

Water Contamination and Quality: A look into Two Toronto Beaches*

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Water quality based on E. Coli contamination levels of two Toronto beaches were examined and analyzed in this report from OpenDataToronto (Gelfand 2022), spanning from 2007 to 2024. The contamination levels of E. Coli are based on the number of colonies per 100 mL of sample water. Investigation reveals one particular beach, Marie Curtis Park East Beach, had higher average yearly levels of contamination through the 17 years of data collection. This highlights the need for additional public health measures to be directed towards this beach in an effort to keep citizens safe and healthy.

1 Introduction

Contamination of water continues to be a prevalent problem for human health, as contaminated water consists of fecal bacteria that can result in various diseases and death. It is estimated to cause 1.8 million deaths each year (Ishii and Sadowsky 2008). Contamination of larger water bodies, such as Lake Ontario, can result from leakage of sewage or agriculture runoff and poses a serious issue to the ecosystem and human health. As a result, drinking, ground, and recreational water is continuously monitored for levels of indicator bacteria, which are used to determine presence of pathogens in water. Two common types of indicator bacteria are E. Coli and Enterococci. While these two strains are milder strains of bacteria and often do not cause severe disease, their presence is often linked to the presence of more pathogenic bacteria that can cause severe disease in humans (Price and Wildeboer 2017). For example, some more pathogenic strains of bacteria that replicate in water bodies include Shiga toxin-producing E. Coli (STEC), which can cause bloody diarrhea and potentially fatal human diseases, such as hemolytic uremic syndrome and hemorrhagic colitis (Ishii and Sadowsky 2008).

*Code and data are available at: <https://github.com/michj3/toronto-beaches-water>

In Toronto, water contamination at beaches is monitored and data is collected daily. The provincial safety standard for *E. coli* in Ontario, Canada, is 100 colonies per 100 mL of water. If the amount of *E. coli* surpasses this threshold, Toronto Water and Safety is flagged and posted against swimming. Currently, Toronto is conducting projects, investing funds into enclosing a portion of frequently contaminated beaches and providing water that meets the provincial recreational water quality standard. Other courses of action include relocation of beaches where the water quality is consistently better and safer for citizens to swim in (“Action Required: Toronto Beaches Plan” 2009).

To examine the impact of water contamination of *E. coli* on two Toronto beaches, Sunnyside Beach and Marie Curtis Park East Beach, this paper is broken down into various sections, including Data, Results, Discussion, and Conclusion. This paper uses data made available by (Gelfand 2022) related to the contamination of the waters of the two beaches listed above. Section 2 explores the data, highlighting certain key aspects that may be alarming to public health safety. Using this data, investigation is conducted into the relationship of the average contamination level and the relative beach, average yearly trends of contamination, the distribution of *E. coli* levels by beach, and if there is a relationship between the relative date and the contamination levels. Section 3 introduces observations and potential conclusions from the data analysis. Section 4 ties the previous sections to potential action courses and insights. Finally, Section 5 summarizes the key findings of this paper.

2 Data

The dataset was obtained through the City of Toronto’s OpenData Library (Gelfand 2022) and is titled “Toronto Beaches Water Quality”. As a part of the city’s commitment to clean water, Toronto Public Health, Toronto Water, the Marine Police Unit, and Parks and Recreation Department have a joint effort to measure and monitor the city’s water of nearby beaches. Every year from June to August, which is peak beach season, the Toronto’s Forestry and Recreational division collects water samples from Toronto’s supervised beaches daily to measure *E. Coli* levels. The Forestry and Recreational division collect samples and have their own lab to measure contamination level. When levels are unsafe, flags will be posted for civilian notice. The dataset includes daily water measurements of *E. Coli* levels from 2007 to 2024.

In the City of Toronto’s OpenData Library, there was one other dataset that detailed similar content to the dataset used in this paper, called “Toronto Beaches Observations”. However, the only variable of interest was “turbidity”, a unit of measurement for water contamination. However, that dataset was not chosen since water contamination levels were not as clearly defined and would be harder to interpret. Other variables in that dataset were not of interest and therefore, that dataset was not used.

