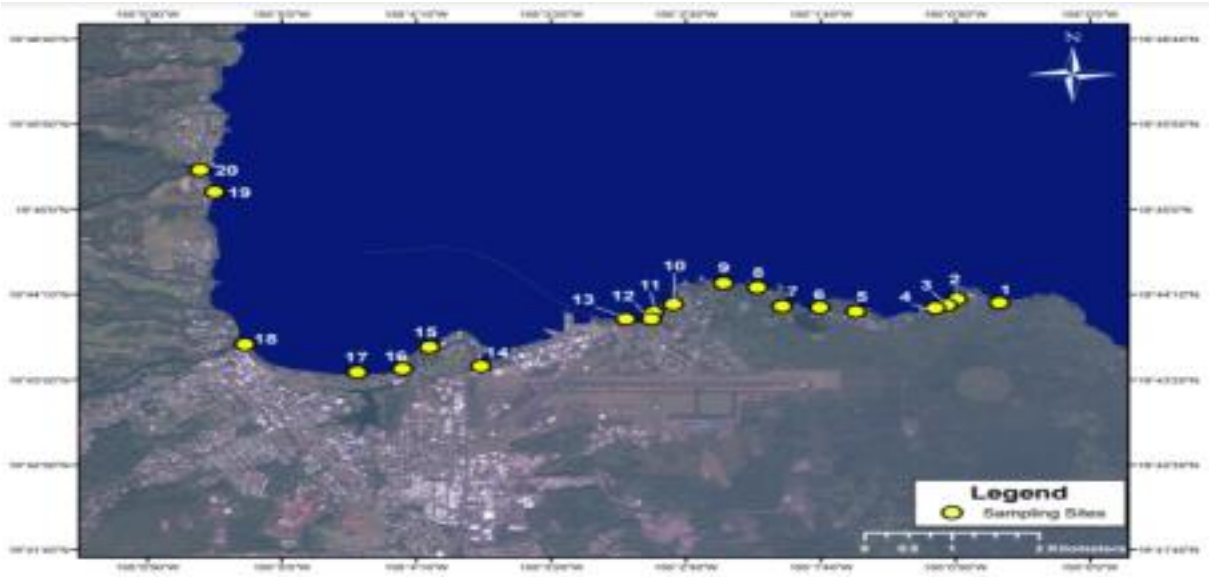


Figure 1: Map of coastal study sites along Hilo, HI
The yellow dots represent 20 sampling sites along Hilo, HI where water samples were taken. Sites 1-13 are located in Keaukaha Beach Park. Sites 14-20 are located sling Hilo Bay, with the last sites concluding at Honoli'i.

Working in the field

Field work was conducted starting 8/3/20 and 8/4/20 and has been continuing twice a month for two days, till 10/19/21. During this time, 20 sites located in Hilo, determined by TCBES students, were visited to collect water and limu samples. Sites 1-13 are located in Keaukaha Beach Park to measure sewage pollution on the Keaukaha coast. Sites 14-20 are located along Hilo Bay, with the last sites concluding at Honoli'i to analyze sewage from cesspools and how the sewage level spread along the coastline. I got to learn how to take proper water samples and to experience what is like to work in the field. All water and limu samples were taken back to the UHH analytical Lab for water quality analysis.

Analyzing Water Samples in the Lab

Water samples were taken from all 20 sites for analysis of two common fecal bacteria indicators, Enterococcus and Clostridium Perfringens, and for nutrient sampling to determine the amount of sewage in the water samples. Enterococcus samples were prepped and scanned under UV light to count the amount present to compare to HDOH standards. Clostridium Perfringens were prepped to count the number of colonies based on color. If Clostridium Perfringens were present in the water sample, it could be counted by having a pink color. Water samples were filtered to analyze certain nutrients such as: Nitrate, Phosphate, Silicic Acid, Ammonium, Total Dissolved Phosphorus, Dissolved Organic Carbon, and Total Dissolved Nitrogen, which in high amounts can be an indicator for sewage pollution. Limu samples were dried and grinded down to a powder to be processed for stable isotopes of nitrogen, which can be a determinant for sewage pollution. I was able to aid in all these

processes and learn how to process and analyze water samples, how to prep fecal bacteria indicator samples, and set up filtrations for water samples for certain nutrients. I was also able to handle and use water quality equipment such as YSI to measure temperature, salinity, dissolved oxygen in the water samples.

Dye Tracer Tests

Dye Tracer Tests were conducted in anonymous homes along Keaukaha, HI. TCBES students placed green, organic dye directly into the cesspools. 12 hours later, water samples were taken at Keaukaha Beach Park to measure amounts of dye, distance traveled, and how long the dye lasts, to indicate how sewage from cesspools is affecting Keaukaha Beach Park. From the 4 tests, it was found that sewage from cesspools can travel far distances with the 4 tests seeing dye up to 420m, 300m, 150m, and 185m. The sewage can also have long lasting effects, with the dye lasting several days, the longest was found to last 12 days.

