The Perils of NYC Pollution: Invertebrates in Decline

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SCIENCE SANDBOX

Abstract

Biodiversity is the variation of species within a given area and is determined by measuring species richness and species evenness. Factors that can affect biodiversity are air and water pollution, chemical and waste contamination, climate change, and infectious diseases. Air pollution has been shown to decrease biodiversity of invertebrates. Invertebrates are essential to sustain all ecosystems: they play the role of being a significant food source for other species, decomposers which provide nutrients for soil, and transporters of food for plants. Our project aims to measure the effect of air pollution, specifically black carbon pollution, on invertebrate biodiversity in parks in Brooklyn, NY (Sunset Park, John Paul Jones Park, and Dyker Beach Park) by identifying invertebrates captured in pitfall traps through DNA sequencing. Due to local high pollution in NYC, we expect a correlation between pollution and invertebrate biodiversity, and we hope that our experiments will encourage conservation efforts.

Introduction

- Invertebrates provide essential nutrients to consumers[1], help with pollination[2], act as decomposers[3], and promote plant growth[4].
- Some specific widespread threats to the biodiversity of invertebrates are habitat loss, invasive species, and other types of pollution. New York City, in particular, largely suffers from particle pollution due to transport exhaust from heavy vehicle traffic and residual oil burning from industrial businesses.[5]
- Particle pollution has greatly affected the biodiversity of invertebrates in recent years, especially invertebrates with regimented social systems, such as ants, who are susceptible to toxic pollutants, such as pesticides and airborne particles because they take these pollutants into their bodies while foraging and spread it to their colonies.[6]
- One method of assessing invertebrate biodiversity is by collecting samples through the pitfall trap, which can be left for days underground to collect ants and other insects.
- Our goal of this experiment was to determine the effects of air pollution on the biodiversity of invertebrates in New York City.
- Our group expects to find that areas with higher air pollution have lower biodiversity of invertebrates as 40% of all insect species are in decline with a third of them being endangered, and this is potentially linked to pollution.[6] Thus, it is likely that in areas with higher levels of pollutants, there will be fewer species of invertebrates in a given area.
- This project will bring awareness to the potential effects of pollution on biodiversity in New York City while contributing to the existing knowledge base surrounding the effects of pollution on all animals. The results of this experiment will encourage others to take initiatives to protect our city and all of the organisms living in it.

Materials & Methods

Nine pitfall traps (Figures 2 and 3) were set up, three at each of three different levels of pollution (low, medium, high), in the locations indicated below on the map (Figure 1), in order to capture invertebrates native to New York City. The New York City Community Air Survey map of black carbon pollution from 2019 was used to determine the three sampling sites.[7] Maps from 2020 did not accurately represent the true extent of the air pollution in these areas due to the COVID-19 pandemic and quarantine. These sites are Sunset Park (high pollution), John Paul Jones Park (medium pollution), and Dyker Beach Park (low pollution) because of their differing levels of black carbon pollution.[8] For the first collection, pitfall traps were set on Sunday, March 5, 2023 and the invertebrate samples were collected the following day on Monday, March 6, 2023. For the second collection, pitfall traps were set on Sunday, March 19, 2023 and samples were collected on Tuesday, March 21, 2023.