The variables used in the dataset include observation, beach number, beach name, site location, collection date, and *E. Coli* levels. The “observation” variable is to help keep track of the number of observations there are in the dataset. Since there are two beaches that are of

interest in this dataset, “Beach Number” denotes Marie Curtis Park East Beach as “beach 1”, and Sunnyside Beach as “beach 2”. This helps differentiate the beaches. The “Beach Name” variable differentiates the beaches by name, as listed above. “Site Number” is used by Toronto officials to refer to specific areas within each beach. “Collection date” refers to the specific date in which the sample was collected, which will range from the months of June to August between 2007 and 2024. Finally, “E. Coli levels (# colonies/100mL)” is a variable that refers to the level of contamination of the water sample. Table 1 details the first few observations of the cleaned dataset, in which I removed unnecessary variables.

Table 1: First few observations of cleaned data set

Observation	Beach Number	Beach Name	Site Location	Collection Date	E. Coli Levels (# colonies/100mL)
1	1	Marie Curtis Park East Beach	29W	2024-09-08	0
2	1	Marie Curtis Park East Beach	33W	2024-09-08	0
3	1	Marie Curtis Park East Beach	32W	2024-09-08	0
4	1	Marie Curtis Park East Beach	31W	2024-09-08	0
5	1	Marie Curtis Park East Beach	30W	2024-09-08	0
6	2	Sunnyside Beach	23W	2024-09-08	0
7	2	Sunnyside Beach	18W	2024-09-08	70
8	2	Sunnyside Beach	17W	2024-09-08	60
9	2	Sunnyside Beach	20W	2024-09-08	130
10	2	Sunnyside Beach	21W	2024-09-08	120

For further analysis, the cleaned dataset was separated into two different datasets by beach name, for simplicity purposes. Data was analyzed through the R programming software (R Core Team 2023) and packages such as tidyverse (Wickham et al. 2019), ggplot2 (Wickham 2016), knitr (Xie 2014), and dplyr (Wickham et al. 2023) were used to help download, clean, simulate, analyze, and test the data.

3 Results

During the data collection between 2007 and 2024, Marie Curtis Park East Beach had the highest average contamination levels when compared to Sunnyside Beach, which is detailed in Figure 1. Figure 1 illustrates that during the 17-year collection period, Marie Curtis Park

East Beach had an average of 220.5 colonies per 100 mL of sample water, whereas Sunnyside Beach had an average of 174.765 colonies per 100 mL of sample water.

