Effects of Homeless Encampments on E.coli Concentrations in BV Creek

AP Research

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Introduction

Homelessness is a palpable concern that brings disquiet to the daily lives of many. In San Diego region cities, data reports from the San Diego Regional Task Force on Homelessness (SDRTFH, 2023) found that the population of unsheltered homeless individuals totaled 5,171 as of 2023, a 25.9% increase from the previous year. However, societal prejudices toward homeless individuals and continued community negligence of the issue often deter an individual from understanding the magnitude of this dilemma. A statewide survey conducted by the Public Policy Institute of California, a nonprofit and nonpartisan research institute, found that those who are "very concerned" about the problem of homelessness in Orange and San Diego counties have only gone up by 2% from 2019 to 2022 (Thomas, 2022), which is not proportionate to the growing homeless population. These statistics highlight the alarming indifference San Diego County has to the pervasive issue of homelessness and demands for more awareness and attention to the homeless crisis.

Unsheltered homelessness (UH), defined by the U.S. Department of Housing and Urban Development (HUD), is when an individual lives "in a place not meant for human habitation" (Dunton et al., 2020). People experiencing UH comprise over half of the total homeless population in San Diego region cities (SDRTFH, 2023), and often reside in encampments. Although there are no standard criteria to be met to define an encampment, HUD's literature review identified three concepts commonly used in defining the term: (1) the presence of structures, (2) the continuity of location, and (3) the permanency of people staying there (Dunton et al., 2020).

Many residents of encampments take refuge along waterways, such as rivers, lagoons, and creeks. Waterways and their associated vegetation yield environmental advantages as well as provide seclusion from the public eye and "accompanying harassment," ultimately invoking a sense of privacy and safety (DeVuono-Powell, 2013). Police scrutiny and prohibition also drive individuals experiencing UH to remote areas. In a study by Welsh and Abdel-Samad, associate professors at San Diego State University, participants experiencing street homelessness recount "marginalizing effects" of San Diego's system of policy, describing destructive encampment "sweeps," and their perception of police exploits as being motivated by preconceived notions of criminality of those experiencing UH (Welsh & Abdel-Samad, 2018, 33, 41-42).

Although shied away from social and policy threats, the health risks associated with living by waterways are often overlooked. The annual risk of infection for homeless people who use river water for personal hygiene or laundry surpasses 88%, and for some pathogens, approaches 100% (Donovan et al., 2008). These waterborne pathogens are largely attributed to the fecal waste of animals and humans, one of the most abundant being Escherichia coli [E. coli] (United States Environmental Protection Agency [USEPA], 2023). Epidemiological studies established a correlation between levels of E. coli from known contaminants in recreational waters and cases of gastrointestinal illnesses (Jang et al., 2017), drawing concern for the health of those exposed to these waterborne pathogens as well as illustrating the increased vulnerability of the UH population living near waterways. Additionally, recent declines in the availability of public restrooms were found to be directly correlated with a decrease in the hygiene of people experiencing UH (Swayne et al., 2023), an example being open defecation, which has been hypothesized to be a source of human fecal contamination in urban water bodies (Verbyla et al., 2021). An in-depth study of 84 semi-structured interviews of individuals experiencing UH by waterways found that as of 2020, 73.2% of river-dwelling respondents reported either themselves or their encampment members practiced open defecation (Flanigan & Welsh, 2020). Therefore, the lack of availability for public restrooms could only be further perpetuating this practice, causing an increased risk of contamination from fecal coliform in nearby water bodies.

Gap in the Research and Hypothesis

Fecal matter's association to water contaminants, such as E.coli, and it's increased exposure waterways via the open defecation of homeless encampments suggests that the relationship between homeless encampments and E.coli contamination concerns to be analagous to a positive feedback loop. Despite this growing dilemma, there has been only one study examining the possible relationship between E. coli contamination in waterways and the presence of homeless encampments. This study, done by postdoctoral researchers at San Diego State University, assessed water samples upstream and downstream of homeless encampments to analyze the impact that homeless encampments had on the water flowing through them. Although limited evidence was found that homeless encampments hold responsibility for fecal microbial pollutants in the San Diego River (Verbyla et al., 2021), traces of caffeine, sucralose, and HF183 (a human fecal pollution marker) were detected throughout the study, suggesting that there are still anthropogenic pollutants interacting with the river. As this is the only study on this topic, which only assessed waterways along the San Diego River, there remains a lack of understanding on the direct relationship between these two variables in a context outside of this geological area where topography and waterflow differ. Additionally, that study only looked for a set statistical association between water samples taken upstream and downstream of multiple homeless encampments, and did not compare the difference of these paired samples to a site without a homeless encampment. These deficits in the body of research accompanied by the potential spread of the fecal bacterium, E.coli, through the open defecation of homeless encampments, leads to the conjecture that homeless encampments are a potential contributor to E.coli pollution.

