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Article

A comparison of the water quality between Chinatown and Bayside: two demographically different regions

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SUMMARY

To ensure the absence of environmental injustices in water quality disparities between two regions, it is imperative to research the correlation between each region's accessibility of clean drinking water and its racial and economic demographics. We compared the water quality between Chinatown, a neighborhood with a majority low-income Asian population, and Bayside, a more affluent and well-funded region in New York City. We hypothesized that Bayside's water would be safer to drink than Chinatown's since Bayside received a 62.5 million dollar grant to renew its piping system. In addition, drinking water injustices have plagued communities with high rates of racial and economic minorities, as seen in the Flint Michigan water crisis. We selected 15 restaurants from each region and measured the pH and total dissolved solids in collected water samples. We then used DataClassroom to conduct t-tests and linear regression tests to analyze our data. We found that Chinatown's water quality was not significantly different from Bayside's water quality. Our study raises several important future research questions, such as whether the year a building is built correlates to the pH level of the water, as we saw a negative correlation between these two factors in our study.

INTRODUCTION

Accessibility to safe drinking water is recognized as a human right, as water is required for survival and adequate health (1). However, many low-income regions still rely on unsafe drinking water (2). Since bottled water is more expensive, people living in low-income regions are forced to consume unsafe tap water, bringing many risks to their health (3). The Safe Drinking Water Act of 1974 allowed the Environmental Protection Agency (EPA) to pass standards for sources of tap water designed for drinking usage (4). pH is a parameter indicating how acidic or alkaline a sample is. Water with a pH of 7 is neutral, while water with more free hydrogen ions is acidic (pH < 7), and water with more free hydroxyl ions is alkaline/basic (pH > 7) (5). Total dissolved solids (TDS) are the concentration of inorganic salts and organic matter that are dissolved in a sample of water, such as zinc, iron, lead, and pollutants (6). The EPA states that safe drinking water should have a pH range of 6.5 to 8.5 and should not exceed 500 parts per million (ppm) for TDS values (7). Unlike national primary drinking water regulations, these two variables are secondary regulations, meaning they are not enforced by the EPA but only recommended (7). Without EPA enforcement, the likelihood of these standards not being met increases, and drinking water that does not meet the standards proposed can frequently lead to negative health impacts such as organ damage and lead exposure, emphasizing why these are important metrics to test for when determining the water quality of a sample (6, 8). The purpose of our research was to use water quality testing tools to determine if these two secondary regulations were being followed differently between two demographically different regions of New York City.

Ten percent of New York City's water comes from the Croton watershed, while the rest comes from the Catskill/Delaware watershed (9). Although all of New York City's water comes from these two watersheds – which are often considered extremely clean – local distribution of the water may degrade its quality depending on the piping conditions of the region (9). While Chinatown is in lower Manhattan, Bayside lies in northeast Queens. The regions are around 14 miles apart, suggesting their pipelines are likely to be different in age and condition. To deliver safe water supplies to consumers, old water pipes must be replaced or upgraded, but renewing them can cost a substantial amount (10). In 2018, Bayside received 62.5 million dollars to replace the old cast iron pipes with new ductile iron water mains (11). These funds improved water distribution greatly, allowing for increased accessibility of high-quality drinking water (11). However, there was a lack of information concerning funding for Chinatown's drinking water.

Seventy-one percent of Chinatown's population are Asian and 21% of its population are white, and the median annual household income of this region is $43,400 (12). Over the past several years, Chinatown has been experiencing dramatic gentrification, which is the process of landlords raising their rent, causing lower-income residents to be displaced by wealthier ones (13). This means that the median household income in Chinatown may have been artificially increased through the process of displacing economic minorities (13). On the other hand, Bayside's population is 44% Asian and 36% white, and the median annual household income is $94,096 (14). Bayside is not experiencing any form of gentrification which means Bayside's median household income data is not being artificially increased since wealthier people are not displacing lower-income residents (15). During the Flint, Michigan water crisis, it was mainly residents living in economically depressed areas with high percentages of racial minorities that were affected by the lead-infiltrated water (16). Chinatown's demographic profile matches those affected by the Flint, Michigan water crisis, which stressed the need to conduct our study to ensure that environmental injustices were not occurring in this region as well.