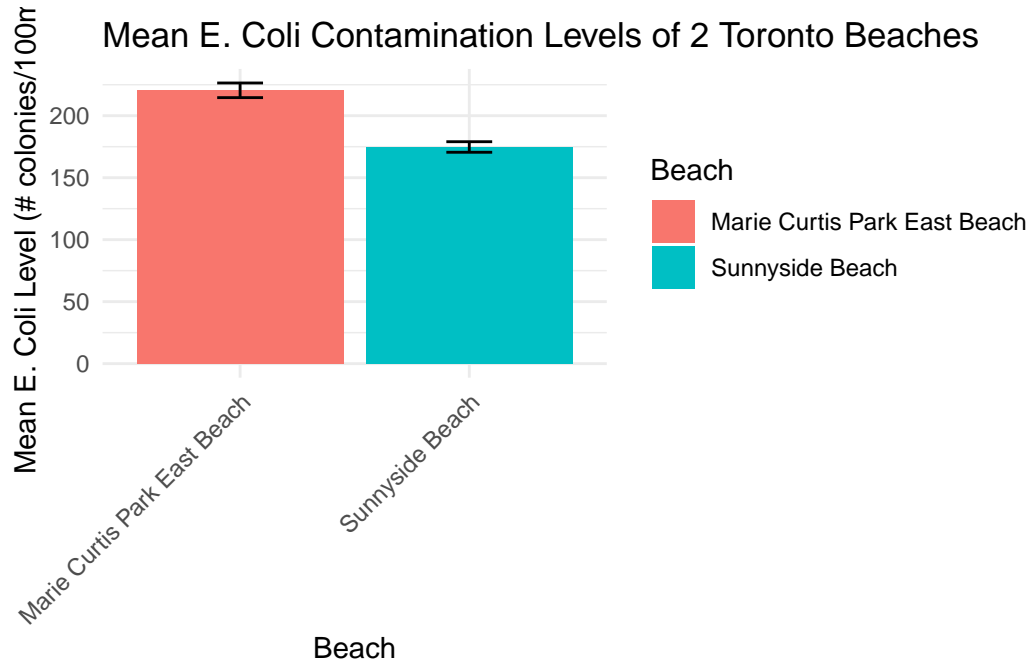


Figure 1: Average number of E. Coli colonies for each beach

Table 2 is a table showing the mean, standard deviation, and median contamination levels of E. Coli for the two beaches. From the table, the median contamination level of Marie Curtis Park East Beach is also higher than Sunnyside Beach, with a median contamination level of 3600 colonies per 100 mL of water compared to 3350 colonies per 100 mL water respectively.

Table 2: Summary table of beach contamination level data

Beach	Mean	SE
Marie Curtis Park East Beach	220.4877	5.902066
Sunnyside Beach	174.7646	4.262949

Figure 2 illustrates the yearly average contamination levels between the two beaches on a closer level, looking at the yearly average per year. The red line represents Marie Curtis Park East Beach and the blue line represents Sunnyside Beach. Looking deeper into the yearly trends, the graph illustrates that from 2007 to 2010, there is an average upward trend of contamination levels for both beaches, with a very concerning peak for Marie Curtis Park East Beach in 2010. Following 2010, there is a general decrease in E. Coli levels and the average seems to have remained steady in the upper 200s for the number of colonies per 100 mL of sample water.

It is apparent that Marie Curtis Park East Beach almost consistently has higher levels of contamination than Sunnyside Beach.

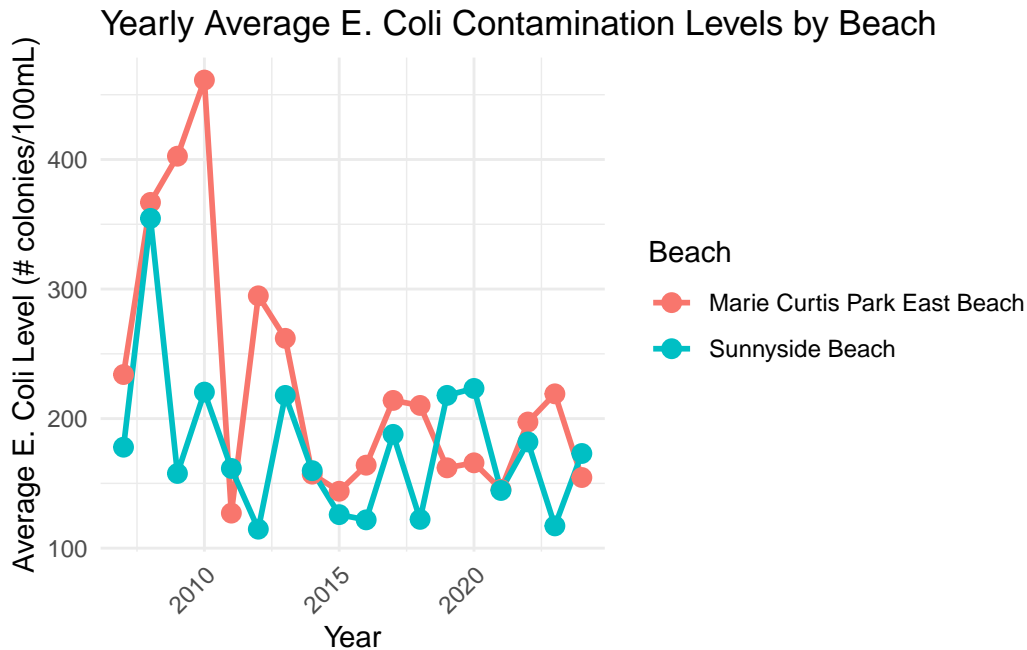


Figure 2: Yearly average amount of E. Coli contamination for 2 Toronto beaches

Figure 3 highlights the distribution of E. Coli levels for both beaches. The graph shows how often a specific level of contamination of E. Coli was recorded and is broken down into seven intervals. The main level of concern is from 0-100 colonies per 100 mL of water sample and anything above it. 100 colonies of E. Coli per 100 mL of water sample is the threshold in which Ontario deems the water unsafe for recreational use and should be flagged and closed.