This study looks to explore this conjecture by answering the research question, “Is there a statistical association between the elevated E.coli levels in BV Creek (BVC) and the presence of homeless encampments in the vicinity of the water?” in which the response to this is predicted by this study’s hypothesis; “The E.coli concentration difference between water samples taken upstream and downstream of the encampment will be statistically greater than those taken at the control site.” Unlike previous studies, this study takes more of an experimental approach by comparing the presence of the homeless encampment, the treatment condition, to the absence of a homeless encampment, the control condition. Taking this unique approach as well as filling the research gap in another location could aid in understanding of how homeless encampments and water quality interact, build reliability on past data, and bring awareness to the health concern that is occurring at the heart of our community waterways.

Study Area

BV Creek (BVC) encompasses 11% of the coastal city’s total hydrologic unit, spanning approximately 10.6 miles inland to the coast and totaling 14,437 acres in the area. The freshwater creek begins along the western slopes of the SM Mountains, and descends down towards the coast, discharging into the Pacific Ocean through the BV Lagoon (Buena Vista Audubon Society, n.d.). Out of all the water samples taken in 2023 from BVC by the North San Diego County Watershed Monitoring Program (NSDCWMP), approximately 45.83% of them exceeded the USEPA recommended threshold of 320MPN/100mL for E.coli (USEPA, 2021), and outweighed the E.coli concentrations of its neighboring waterways (NSDCWMP, 2023). This history of elevated E.coli levels, alongside the presence of a homeless encampment near the testing site, demonstrates the aptness of BVC as a testing site.

Methods

Rationale

To explore this research question, a comparative analysis using some elements of experimental design was used to seek out a relationship between the presence of homeless encampments and E.coli concentrations in the BVC watershed. Although experimental research would've been ideal, many confounding variables in the environment—weather conditions, slight movement of the encampment, stormwater runoff, MS4 outfalls, and other nonpoint sources of pollution—cannot be controlled in a natural setting, making it difficult to draw a causal relationship. The equipment and methods used to assess these water quality parameters was adopted from the standard procedures of the NCSDWMP, which are in compliance with the USEPA's approved methods for water quality assessment.

Sampling Sites and Experimental Design

The encampment studied is located south of the Oceanside DMV, and was used as the treatment group for this study. This site is an established testing site for the NCSDWMP, who I will be working closely with as an expert advisor throughout the duration of my project. To choose a control group site, candidate sites upstream from the encampment were evaluated for similar topography, width and depth of the water, flow, and vegetation, as well as the absence of homeless encampments nearby, a close proximity to the treatment site, and the overall feasibility to collect water samples. Ultimately, the site selected to be a control that best fit these criteria was located ~7,646ft upstream from the treatment site, measured using Google Earth's software, and is adjacent to the 78 freeway.

Prior to sampling, the pinpoint upstream and downstream sampling locations were determined by first marking the immediate upstream and downstream sampling locations of the treatment site, which were in alignment with the “head and tail” of the homeless encampment. In order to mirror these locations at the control site, the length of the encampment alongside the creek was measured to be 135.5ft using a Zozen measuring wheel. This distance was then measured between the upstream and downstream sites at the control site. Doing this permits direct comparison between the treatment and control conditions by keeping the distances between upstream and downstream samples consistent, as well as minimize a skewed interpretation of the data if the baseline E.coli concentrations at these general locations are greatly varied due to other environmental factors. Figure 1 details the locations of these sampling sites visually, while Figure 2 provides a visual representation of this study’s experimental design.

Figure 1

Locations of treatment and control sites and their upstream and downstream sampling locations

