Introduction

By 2020, the New York City ferry service is expected to begin servicing all five boroughs and serving 11 million residents by 2023 [1]. The New York City ferry system has been framed as the next reliable and affordable transit system in the city and as the interest in expanding urban passenger systems in the United States grows, so does the attention to air pollution concerns regarding ferries. Passenger ferries operate using marine diesel engines, which are considered to be one of the largest contributors to environmental pollution from exhaust emissions in the world. Our study aims to develop a better understanding of the current state of NO₂ emissions in New York City as a result of the ferry service and their potential impact on the residents of the city.

What is NOx?

Nitrogen Oxides, commonly referred to as NOx, are one of the leading air pollutants in major cities. The majority of them are human-made and come from coal and oil at electric power plants and gasoline in automobiles [2]. Because NOx is an irritant gas, it can lead to respiratory problems, and children with asthma and the elderly population with heart disease are advised to be especially be wary [3]. NOx is also a contributor to various secondary air pollutants, including nitric acid, ozone, and particulate matter, which causes an additional increased risk for health hazards [4].

EPA Standards

The EPA's National Ambient Air Quality Standards table (updated December 20, 2016) cites the primary standard for NOx exposure as 0.1 ppm in an hour long interval, and secondary standard as 0.053 ppm in a year long interval [5]. Primary standards are developed with the purpose of public health protection (especially for vulnerable populations), while secondary standards are designed for public welfare protection (including preventing adverse effects to animals, crops, visibility, and climate) [5].

The amount of power generated by an engine is a function of the size of the cylinder, the number of cylinders, and the engine speed. Thus, marine engines are divided into different categories and tiers based on these differences. The higher tier numbers reflect the novelty and stricter standards applied to new engines over time. The EPA Tier 3 is the US emissions standard as of 2018, and applies to all marine engines up to 600 mkW [6]. The EPA Tier 4 applies for engines above 600 mkW, and is a standard that was introduced in 2004 that required NOx emissions to be reduced further by 90% [7].



Testing Area

Testing area included background readings taken of NOx concentrations at Pier 11 (Wall Street), East 34th Street Pier, in Downtown Beacon, NY and Tompkins Square Park. Data recorded onboard ferries was taken at the center of the upper deck and was collected throughout the duration of the ride. For all data collection the AeroQual Series 500 sensor was used with NO₂ sensor head, and combined temperature and humidity sensor attachment. All data was logged in 10 second intervals.

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Results

The data collected emphasizes a strong correlation between wind speed, ferry route and concentration of NO₂ measured. The graphs below depict NO₂ concentration and temperature data recorded on two of the NYC Ferry routes: the Rockaway route and the East River route.



Rockaway Ferry - NO₂ Concentration and Temperature

Citations

[1]https://www.nycedc.com/press-release/mayor-de-blasio-expands-nyc-ferry-system-connecting-all-five-boroughs

- [2]https://chem.libretexts.org/Bookshelves/Environmental_Chemistry/Supplemental_Modules_(Environmental_Chemistry)/Acid_Rain/Sources_of_Nitrogen_Oxides [3]https://www.environment.gov.au/protection/publications/factsheet-nitrogen-dioxide-no2
- [4]https://www.greenfacts.org/en/nitrogen-dioxide-no2/level-3/01-presentation.htm#0p0
- [5]https://www.epa.gov/criteria-air-pollutants/naaqs-table
- [6]https://www.northern-lights.com/uncategorized/tier3/
- [7]https://www.dieselnet.com/standards/us/nonroad.php
- [8]https://www.dieselnet.com/standards/inter/imo.php [9]https://www.epa.nsw.gov.au/your-environment/air/non-road-diesel-marine-emissions





Conclusions

Temperature & Speed Correlation

A strong correlation between temperature, wind speed, and ferry speed was observed from real-time data taken onboard each ferry. The Rockaway ferry was faster than the East River Ferry, which can account for the significantly lower NO₂ concentrations measured onboard. A rough estimate of the ferry speed was made for the two ferry routes: the Rockaway ferry traveled at approximately 7.29 m/s, while the East 34th Street ferry travelled at approximately 2.82 m/s. The higher ferry speed generated a higher wind speed, which had an effect of dispersing the NOx emissions more quickly despite proximity to the ferry engine.

Background Readings

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Background readings were taken at the piers in wall street and east 34th street, as well as at downtown Beacon, NY and Tompkins Square Park. Although the background NOx readings were higher at the piers, they were still on average below the EPA standard of one hour exposure, which was at 0.1 ppm. Thus, it was concluded that passengers waiting for ferries at the piers were not at risk, considering that they typically stay on the piers for less than an hour while waiting for the ferries.



Background NO2 Measurments

Future Work

Future work could consist of developing a more comprehensive testing procedure that focuses on the effect of wind speed on NOx measurements. Also, it is important to consistently pay attention to the distance from the engine when collecting data in order to reduce the number of independent variables The study could be expanded onto the data collection of ozone and particulate matter.