Pitfalls traps were dug into the ground under a bush with a piece of plastic raised above it as a covering to prevent debris from entering the trap. Pitfall traps were made up of cups, containing a 50/50 ethylene glycol and ethanol mixture with denatonium benzoate as a preservative. Samples were collected from three different areas of each pollution level, with each area having three traps, to minimize error. There were two sample collections in total. After the invertebrate species were captured, they were kept in a freezer at -20°C until they were used. DNA was extracted from the collected samples using the Chelex Isolation protocol. Next, DNA was amplified by PCR using the UBRP ant invertebrate primers (LCO1490, HC02198, FormCOId_F, and FormCOId_R) (Folmer), and PCR products were confirmed via gel electrophoresis (Figure 4). Finally, the species collected were identified using DNA Subway and BLAST by finding the reference genome of the species most similar to the sequence of the collected samples.[9]
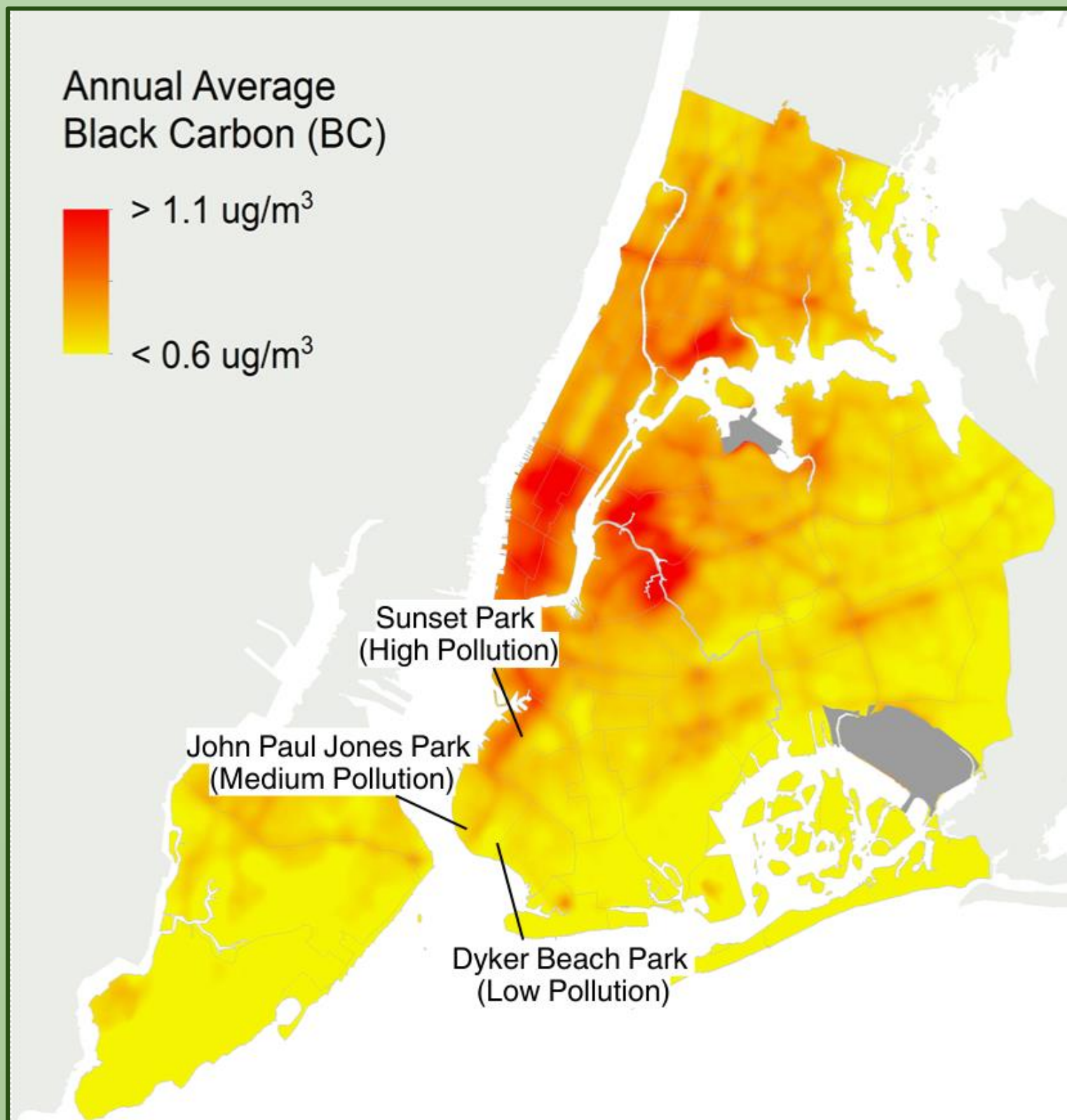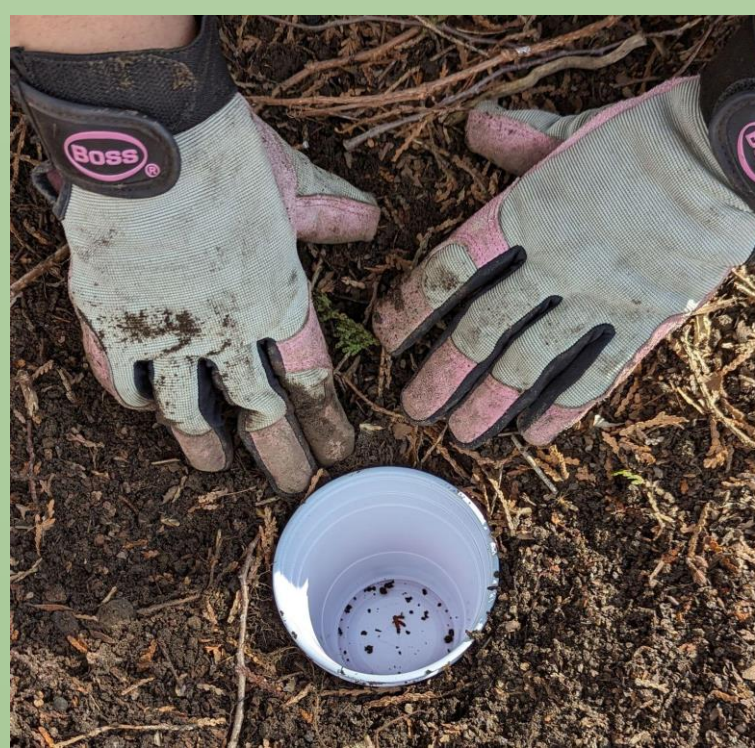

Figure 1. Locations of pitfall traps in different pollution areas. Image is adapted from New York City Community Air Survey (2019).