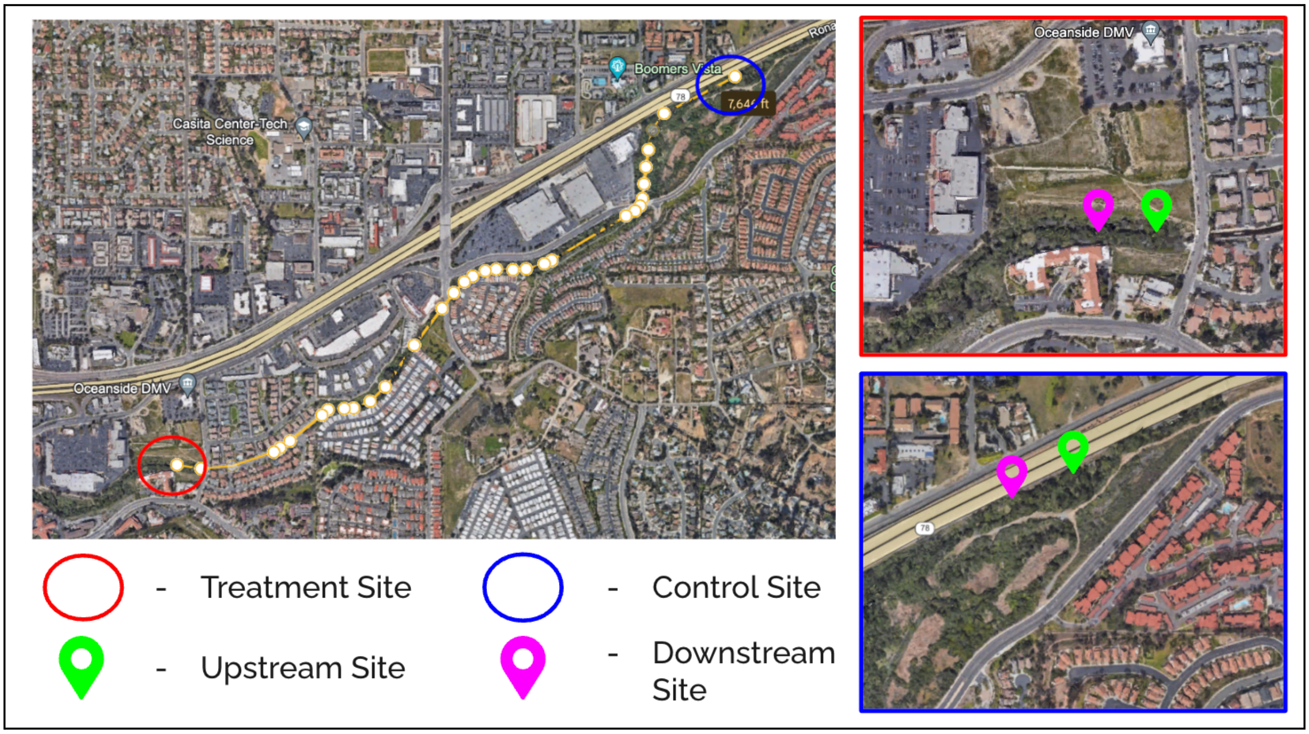
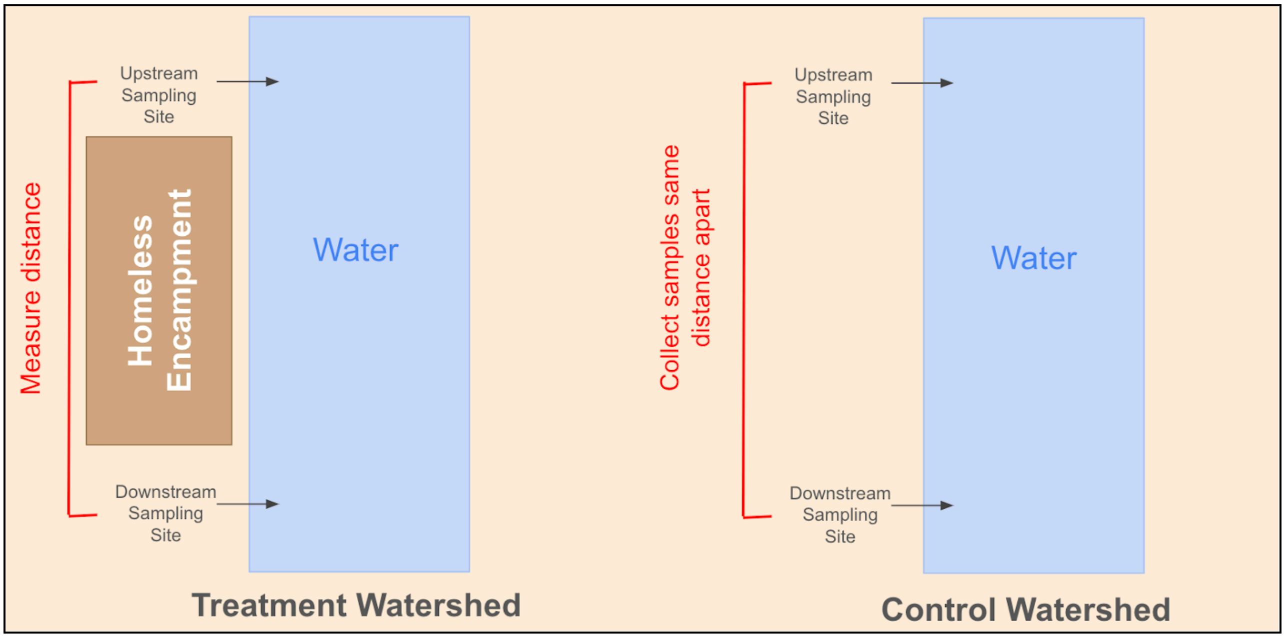


Figure 2

Experimental Design



Sample Collection and Lab Analysis

Samples were collected between December 2023 and February 2024 on 5 sampling dates, each two weeks apart, with the exception of two sampling dates being three weeks apart due to personal complications. Sample collection began around 9-10am, and were processed within six hours of the first sample collection to ensure accurate E.coli readings. Field duplicates were taken at all of the sampling sites for quality control, totaling to 4 paired samples (a pair constituting an upstream and downstream sample) collected per sampling date. This amounts to 20 paired samples taken across the entire duration of the study (N = 20), 10 paired samples per condition, which represented the sample size number used to perform statistical analysis (n = 10). As recommended by the USEPA in their guide for the assessment, listing, and reporting of data in compliance with the Clean Water Act, all the data collected, including field duplicates, were evaluated during statistical analysis in order to yield more accurate conclusions about the

E.coli concentrations at both sites (USEPA et al., 2005, 36) and were treated as independent paired samples from the original paired samples. Using field duplicate samples as data sets during statistical analysis also allowed an increase in sample size whilst having a limited time frame. Water samples were taken from beneath the water's surface near the center of the stream using a sampling stick, and were transported on ice in a Coleman Cooler to the lab for analysis.

