Clearing the Air: NO_2 Pollution's Impact on Local Lichen

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Abstract

Dense urban cities cause significant vehicle emissions, contributing to atmospheric nitrogen dioxide (NO_2) pollution. I analyzed air quality reports across Metro Vancouver over 20 years, to find average NO_2 levels. Five cities showed NO_2 pollution ranging from 3 to 19 parts per billion. Lichen are rootless organisms reliant on airborne nutrients and are particularly sensitive to NO_2. I investigated the relationship between NO_2 pollution and lichen by surveying richness, abundance, and biomass in the field. By using three transects (each 10m long), I recorded trees with lichen within 1m of the transect line. I measured lichen height, width, and length and used other observations that suggested trends between the variables and average NO_2. All variables were inconsistent, and statistical analysis proved trends to be insignificant. While suggestive of the effects of pollution on local lichen, these findings warrant further investigation.

Introduction

The environment suffers from industrial and population growth in Canada. The transportation sector made up 22% of greenhouse gas emissions in 2021, a 4% increase from 2020 (Government of Canada, 2021). Vehicle emissions are linked to city smog, human respiratory illness, and limit or damage environmental sustainability (Government of British Columbia 2023). Vehicle combustion of fossil fuels releases pollutants in the air, notably NO_2 (Government of British Columbia 2023). An annual high NO_2 level in Canada is over 20 ppb (Government of British Columbia 2020). Rootless lichen absorbs nutrients from the atmosphere, risking the uptake of toxins, especially NO_2 (The U.S. National Park Service, 2023). NO_2 can be a nutrient, but as levels rise, may cause stress and mortality, affecting lichen diversity (Greaver, 2023). For this study, lichen is used as a measurable variable to assess if air pollution impacts biodiversity. Lichen provide habitat, nesting materials and nutrients to other organisms. (U.S. National Park Service 2018). I find out how atmospheric NO_2 levels influence lichen richness, abundance, and biodiversity. I predicted to find more lichen in areas with lower NO_2 levels, and less in NO_2-rich locations.

Methods/Materials

- To determine average NO_2 levels, I analyzed 24 air quality station reports from 2004-2024 and plotted the data to choose my sampling locations.
- Statistical analysis found and compared the average amounts of NO_2.
- I visited parks in 5 cities shown in Figure. 1 based on the average NO_2 level.
- At each site, I walked along three 10-meter-long transect lines and recorded trees with lichen within 1m of the line.
- I recorded the number of lichens, and species by using iNaturalist, two are pictured in Figure 5. To assess biomass, I measured each lichen's height (cm), width (cm), and length (cm).
- The collected data went through Correlation ANOVA analysis to determine significant trends between average NO_2 and lichen richness, abundance and biomass.

Lichen Species	Total Abundance	Distance (km) From Boundary Bay
Fluffy Dust Lichen *(Lepraria finkii)*	36	22.6, 33.1, 37.3, 38.1, 70.7
Common Powderhorn Lichen *(Cladonia coniocraea)*	1	70.7
Pea-green Sheild Lichen *(Parmelia fraudans)*	27	22.6, 33.1, 37.3, 38.1, 70.7
Rim Lichen *(Lecanora conizaeoides)*	1	70.7
Common Greenshield Lichen *(Flavoparmelia caperata)*	1	70.0
White Rim Lichen *(Lecanora rupicola)*	3	37.3, 38.1
White Dust Lichen *(Lepraria albicans)*	1	37.3
Candleflame Lichen *(Candelaria concolor)*	2	37.3
Usnea Lichen *(Usnea)*	2	37.3
Mapledust Lichen *(Lecanora thysanophora)*	2	22.6, 33.1
Oakmoss Lichen *(Evernia prunastri)*	1	37.3
Trumpet Lichen *(Cladonia fimbriata)*	1	22.6

Table 1. Common name and nomenclature for observed lichen species, their total richness, and what sites they were found at.

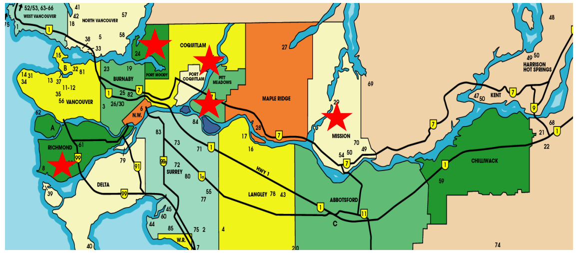

Figure 1. Map of Lower Mainland depicting surveyed cities visited. Mission, Pitt Meadows, Coquitlam, Port Moody, and Richmond are all highlighted with red stars. (Parks of Greater Vancouver).