Figure 4 is a depiction of a possible relationship between the E. Coli contamination levels of the two beaches and the date the sample was collected. The goal was to determine whether a specific date or month was correlated with higher contamination trends. However, from the figure, there is no apparent trend or relationship between time and contamination levels of the two Toronto beaches.

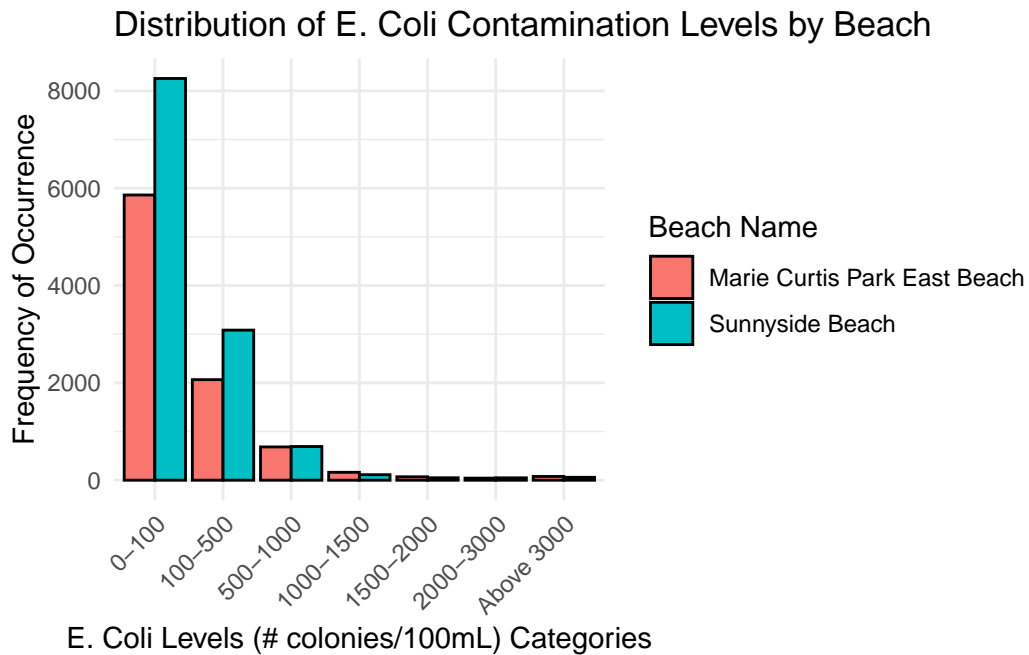


Figure 3: Distribution of contamination levels

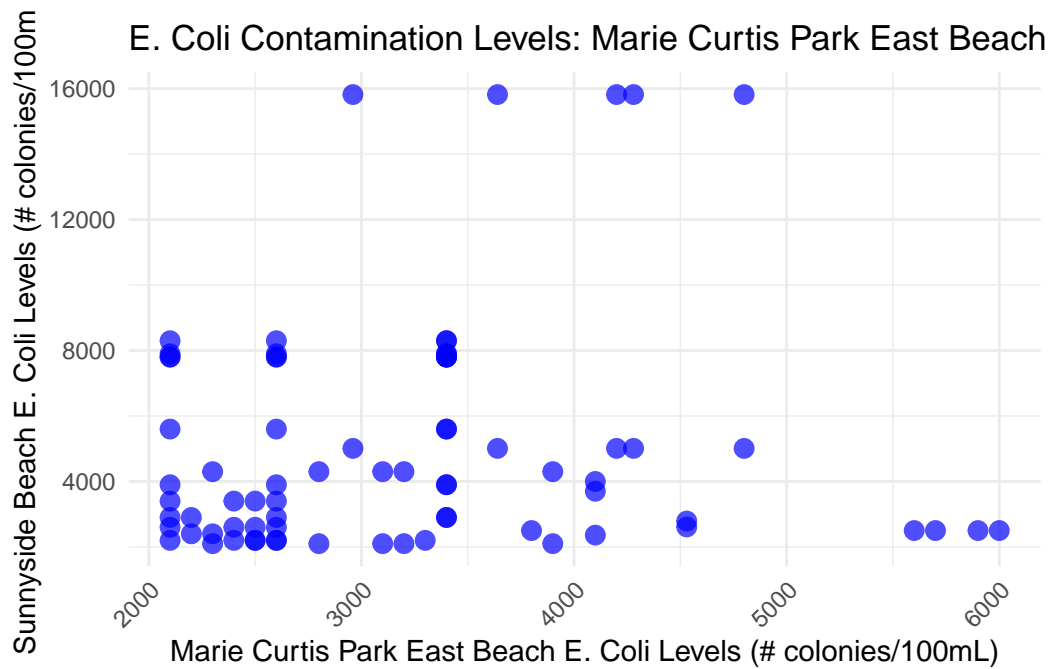


Figure 4: Possible correlation between date and contamination level

4 Discussion

Overall, the data reveals that Marie Curtis Park East Beach consistently had higher levels of contamination, measured through the number of colonies of *E. Coli* per 100mL of sample water, illustrated by Figure 1, Table 2, and Figure 2. Additionally, from Figure 3, the majority of days measured by the City of Toronto is between 0 to 100 colonies per 100 mL of water, which is under the safe threshold deemed by Ontario, so it is safe to swim in. However, in the extremely unsafe intervals, such as above 1000 colonies per 100 mL of sample water, Marie Curtis Park East Beach has more recorded instances than Sunnyside Beach, suggesting it is likely much more hazardous for recreational use. It's important to keep this in mind when participating in activities in these waters; make sure to check contamination levels beforehand, as swimming in highly contaminated waters can lead to illness and other harmful health consequences. While the current measures set in place by the City of Toronto only flag and close beaches if the contamination levels are too high, the city itself should take more action to ensure that the amount of contamination is contained, whether through clean-up projects or more government policies. It is not enough to solely close the beach and re-open when it is safer to swim in.

Moreover, both beaches are frequently contaminated with chemical spillovers from the neighboring creeks, such as Etobicoke and Humber Creek. It is not just potential pathogenic bacteria that are in these waters, but dangerous chemicals too. A potential explanation for Marie Curtis Park East Beach's consistent high contamination over Sunnyside Beach is that Etobicoke Creek is frequently the victim of pollution. Within the past two years, there have been multiple major pollution events affecting Etobicoke Creek, with major