Statistical Analysis

Statistical analyses of fecal bacteria indicators and nutrients were conducted to analyze differences in amounts of fecal bacterial indicators and nutrients at the influent flowing into the plant, compared to effluent flowing out of the plant, and the outfall pipe. Water quality samples from 20 sites along Hilo, HI from 8/3/20 until 10/19/21 were taken to find the average amount of *Clostridium perfringens* present at each sampling site to see how sewage pollution is present at each site. One-way ANOVA and Tukey tests were used on Minitab, to see comparisons.

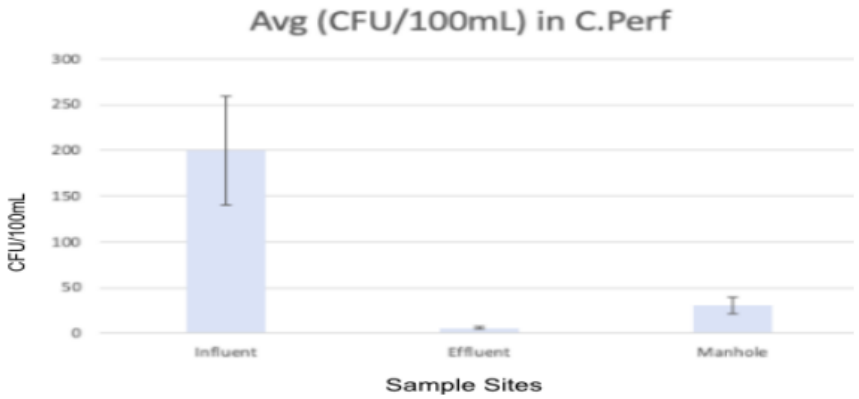


Figure 4: Average Clostridium Perfringens among the Influent, Effluent, and Manhole The Average amount of fecal bacterial indicator ,Clostridium Perfringens, was averaged at each sample site: the influent, effluent, or manhole, to compare the amount of sewage pollutants present at each site.

In figure 4, it demonstrates that the influent, which is untreated wastewater, contains high amounts of fecal bacteria indicator, Clostridium Perfringens, indicating there is high amounts of sewage. This average is significantly reduced at the effluent, where the water has been treated.

Citizen Science

The survey, Pileau Meter, was conducted at Puhi Bay in Keaukaha Beach Park, HI to compare current water and environmental conditions to the water quality data that was collected. Individuals at Puhi Bay were asked to rank current smells as well as to note water and environmental conditions. From January 29th to March 25th, 84 responses were reported. In the “Pileau Meter” survey, participants were asked to rate the smell of sewage pollution on a scale from 1 to 5, with 1 being little to no smell and 5 being a very strong smell.

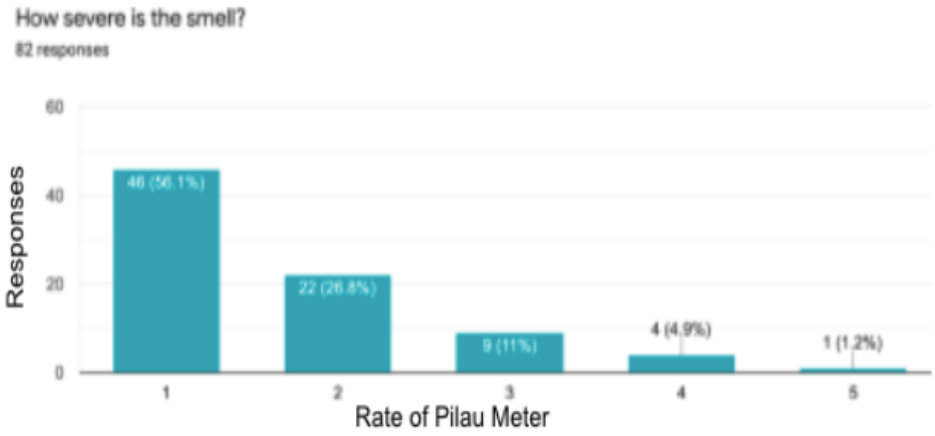


Figure 5: Graph of responses from Pilau Meter Survey categorizes how participants in the survey rated the severity of the smell of sewage pollution at Puhi Bay. Rating 1 indicated little to no smell and 5 being a strong smell.

Based on responses from Figure 5, most people reported back of not having a strong smell or no smell at all. Out of the 84 responses for the rating the smell of the sewage pollution at Puhi bay during the time the participant was present was a 1 or 2, averaging a 1.7.