We wondered if the accessibility of clean drinking water is different in Chinatown compared to Bayside, a more affluent

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and well-funded region in New York City. Although all of New York City's tap water comes from the Catskill/Delaware and Croton watershed, a potential lack of funding to renovate old pipes along with potential demographic preferences can result in Chinatown's drinking water having a greater TDS than Bayside's and an average pH value that is not between 6.5 to 8.5. Contrastingly, since Bayside's drinking water comes from renewed and well-funded water pipes, we expected the water to have a lower TDS value compared to Chinatown's and an average pH value within the 6.5 to 8.5 range. We found out that Chinatown and Bayside had no significant difference in water quality. Overall, the water from both regions was safe to consume, showing how environmental injustices are not necessarily always present in communities with high rates of racial and economic minorities. Future studies are needed to look at other differences in water quality that may be present and also other environmental injustices that may be occurring between Bayside and Chinatown.

RESULTS

We collected water from 15 different restaurants in Chinatown and Bayside. Each water sample was analyzed for pH and TDS using a combo pH/TDS meter. During data collection, we first noticed a significant difference in building age between Chinatown's buildings and Bayside's with the buildings in Chinatown being 55 years older, on average, compared to those in Bayside (**Figure 1,** $p < 0.01$). Although Chinatown's buildings tend to be older, the mean pH and TDS values of the restaurants' water samples were only slightly higher in Chinatown than Bayside, 7.64 ± 0.28 vs. 7.45 ± 0.35, and 51.8 ± 9.65 ppm vs. 47.1 ± 4.84 ppm, for pH and TDS, respectively. After comparing the pH and TDS values between Chinatown and Bayside, we observed no significant differences (**Figure 2 and 3,** $p > 0.05$).

When exploring the potential relationship between the year built of buildings and TDS values, no relationship was found, (**Figure 4,** $p = 0.56$); however, there was a significant relationship between the year built and pH values ($p < 0.05$). There was a negative correlation between the year built and the pH, r value = -0.404. As the year built of the restaurant increases, the pH decreases, with the building age explaining 16.3% of the variation in pH (**Figure 5,** $R^2 = 0.163$).

From all the water samples, only one had a pH outside of the EPA's recommended range, a Bayside sample with a pH of 6.35. No water samples exceeded the TDS recommended value. In conclusion, we observed that Chinatown's restaurants are older than Bayside's, yet there was no significant difference in the pH and TDS values between the two regions. There was a negative correlation between the year built and the pH but no relationship between the year built and the TDS.

DISCUSSION

The average pH of New York City's drinking water is 7.3, but both Bayside's and Chinatown's pH averages were greater than the city's average (17). In contrast, the average TDS of New York City's drinking water was 101, but both regions we tested had a TDS average less than the city's average (17). Using the EPA standards, the drinking water from both regions was still considered safe overall despite these values being different from the city's average. Although Bayside received 62.5 million dollars to renew their water distribution pipes, we

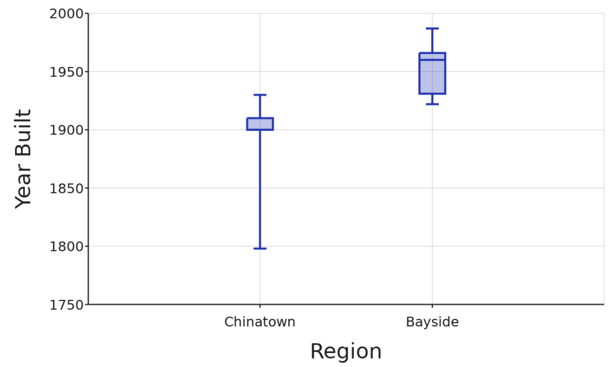

Figure 1. Differences in the year in which Chinatown and Bayside buildings were built. Google Maps was utilized to locate 15 restaurants in both Chinatown and Bayside, and PropertyShark was used to determine the date of the building's construction. The box and whiskers plot shows the median value (line), interquartile range (box), and the full range of the data (whiskers above and below). There is a significant difference in the building age between Chinatown and Bayside, $p < 0.01$.