While out in the field, standard field observation sheets from the NSDCWMP were completed for each site (see Appendix A for the sheet used). These sheets included taking qualitative field observations such as weather conditions, water clarity, water color, biology, vegetation, deposits, floatables, and flow information. Arrival and collection times for the samples were also documented for each site. Quantitative in-field measurements such as water and air temperature, dissolved oxygen (DO), and conductivity were recorded using the Hach HQD field kit, following standard operating procedures. pH was measured using a CHEMetric pH meter. Each measurement was taken three times at each upstream and downstream site with one minute intervals in between each trial to ensure the data was representative of the sampling sites' conditions.

Water samples were taken back to the lab to be analyzed for total coliform, E.coli, and turbidity. Total coliform and E.coli concentrations were quantified using USEPA approved Standard Methods 9223B (USEPA, 2017), a Colilert-18 test with the IDEXX Quanti-Tray 2000 system, which is a specific enzyme substrate test used to detect the enzyme β-glucuronidase produced by E. coli. Samples were prepared under a 1:10 dilution and were later multiplied by 10 to ensure E. coli concentrations wouldn't go over the readable limit. Once diluted, samples were poured and sealed in quanti-trays, and were then placed in a 35(+/-0.5C) incubator for a minimum of 18 hours and a maximum of 22 hours. After the incubation period, samples were quantified by counting the positive wells for total coliform, then using a ultraviolet light to view and count the positive wells of E.coli. The results of this quantification was then translated to MPN/100mL (Most Probable Number) units using a MPN table provided with the IDEXX Quanti-Tray 2000 system to determine a numerical value for the bacterial concentrations. Turbidity was assessed using a 2100Q IS portable turbidimeter operating under standard procedures.

Statistical Analysis

The method for statistical analysis of the collected data described below is ascribed to the aforementioned San Diego River study, which also analyzed E.coli's association to nearby UH encampments (Verbyla et al., 2021). Using the same statistical method allows cross comparison of this study's findings with Verbyla's previous data, allowing for a more nuanced interpretation of results and the situation of newfound conclusions into the research gap.

Due to a high variance of distribution for environmental data, E.coli concentration data was transformed to log10 differences between the upstream and downstream concentrations prior to statistical analysis to ensure the approximate normal distribution of the data needed to perform an accurate statistical *t*-test. Specifically, E.coli concentrations were analyzed using an upper-tailed paired *t*-test—a statistical test used to determine the ratio of the mean differences, *t,* between the upstream and downstream sets of E.coli data to examine the significance of variation that exists within sample sets. Individual upper-tailed paired *t*-tests were performed for the treatment and control site, and the resulting statistics were interpreted in comparison to one another. The null hypothesis for this *t*-test is defined to be, "There is no significant difference ($\mu_0 = 0$) between the upstream and downstream E. coli concentrations," while the alternative hypothesis is, "The downstream E.coli concentrations will be significantly greater than the upstream concentrations ($\mu > \mu_0$)." The null hypothesis was to be rejected and the difference would be considered statistically signficant if the p-value is <0.05. The same statistical procedure was repeated for conductivity and turbidity data, while a two-tailed ($\mu \neq \mu_0$) paired sample *t*-test was performed for pH and DO. Turbidity data equated to the structure of the paired E.coli data, however, other water parameters taken in the field did not follow this structure. Unlike the structured pairing of E.coli samples, no specific measurement out of the three taken upstream were directly paired to the three measurements taken downstream. Therefore, the mean of the three measurements taken of each parameter in the field was calculated prior to pairing the upstream and downstream values in a *t*-test.

In addition to a *t*-test, percent changes in water quality parameters and log10 differences in E.coli were calculated between upstream and downstream samples, and E.coli differences were visualized in a box plot to compare the overall variation between the treatment and control sites. Equation (1) details the calucation used to determine the percent changes of pH, DO, conductivity, and turbidity while (2) details the calculation of the log10 E.coli concentration difference. The variable *C* refers to the measured concentration of the tested parameters. As defined by Verbyla et al. (2021), log10 differences in E.coli concentrations were considered statistically significant if a 0.5log10 difference was found between the upstream and downstream paired samples. Percent changes were considered statistically significant if they fell beyond the standard deviation (SD).

$$\%\ \text{change} = \frac{\left(C_{\text{downstream}} - C_{\text{upstream}}\right)}{C_{\text{upstream}}} \tag{1}$$

$$\log_{10}\text{difference} = \log_{10}\left(\frac{C_{\text{downstream}}}{C_{\text{upstream}}}\right) \tag{2}$$

Geometric means of E.coli concentrations were calculated using non-transformed MPN values for all sampling locations in order to see how the observed values compared to the E.coli thresholds, which are defined in the San Diego Basin Plan by the California Waterboard to be 100MPN/100mL for a 6-week rolling geometric mean in recreational waters, and 2000MPN/100mL for a 30-day rolling mean in nonrecreational waters (California Regional Water Quality Control Board, San Diego Region, 2021). All calculations were performed with Google Sheets, with the exception of the log10 data transformations, which were performed using a TI-30XS calculator.