Annual Average Black Carbon (BC)

> 1.1 ug/m³

< 0.6 ug/m³

Sunset Park (High Pollution)

John Paul Jones Park (Medium Pollution)

Dyker Beach Park (Low Pollution)

Figures 2 and 3. Pitfall Traps

Park	Number of Different Invertebrates		
	First Collection (3/6)	Second Collection (3/21)	Total
Sunset Park	2 (midges, sheet weaver spiders)	1 (ground beetles)	3
John Paul Jones Park	2 (honey ants, midges)	1 (midges)	3
Dyker Beach Park	1 (dung flies)	2 (midges, small flies)	3

Table 1. The number of different invertebrates captured at each of the three parks.
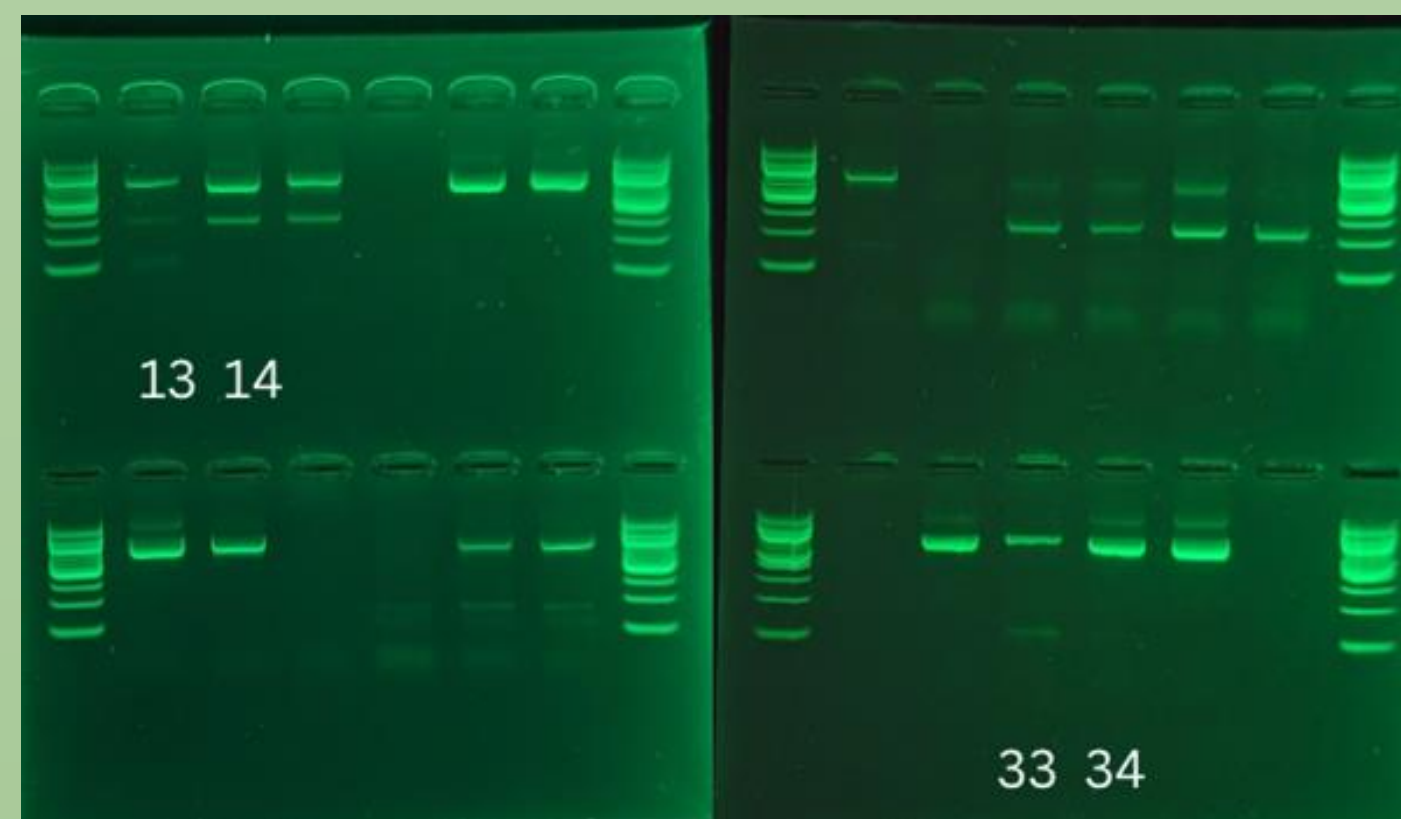

13 14

33 34

Figure 4. Gel electrophoresis results from the first round of collection (3/6/22). Samples 13 and 14 were collected from John Paul Jones Park and samples 33 and 34 were collected from Sunset Park.