Results

- Of the 24 stations, I selected Mission (3 ppb), Pitt Meadows (7 ppb), Coquitlam (14 ppb), Port Moody (15 ppb), and Richmond (19 ppb). In Canada, a high annual amount of NO_2 is > 20 ppb (Gov. of B.C. 2020), so the cities represent relatively low to high NO2 levels.
- A dozen lichen species were counted, measured, and identified, as seen in Table 1 and Figure 5.
- There is no clear trend in richness by average NO_2 as seen in Figure 2. The highest richness value was observed at Coquitlam with an average NO_2 level of 14 ppb, suggesting a possible association between NO_2 concentration and lichen richness. However, it was not significant, $p = 0.65$.
- Abundance by NO_2 concentrations showed inconsistent trends shown in Figure 3, with no apparent pattern based on NO_2 concentrations and was also insignificant, $p = 0.426$
- Biomass by NO_2 concentrations has one exceptionally high value at Port Moody, with an average NO_2 level of 15 ppb displayed in Figure 3. This influences the overall trend, making it difficult to discern a clear pattern. The trend is not significant, $p=0.602$.

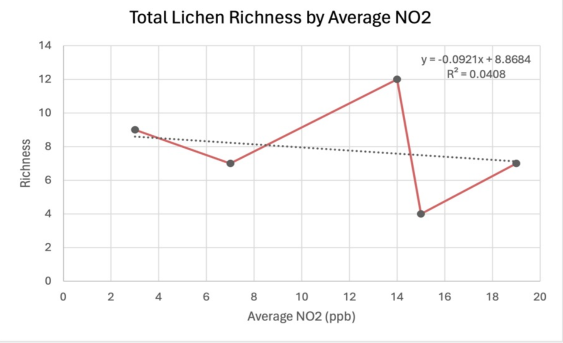

Figure 2. The average NO_2 levels and lichen richness surveyed across different 5 locations with the standard error calculation. The trendline was inconsistent.

Discussion

The purpose of this study was to find out how air pollution affects lichen by using local communities of the lower mainland and to assess how NO_2 pollution affects lichen richness, abundance, and biomass. The data proposes possible connections between variables and the average NO_2. Through the statistical analysis, however, all the variables were shown to be insignificant. Some factors that may have influenced the outcome of my data are that a high reading of NO_2 in Canada is < 17 ppb which only Richmond (22.6 Km) exceeds, while the rest fall < 17 ppb. Richmond could be affected by Delta nearby as the air pressure gradient near water bodies can pull pollutants away from land. (Zhu, 2019). This may have caused lower numbers than expected. Alongside vehicle combustion, other sources of NO_2 emissions come from heat-generating household appliances and the burning of coal or wood (Jarvis 2010). The factor of wood combustion releasing NO_2 into the atmosphere is very relevant in British Columbia. Wildfires have become a common occurrence every summer as temperatures rise, which release a high volume of NO_2 at once, I imagine in an area heavily impacted by smoke, the lichen may be more affected as well. Conducting a larger-scale field survey may be able to provide more data to support the possible connection between air pollution and lichen. My study was unable to support my hypothesis, even so, lichen is important for many organisms in an ecosystem, and they can be altered by NO_2 pollution which may lead to disturbances in other systems in the environment.

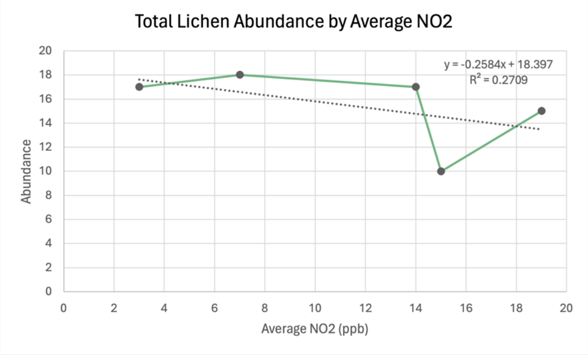

Figure 3. The relationship between abundance and average NO2 levels in the 5 surveyed locations, along with standard error. Notice the inconsistent trendline.

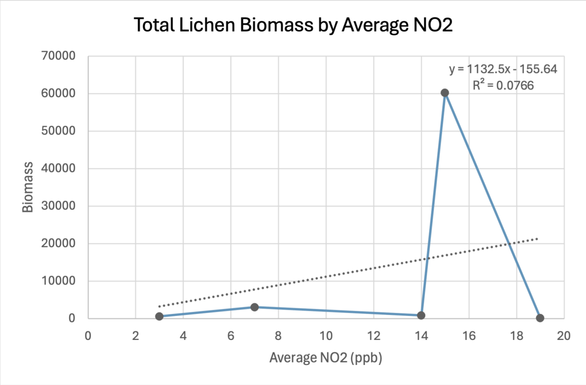

Figure 4. The graphed data shows the total calculated biomass across all 5 surveyed sites with the standard error. The trendline has one high value that throws off all the data

Figure 5. Two surveyed lichen species. On the left, Pea-green Shield and Powderhorn Lichen. On the right, White Rim lichen surrounded by more Pea-green shield lichen

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