Results

E. coli Concentrations

Across both conditions, 10 samples were collected at all four upstream and downstream locations (*n* =10). The geometric means of E.coli concentrations for the treatment site's upstream and downstream locations were 877 and 813 MPN/100mL respectively. For the control site, the geometric mean was 615 MPN/100mL for the upstream location and 568 MPN/100mL for the downstream location. All of these values are significantly higher than the threshold of 100MPN/100mL for recreational waters. The means of these concentrations for the treatment condition were 3788.8 MPN/100mL upstream and 4623.8 MPN/100mL downstream, and 1001 MPN/100mL upstream and 975.4 MPN/100mL downstream for the control condition. The mean E.coli concentrations exceeded the threshold of 2000MPN/100mL for nonrecreational waters for both locations at the treatment site, but not for the control site.

Table 1 showcases the numerical values derived from statistical analysis, visualizing the comparison of data between the treatment and control conditions. Results of the log10 differences between paired upstream and downstream samples is visualized in figure 3. The means for these log10 differences between paired samples for treatment and control condition were, respectively, -0.023 and -0.015. As these values do not succeed the defined significant value of 0.5, no statistically significant difference was found. Results of the paired-t test for the treatment condition indicated that there is a non-significant small difference between upstream samples (*M* = 2.9 ,*SD* = 0.8) and downstream samples (*M* = 2.9 ,*SD* = 0.9), *t*(9) = 0.7, *p* = .743. The results from the paired-t test for control condition also found a non-significant small difference between upstream samples (*M* = 2.8 ,*SD* = 0.5) and downstream samples (*M* = 2.8 ,*SD* = 0.5), *t*(9) = 0.8, *p* = .764.

Table 1

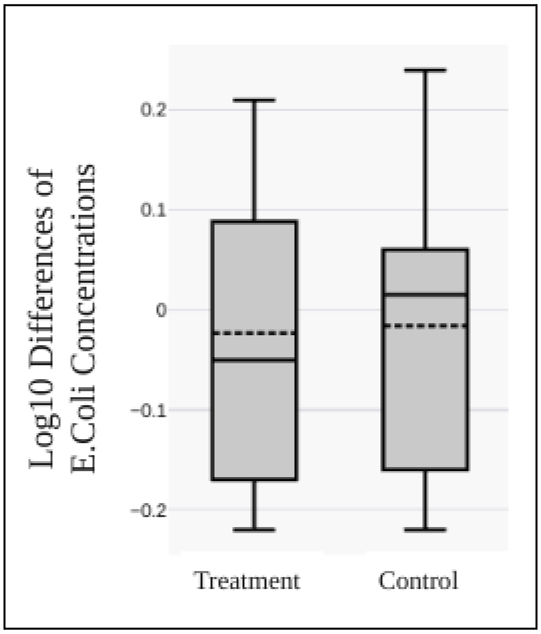
E.coli data

Sampling site	Log10 difference in the upstream and downstream concentrations[a]			*t*-test results		
	Mean	Median	SD	Sample Size (*n*)	*t*-statistic	*p*
Treatment	-0.023	-0.050	0.14	10	-0.68	.743
Control	-0.015	+0.015	0.14	10	-0.75	.764

[a] Positive values (+) signify that concentrations were greater downstream than upstream, while negative values (-) indicate that the concentrations upstream were greater than downstream.

Figure 3

Boxplot of the log10 differences of paired samples in treatment and control conditions



Note. The dashed line signifies the mean, while the solid line signifies the median.

Water Quality Parameters

After taking the means of the three measurements collected for the in-field water parameters per site over the course of five sampling dates, a total of five paired samples were analyzed for pH, DO, and conductivity in each *t*-test ($n = 5$) with the exception of turbidity, which had the same sample size of the E.coli data ($n = 10$). Table 2 shows the percent changes between upstream and downstream samples and the results of the paired *t*-tests of the remaining water quality parameters, and puts the data of the treatment and control conditions side-by-side. The differences between the concentrations of paired samples were found to be nonsignficant for most parameters. A significant large difference was found between paired samples for DO concentrations in both the treatment ($p = 0.008$) and control ($p = 0.002$) site, however, they changed inversely to each other. At the treatment site, upstream samples had higher DO levels, while at the control site, downstream samples had higher DO concentrations. A significant difference was also found in the conductivity levels between paired samples at the control site (*p* = 0.027), and downstream levels were significantly higher than upstream sites.

Table 2

Water Parameter Data

Sampling site	Parameter	Percent change in concentrations (%)			*t*-test results		
		Mean	Median	SD	Sample size (*n*)	*t*-statistic	*p*
Treatment	pH	-0.3	-0.5	1.1	5	-0.57	.602
	DO (mg/L)	-9.2	-8.0	3.7	5	-4.81	.008
	Conductivity (μS/cm)	+1.0	+0.5	1.5	5	1.47	.108
	Turbidity (FNU)	+25.1	-6.5	86[a]	10	0.05	.481
Control	pH	+0.4	+0.4	0.5	5	1.73	.159
	DO	+2	+2	0.7	5	7.16	.002
	Conductivity	+0.4	+0.3	0.3	5	2.69	.027
	Turbidity	+25.8	5	71[a]	10	1.21	.129

[a] Turbidity at both sampling sites spiked on 1/13/24, contributing to a high SD. Without these outliers, the treatment's mean would be -13.8 with an SD of 15.7, and the control's mean would be +6.6 with an SD of 38.7.