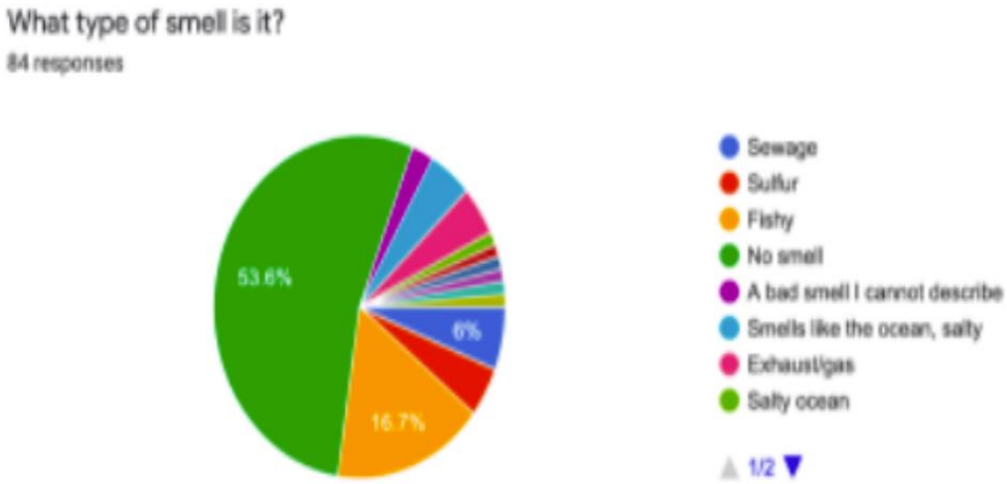


Figure 6: Chart of Smells Reported from Pilau Meter Survey
Pie chart shows what type of smell participants reported smelling at Puhi Bay. Participants chose what category best describes the smell that was occurring at Puhi Bay while taking the survey.

In Figure 6, it shows most people reported back that there was no smell with 53.6% of participants answering there was no smell. Only 6% of people reported smelling a sewage smell. This survey is still ongoing with environmental conditions still being monitored and analyzed back to water quality data.

Data sampling from WWTP has been recording samples of the influent, effluent, and manhole along Keaukaha, HI and measuring the samples for sewage pollution by performing Enterococcus and Clostridium Perfringens tests along with nutrient sampling. The bacteria and nutrient sampling started on 8/3/20 and 8/4/20 and has been continuing twice a month for two days, till 10/19/21. From these samples, an average and standard error for bacteria and nutrients can be calculated and compared throughout the influent, effluent, and manhole.

This study was conducted along Keaukaha Beach Park along 20 different coastal sampling stations. Dye tracer testing was also conducted at this site to see impacts of local cesspools. Keaukaha is an important part of the local community. It dates back to the first establishments in the 1920s that brought in the first Hawaiian homes (DHHL 2014). Over the past 100 years, locals have established a sense of community and history in Keaukaha spanning over generations. Keaukaha is characterized by its rocky coastline with numerous freshwater springs and can be found on the southern flank of Mauna Kea in the district of Hilo. Local community members have been concerned with water quality levels in Keaukaha. Residences and regular beach attendees have been reporting smells of sewage at the beaches in Keaukaha for the past few years.

A Google Forms survey called the “Pilau-Meter” was spread throughout the Keaukaha community. This survey used citizen science to document what the community has experienced around the area of Puhi Bay in Keaukaha that contains the outfall pipe from WWTP. From each response, environmental conditions were also noted to factor if environmental conditions affect water quality conditions and cause an impact on the bacteria and nutrient data collected. Flyers of this survey were shared around the community to gain responses from community members about the “stink” of the sewage pollution at Puhi Bay. Each response was dated and time stamped for comparison to data analysis.

Puhi Bay is a specific site located within Keaukaha Beach Park that contains the sewage outfall pipe from the WasteWater Treatment Plant. The Wastewater treatment plant is located outside of the Keaukaha beach park,but it is responsible for treating contaminated water.

RESULTS/ DISCUSSION

Working with SHARP was my first time I got to experience working in the field and in the lab outside the classroom. I got to work more independently and show my knowledge and skills of water quality science. I was able to learn new lab techniques such as how to take water samples, how to prep nutrient, fecal bacteria, and limu samples, and also how to count bacterial colonies on different bacterial indicators. I was introduced to how to use water quality equipment
such as YSI, turbidity meter, and fluorometer. I expanded on my statistical mathematics performance by using software such as Excel and Minitab to contribute to statistical findings of the project. I got to interact directly with the Keaukaha community during the citizen science portion of the project and during Keaukaha Town Association meetings and hear about concerns about local beaches and water quality, overall contributing to my understanding of the importance of the project. It was insightful to work with graduate students and experience the protocols and steps it takes to write a Master Thesis, for as I am considering going to graduate school in the future. Overall, I am thankful for the opportunity to work with SHARP and the TCBES students and I got to take away valuable skills that make me a better researcher and prepare me for my future career.

CONCLUSION

From my project, I collected data sets of the bacteria and nutrient sampling of the influent, effluent, and manhole and also a report of community responses from the “Pilau-Meter” survey. This data will be available to the community. All the data will be reported back to WWTP. The WWTP hopes the data will bring more insight to the water quality issue they are facing and they can bring it to the state to advocate for an allowance in the budget. I will also create a presentation to share an overview of my project and my data at the MOP symposium.

I am planning to share this presentation with the Keaukaha community at a Keaukaha Town Association Meeting, so the public is informed about water quality levels on their beaches.

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