Results

Although we set three different traps at each of the three parks, only the samples collected from John Paul Jones Park had invertebrates in each of the three traps when they were collected on Monday, March 6, 2023. At Sunset Park, only two of the traps held invertebrates, and at Dyker Beach Park, only one did. We sequenced 13 samples in total (5 from Sunset Park (high pollution), 6 from John Paul Jones Park (medium pollution), and 2 from Dyker Beach Park (low pollution). We found midges and sheet weaver spiders in Sunset Park, honey ants and midges in John Paul Jones Park, and dung flies in Dyker Beach Park (Table 1).

Collection of the traps on Tuesday, March 21, 2023 revealed three traps with invertebrates at John Paul Jones Park, two at Sunset Park, and one at Dyker Beach Park. However, the sequencing results from the second round were of lower quality than the first round. Sequences were submitted for 9 samples (2 from Sunset Park, 5 from John Paul Jones Park, and 2 from Dyker Beach Park), but because of low sequence quality, we were only able to analyze three of them. For two of the samples, one from Sunset Park and one from Dyker Beach Park, we were only able to sequence the forward strand. We found ground beetles in Sunset Park, midges in John Paul Jones Park, and midges and small flies in Dyker Beach Park (Table 1).

Discussion

Though our experiment succeeded in capturing a variety of invertebrate species across our different locations, we were not able to capture enough invertebrates to accurately produce a consensus regarding the effects of pollution on invertebrate populations in New York City. This study likely did not work as we originally hypothesized because of the time limitations on this experiment. However, our invertebrate results were in line with the results that we expected, except for the dung fly, which might have resulted from close proximity to fecal matter in a dog park. For future studies, we suggest that invertebrate collection occurs over a longer period of time with more frequent intervals of collection and DNA sequencing in between. We also produced low quality sequencing data from our second round of DNA sequencing, which could have resulted from contamination or low amounts of DNA, as we chose to sequence each invertebrate separately instead of grouped by location for our second DNA sequencing. Though our study did not work as expected, it still poses a relevant and important question as pollution continues to be an issue in NYC. We hope that our study will bring attention to this problem and future studies will be able to build upon our initial findings.

References

[1]Fahmer, O. (2021, July 7). *Invertebrate food web at NCOS*. CCBER. Retrieved from https://www.ccber.ucsb.edu/news-events/invertebrate-food-web-ncos

[2]New, T. R., & Yen, A. L. (1995, July). *Ecological importance and invertebrate conservation - cambridge.org*. cambridge.org. Retrieved from https://www.cambridge.org/core/services/aop-cambridge-core/content/view/S0030605300021116

[3]Griffiths, H. M., Ashton, L. A., Parr, C. L., & Eggleton, P. (2021). The impact of invertebrate decomposers on plants and soil. *The New phytologist*, 231(6), 2142–2149. https://doi.org/10.1111/nph.17553

[4]Hibbert, T. (2020, June 15). *Why should we care about insects?* Devon Wildlife Trust. Retrieved from https://www.devonwildlifetrust.org/blog/tom-hibbert/why-should-we-care-about-insects

[5]New York City Department of Health. *New York City Community Air Survey*. New York City Department of Health. (2011). Retrieved 2022, from https://www1.nyc.gov/assets/doh/downloads/pdf/eode/air-survey-spring11.pdf

[6]Feldhaar, H., & Otti, O. (2020, March 1). *Pollutants and their interaction with diseases of Social Hymenoptera*. MDPI. Retrieved from https://www.mdpi.com/2075-4450/11/3/153

[7]*Health Department releases report on improvements in Citywide Air Quality*. Report on Air Quality - NYC Health. (n.d.). https://www.nyc.gov/site/doh/about/press/pr2019/health-department-releases-report-on-air-quality.page

[8]NYC Environmental Health (n.d.).*The New York City Community Air Survey: Neighborhood Air Quality 2008-2020*. Retrieved from https://nyccas.cityofnewyork.us/nyccas2022/report/3

[9]*DNA subway*. CyVerse. (n.d.). https://cyverse.org/dna-subway

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