Discussion

E. coli Concentrations

The results of this study, such as the high *p*-values of .74 and 0.76 as well as the extremely similar data trends between the treatment and control site, reject the hypothesis that "the E.coli concentration difference between water samples taken upstream and downstream the encampment will be statistically greater than those taken at the control site." Interestingly, the results of the *t*-tests, -0.68 and -0.75 for the treatment and control sites respectively, showed concentrations of E.coli to be greater at upstream sampling sites rather than the predicted outcome of concentrations to be greater downstream. These results are discordant with the findings of Verbyla and colleagues, which concluded that the log10-transformed E. coli concentrations were significant at all three sites they examined (Verbyla et al., 2021). The study design and sample sizes used in their study per site were similar to this study's (*n* = 4, 8, and *n* = 10, respectively), however, sampling weather conditions were varied. For context, sampling weather is categorized into two conditions; wet and dry. Section 6.1.3 of USEPA's 2015 Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activity, classifies wet weather conditions to be characterized by a measurable storm event that results in an "actual discharge" of stormwater within 72 hours of sampling (USEPA, 2015). Throughout the duration of this study, storm events were documented on 12/22, 2/10, and 2/21, all of which exceeded an inch of rainfall and fell within 72 hours of three sampling dates for this study. Therefore, three out of the five sets of samples for this study were collected during wet weather conditions, while the study by Verbyla and colleagues (2021) sampled exclusively during dry weather conditions. These varied weather conditions could be a exogenous variable that contributed to the discrepancy of these findings. Research comparing E.coli virulence and pathogenicity during dry and wet periods led by Dr. Jatinder Sidhu—senior research scientist within the coasts program of the Oceans and Atmosphere Business Unit—observed that the mean E. coli concentrations after the storm events were significantly higher than the dry period (Sidhu et al., 2013). These spikes in E.coli are hypothesized to be attributed to the stormwater runoff into waterbodies, which can be contaminated by a number of nonpoint source pollutants such as sewer overflows, agricultural runoff, defective septic systems, defecation of mammals, and discharge of treated sewage (Ahmed et al., 2019). The spikes in the data could've contributed to the exceeding geometric means of E.coli concentrations across all sites, as well as potentially influence the conclusivity of the relationship between the treatment and control sites. Therefore, it is possible that the wet weather conditions on three of the sampling dates could have introduced E.coli pollution from other sources in disimilar amounts to the treatment and control site by discharging runoff in proximity of the upstream and downstream locations, ultimately interfering with the experiment's design to isolate a quantified value of E.coli contribution from the homeless encampment alone for analysis. The effects of the rain on E.coli concentrations were acknowledged prior to sampling, however, the limitation that my data collection was confined to the scope of the AP Research course timeline accompanied with my limited availability to conduct sampling as a full time student, led to sampling exclusively in dry weather conditions to be unattainable for this study. Furthermore, the influx of stormwater into the stream dramatically rose the water level at both sites, resulting in the uphill migration of the homeless encampment. Although this could interfere with the detectability of homeless encampment pollutants, the encampment still remained within ~200m from the stream, and therefore was still defined as being in "close proximity" (Verbyla et. al, 2021) to the riverbank. For continuation of evaluating the relationship between waterborne pathogens and homeless encampments, future research would benefit from sampling in dry weather conditions to minimize the inundation of contaminants interfering with observing the direct relationship between pathogens and encampments.

Although the hypothesis of this study was not supported by the data quantified, the findings of this analysis remains to be summative of the environmental conditions that unsheltered homeless encampments residing by BVC are unprotected against. The geometric means and total means of the treatment site greatly exceeding the defined thresholds of 100MPN/100mL and 2000MPN/100mL for both recreational and nonrecreational use, respectively, highlight the immense health risk that the homeless population is continually exposed to, especially since they employ BVC for recreational and potable uses.