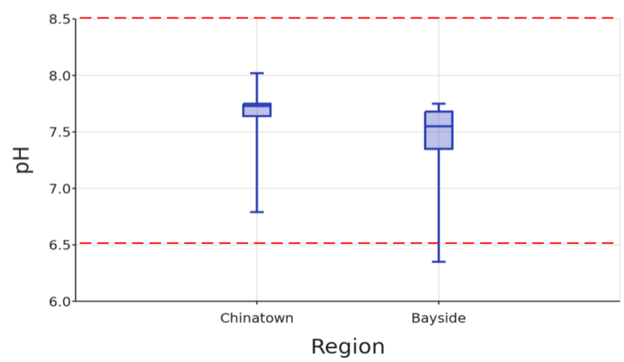

Figure 2. A comparison of the pH values between the two regions' collected tap water samples. The VIVOSUN pH meter was used to determine each water sample's pH value. The values within the two red dotted lines represent the recommended pH range set by the EPA (6.5 to 8.5). There is no significant difference in pH levels between Chinatown and Bayside, $p = 0.10$, n = 15 for each site.

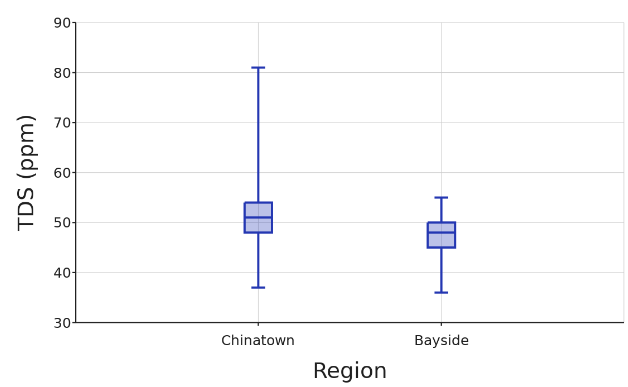

Figure 3. A comparison of the TDS values between the two regions' collected tap water samples. We used the VIVOSUN TDS meter to determine each water sample's TDS value. The EPA recommends TDS values not exceed 500 ppm. There is no significant difference in TDS levels between Chinatown and Bayside, $p = 0.11$, n = 15 for each site.

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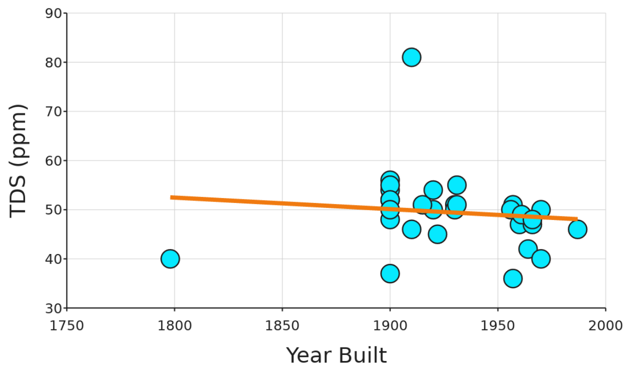

Figure 4. Relationship between the year a building was built and its TDS value. (n=30). The orange linear line of best fit shows the correlation between the year built and TDS ($y = -0.02348x + 94.72$, $R^2 = 0.0123$). No significant relationship between the two variables was found, $p = 0.56$.

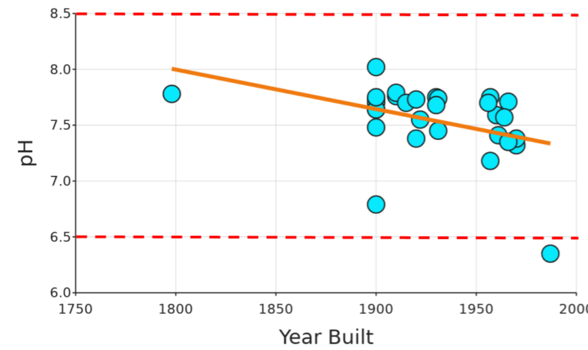

Figure 5. Relationship between the year a building was built and its pH value. (n=30). The orange linear line of best fit shows the correlation between the year built and pH ($y = -0.00354x + 14.37$, $R^2 = 0.163$). There is a significant relationship, $p = 0.03$.

observed no significant differences in the pH or TDS between Chinatown and Bayside (**Figure 2 and 3**) (11).