runoff into the water of Marie Curtis Park East Beach, which could explain the upward trend in Figure 6 for years after 2020 and before 2024. For example, in September 2023, Brenntag Canada, a chemical company, reported a fire in one of its industrial buildings near Etobicoke Creek and neighboring water, resulting in chemical and oil spillage (Swadden 2023). The contamination was not cleaned up in a timely manner and caused much of the ecosystem to collapse, struggling to recover. The chemical spillage potentially creates a favorable environment for additional bacteria to grow, causing *E. Coli* and other bacteria to increase in average number of colonies present.

While the dataset and paper provides better insight into the contamination levels of Toronto beaches, limitations do exist. First, the data collected is only through the months of June to August of each year. While these months are more crucial because of the beach season, a more thorough analysis can be done if year-round data were available. This could potentially give more insight into trends with respect to time; for example, if specific months had higher levels of contamination than others. Perhaps some months have higher levels of industrial production, which would correlate with higher levels of contamination. This could also provide an explanation for why the current analysis detailed in Figure 4 has no correlation. Perhaps the current data collection time frame of June to August is too narrow to see any further correlation or relationship. This would also help with future policies directed at keeping Toronto's water clean. Another limitation is that both beaches in the dataset are geographically located near

the Etobicoke Creek. While Marie Curtis Park East Beach is a lot closer to the creek, this may influence the sampling data. For a broader scope of Toronto beach water quality, it can be useful to collect data from beaches that are evenly spaced out.

5 Conclusion

The results of this investigation can help local and provincial governments, as well as the general public, understand and address gaps in overall trends of water contamination, providing important insights to location-specific sanitation. Additionally, the findings can help better inform policymakers by highlighting whether contamination levels are alarming, providing a basis to decrease health risks of its citizens.

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