Water Quality Parameters

Out of all of the tested parameters, the only parameter found to have a significant difference between upstream and downstream samples at both conditions was DO. However, unexpectedly, the relationship between upstream and downstream samples of the treatment and control sites were inverse. The USEPA defines dissolved oxygen (DO) as “the concentration of oxygen gas incorporated in water,” via direct absorption from the atmosphere and the release of oxygen as a byproduct of photosynthesis from aquatic plants (Marcy et al., 2023). Inadequate concentrations of DO can kill off aquatic animals and vegetation, a condition known as hypoxia. According to the National Ocean and Atmospheric Administration (NOAA), hypoxial conditions are often “a consequence of human-induced factors,” especially nitrogen and phosphorus nutrient pollution (NOAA, 2022), which provide favorable conditions to harbor E.coli coliforms. Aram and his colleagues at Taiyuan University of Technology also identified that in surface waters, higher values of DO were statistically associated with lower odds of fecal coliform contamination (Aram et al., 2021). This establishes a correlation between DO concentrations and E.coli abundance, albeit, whether this relationship is direct or mediated by an exogenous factor remains unclear. In a study published the peer-reviewed journal, Journal of Biological Chemistry, Dukan and Nyström found that when cultivating glucose-starved wild-type E.coli cells in aerobic and anaerobic environments, approximately 98% of the cells in the aerobic culture died within 10 days, yet there was no significant killing of the anaerobic culture during the same time period (Dukan & Nyström, 1999). These findings also show oxygen levels to be negatively correlated with E.coli survival, and furthermore, lead to notion that the water physiology of the BVC watershed itself could be harbor E.coli coliforms. The "opposite" yet both significant DO differences between the upstream and downstream samples of both conditions are speculated to be attributed to the surrounding geographic terrain. Throughout this study, the water level rose dramatically due to heavy rainfall, and the width differences between the two conditions caused varying speeds of water flow. At the treatment site, the width of the upstream waterway was narrower in comparison to its downstream counterpart, which gave the appearance that the downstream site's water was noticeably more "stagnant." At the control site, the width of the stream was narrow at both the upstream and downstream sites, and the increased water flow caused a waterfall to precede the downstream sampling site. These varying speeds are likely to have circulated unproportionate amounts of oxygen into each of the sampling sites, thereby accounting for these unexpected findings. Although these differences in DO do not show any relationships in respect to the collected E.coli data in this study, understanding the role of DO and the way it interacts with E.coli and other fecal coliform allows us to employ DO as supplemental information to assess the other environmental factors that could indicate increased susceptibility of E.Coli abundance in the BVC watershed as a whole.

The other parameter that showcased a significant difference between upstream and downstream concentrations was conductivity. Conductivity is defined as “a measure of the ability of water to pass an electrical current” (USEPA, 2023). There are no specific water quality objectives for conductance in the San Diego region, however, the USEPA (2023) describes how most bodies of water have a relatively stable range of conductivity levels. In regards to fecal pollution, a study on the Toga River led by Dr. Horiguichi from Osaka University published in the peer-reviewed journal, Journal of Water and Environment Technology, reports that water conductivity from the Toga River was highly correlated with fecal coliform densities, thereby acting as a predictor to quantify fecal coliforms (Horiguchi et al., 2023, 204). It is also noted that conductivity was selectively chosen to predict fecal contamination out of all the parameters due to the constituents of fecal matter. This largely pertains to the inorganic salts within animal feces that can conduct electricity, however, it’s also been shown that pathogens within bacterial samples are “significantly positively associated” with water conductivity (Guzman-Otazo et al., 2019). Therefore, assessing conductivity could provide a means to not only predict fecal coliform abundance but also the likelihood of these coliforms being pathogenic. However, conductivity was only found to be significant at the control site. Although the sample size was relatively small (N=5), the small standard deviation of 0.33 signifies that this difference was persistent across all five paired samples, regardless of weather conditions. Albeit intriguing, this relationship did not directly contribute to the answering of this study’s research question as no significant differences were found between treatment and control conditions for E.coli, nor was there a significant difference in conductivity at the treatment site to compare it to.

Conclusion

Considering the multitude of complexities and limitations within the results of this study, future studies examining similar relationships between homeless encampments and microbial pollutants would greatly benefit from sampling during drier weather conditions, more frequent sampling for a greater sample size, and the usage of other testing methods in supplement with E.coli concentrations. For example, a more “pinpoint” microbial test for examining human E.coli contribution would be the aforementioned human fecal pollution marker, HF183. Albeit more expensive than general E.coli quantification, targeting these specific markers in E.coli coliforms can aid in a more accurate analysis of the contribution of anthropogenic sources to microbial pollution in waterways. Additionally, when analyzing trends in DO, having supplemental information such as nitrogen and phosphorus concentrations would be beneficial to gain a complex understanding of how the different chemical variables of water interact with one another.

Ultimately, although the hypothesis of this study was rejected by the results of my analysis, the conclusion of rejection is just a significant as a conclusion of support. Although there were confounding variables, the non-significant differences between upstream and downstream samples between the treatment and control conditions highlight refuting evidence to claims that homeless encampments need to be “swept” away for the safety of the waterways. Rather, the conclusions of this study show that the concerns for homeless encampments should be about their health and safety. Urgent action needs to be taken to provide safer modes of shelter for UH individuals.