Only one of Bayside's water samples was unsafe to drink, with a pH of 6.35, which is below the EPA-approved drinking water pH standard of 6.5 to 8.5. As a result, the drinking water from this restaurant may have a bitter metallic taste (7). If consumers are frequently exposed to this acidic water, it can result in diarrhea, shortness of breath, and organ damage (8). Drinking water that has a TDS value above 500 ppm may have a salty or bitter metallic taste, an unpleasant odor, or be discolored (6, 7). When consumers frequently drink this kind of water, it can lead to lead exposure, laxative effects, and constipation (1, 6). However, the TDS in all 30 locations sampled was within the EPA recommended range and is thus of least concern.

Since Bayside received substantial funding for the renewal of its pipelines, it raised the question of why its drinking water quality was not significantly different than Chinatown's, and in one instance, worse. We hypothesize that Bayside's water quality could have been worse prior to when the infrastructure project began in 2018. Therefore, the pipeline upgrade only improved it to match the water quality of other regions in New York City, such as Chinatown. However, there is a lack of information regarding water quality tests in Bayside before 2018. One possible explanation for the 6.35 pH value in a water sample could be that the infrastructure project mainly upgraded pipelines in residential areas, but we tested the water quality from restaurants. Therefore, the pipelines beneath Bayside's restaurants may still be the unrenewed ones. But since State Senator Tony Avella and DDC Acting Commissioner Ana Barrio promised that the infrastructure project will greatly improve the water distribution system in Bayside and the neighborhood's water, it implies that this project will benefit the entirety of Bayside, not just selected residential streets (11). This uncertainty proposed a future case study comparing the water quality of houses in Bayside that are directly above where pipelines were replaced to houses that are not directly above the mapped areas of pipeline renovation. The importance of this research is to see whether the pipelines are beneficial to the rest of Bayside or only selected streets.

On average, Chinatown's restaurants are about 55 years older than Bayside's restaurants (**Figure 1**). This can be explained by Chinatown's development in the mid-1800s and Bayside's development later, in the mid-1900s (18, 19). Despite this disparity in building age, we observed no impact in a region having poorer water quality. However, there was a negative correlation between the year built and pH values (**Figure 5**). Since the reasoning for this is unknown, we believe a future study to determine how the year a building is built can influence the pH of its water should be conducted. This study can answer important questions such as: does the pH continuously decline past 7 and does pH and building age still show a negative correlation when a larger sample size is used?

The pH of a water sample is inversely proportional to the temperature (20). Since we collected our data samples in bottles and waited 6 hours before we tested for the pH and TDS, temperatures could have risen or declined within those 6 hours, which then altered the pH value. Therefore, a potential flaw in our study could be the inaccurate data reporting in the pH values. To fix this issue in future studies, we would measure the pH and TDS values of the water samples as soon as we collect them to prevent any potential fluctuations in pH levels.

A water quality study conducted in the Wondo Genet Campus region of Ethiopia, a developing country, showed that all sampling sites met the World Health Organization standards (1). This illustrates that developing countries are not always aligned with poor-quality drinking water (1). Additionally, our research showed that both Chinatown and Bayside had safe drinking water and no significant differences in quality despite differences in median household income and upgrades to water delivery systems. Ultimately, this suggests that racial and economic factors are not always present in the accessibility of clean drinking water.

MATERIALS AND METHODS

Google Maps was utilized to locate 15 restaurants in both Chinatown and Bayside. The website PropertyShark returned the date of each restaurant's construction. One tap water sample from the kitchen of each of the 30 restaurants was collected. Each sample's pH and TDS (ppm) were tested using the VIVOSUN pH and TDS Meter Combo. After calibrating the pH and TDS meters, the same procedure was

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used to test for each sample's pH and TDS values. First, the pH/TDS meter was rinsed with distilled water and then patted dry with a clean cloth. Next, the pH/TDS meter was stuck in the tap water sample, and when the reading was stabilized, the data was recorded. This process was repeated until the two variables for all 30 water samples were recorded.

The data collected was then compared to the EPA safe drinking water standards to determine if all water samples fell within a pH range between 6.5 to 8.5 and had a TDS value between 0 and 500 ppm (7). Finally, DataClassroom was used to create data visualizations and conduct statistical tests. T-tests were used to determine significant differences between Chinatown and Bayside for pH, TDS, and the year built of the building, and linear regression was used to explore relationships between the year built and the water quality variables.

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