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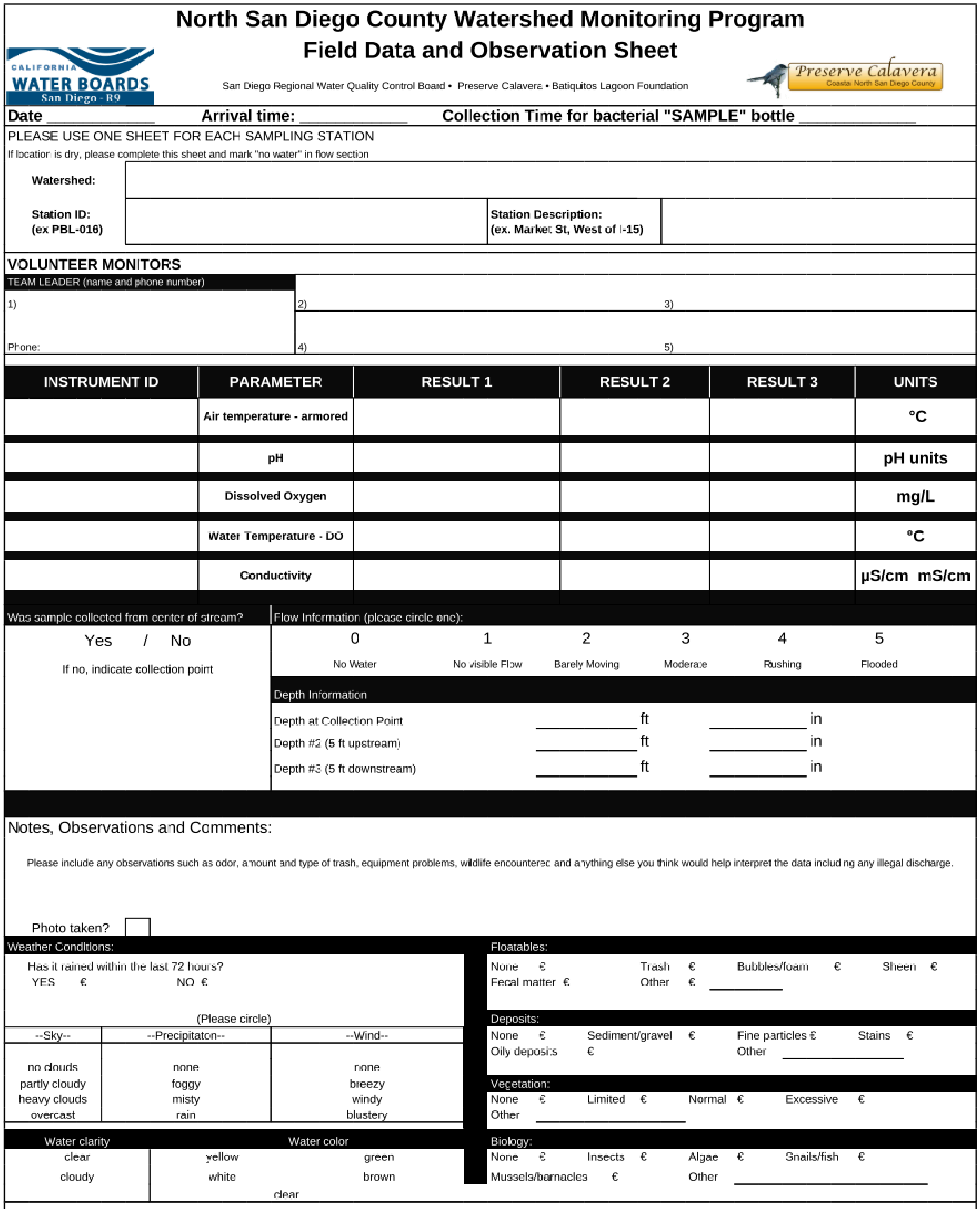
Appendix

Field Observation Sheet



North San Diego County Watershed Monitoring Program
Field Data and Observation Sheet

San Diego Regional Water Quality Control Board • Preserve Calavera • Batiquitos Lagoon Foundation

Date ______________ **Arrival time:** ______________ **Collection Time for bacterial "SAMPLE" bottle** ______________

PLEASE USE ONE SHEET FOR EACH SAMPLING STATION
If location is dry, please complete this sheet and mark "no water" in flow section

Watershed:			
Station ID: **(ex PBL-016)**		**Station Description:** **(ex. Market St, West of I-15)**	

VOLUNTEER MONITORS

TEAM LEADER (name and phone number)		
1)	2)	3)
Phone:	4)	5)

INSTRUMENT ID	PARAMETER	RESULT 1	RESULT 2	RESULT 3	UNITS
	Air temperature - armored				**°C**
	pH				**pH units**
	Dissolved Oxygen				**mg/L**
	Water Temperature - DO				**°C**
	Conductivity				**µS/cm mS/cm**

Was sample collected from center of stream?

Yes / No

If no, indicate collection point

Flow Information (please circle one):

0	1	2	3	4	5
No Water	No visible Flow	Barely Moving	Moderate	Rushing	Flooded

Depth Information

Depth at Collection Point ____________ ft ____________ in
Depth #2 (5 ft upstream) ____________ ft ____________ in
Depth #3 (5 ft downstream) ____________ ft ____________ in

Notes, Observations and Comments:

Please include any observations such as odor, amount and type of trash, equipment problems, wildlife encountered and anything else you think would help interpret the data including any illegal discharge.

Photo taken? ☐

Weather Conditions:

Has it rained within the last 72 hours?
YES € NO €

(Please circle)

--Sky--	--Precipitaton--	--Wind--
no clouds	none	none
partly cloudy	foggy	breezy
heavy clouds	misty	windy
overcast	rain	blustery

Water clarity: clear, cloudy

Water color: yellow, green, white, brown, clear

Floatables:
None € Trash € Bubbles/foam € Sheen €
Fecal matter € Other € __________

Deposits:
None € Sediment/gravel € Fine particles € Stains €
Oily deposits € Other __________

Vegetation:
None € Limited € Normal € Excessive €
Other __________

Biology:
None € Insects € Algae € Snails/fish €
Mussels/barnacles € Other __________