Appendix

Section 1:

Definitions

Environmental justice. Environmental justice refers to the fact that low-income communities, many of which are Indigenous people or people of color, are disproportionately overburdened with environmental contamination and hazards.

Environmental justice community. For the purposes of this study, we developed a systematic, quantitative categorization to classify census tracts as either environmental justice communities or non-environmental justice communities using race/ethnicity and poverty indicators.

Objective of Study

This analysis investigated the atmospheric dispersion of an air pollutant (particulate matter less than 2.5 micrometers, $PM_{2.5}$) directly emitted by natural gas and coal-fired power plants in selected states in the Northeast United States between 2011 to 2015.

Methodology

Step 1. Socio-demographic data on poverty status and race/ethnicity by census tract were obtained for 2010 from the U.S. Census Bureau. Two indicators commonly used to identify environmental justice communities were calculated: First, "Percent non-white" was defined as the percentage of the total population in a census tract that is African American, American Indian, Alaska Native, Asian, Pacific Islander, or other non-white race, or of Hispanic origin of any race, a variable we refer to as "percent not White". Second, "Percent in poverty" was defined as the percent of individuals with a ratio of income to poverty level below one, that is, individuals with incomes below the federal poverty threshold. We used percent not White and percent in poverty and in a *k*-means cluster analysis to classify census tracts into one of two categories: environmental justice communities, or non-environmental justice communities.

Step 2. We used information from a yearly survey that the U.S. Energy Information Administration administers to electric power producers. The survey provides information on all power plants that are currently in operation or have been retired since 2001, including data on the generator's prime mover, latitude and longitude of the unit's location, first and last years of operation, and information on installed environmental controls.

Step 3. We first calculated the straight-line distance (in miles) of the nearest power plant to the geographical center of each census tract. We then selected the 285 census tracts with at least one power plant located within each tract. We then estimated the potential for each power plant to pollute by calculating the capacity of the facility to generate power for all fuel types and then provided an estimate of $PM_{2.5}$ concentrations. Emissions data on mean annual daily 24-hour $PM_{2.5}$ concentrations were combined with the location data of natural gas– and coal-fired power plants and community categories in order to carry out the analysis.

Section 2: Methods for Proximity Analysis of Environmental Justice Communities near Facilities Contaminated with Polyfluoroalkyl and Perfluoroalkyl Substances (PFAS)

Definitions

GIS (geographic information systems). Geographic analysis software and data management systems such as ArcGIS, ArcGIS Pro, or QGIS were used. GIS can also refer to geographic information science, the study of geographic information and the means through which it can be obtained, managed, analyzed, and presented to increase understanding of geographic phenomena.

Census block group. The smallest geographic unit at which the US Census Bureau provides data. A block group is made up of a collection of census blocks—defined by roads, streams, and other physical phenomena—from within a census tract whose identification numbers start with the same number. For example, a block group could be made up of all blocks within a census tract whose ID number starts with "300" (US Census).

Buffer. Within the context of GIS, a zone around a geographic feature defined by an often-predefined distance. For example, a buffer around a point location such as a PFAS-contaminated facility would be shown as a circular region with a predefined radius (e.g., one, three, or five miles) whose center intersects with the facility location.

Objective of Study

To determine whether the households of people of color and low-income households are more often found living around PFAS-contaminated facilities than white and higher-income households.

Methodology

To estimate the number of people living within PFAS-contaminated facilities, a buffer analysis was carried out in the geographic analysis software ArcGIS Pro. Facility locations were provided by Northeastern University Social Science Environmental Health Research Institute, which included data on the type, amount, source, and date of PFAS contamination. Northeastern University obtained this information by compiling information from government websites, news articles, and other publicly available documents, including a presentation on PFAS contamination by the Department of Defense. Latitude and longitude values were obtained using Google Maps.

Step 1: The first step of this analysis was to determine how many people lived in three buffer zones, which, for the purposes of this analysis, was defined as the number of people living within a one-mile, three-mile, and five-mile radius near an area of PFAS contamination. To do this, we first imported a point location (latitude, longitude) for PFAS-contaminated areas using the dataset provided by Northeastern University. Buffer zones were then created by drawing circles around each point location with a one-, three-, or five-mile radius using the buffer analysis tool in ArcGIS Pro. We then imported census block group data. Many census block groups (which were polygons) fell partially outside of the buffer zones; therefore, to more accurately estimate the number of individuals living within each buffer zone, we calculated the percentage of land area of each census block group located within each buffer zone, using the tabulate intersection tool. The determined percentage of land area for each census block group was then multiplied by the total number of individuals within that census block group. This provided the total number of individuals living within a specific census block group that fell within a buffer zone. The estimated number of individuals within all census block groups falling within a buffer zone, either fully or partially, was then summed to estimate the total number of individuals living within that buffer

zone. This process was repeated for all buffer zones (one, three, and five miles) surrounding a point location (see Figure A-1). We assumed an even distribution of the population throughout the census block group.

Step 2: We calculated the number of low-income households and households of people of color within each buffer zone of a PFAS-contaminated facility. First, we determined the number of people of color within each block group. This number was calculated by taking the total population of each block group and subtracting the number of individuals who identified as "white alone" in the US Census American Community Survey (ACS 2017). The number of non-white individuals in each block group was then multiplied by the percentage of land area within the buffer region to calculate the number of nonwhite individuals living within the buffer region. To calculate the number of low-income households within each buffer zone, similar methods were used. Low-income households were defined by the number of households with income below the poverty line within the last 12 months (ACS 2017). The number of low-income households within each census block group was multiplied by the percentage of land within the buffer zone to calculate the number of low-income households within the buffer zone.

Step 3. To determine whether there were more or fewer people of color and low-income households living near PFAS-contaminated areas than expected based on US Census data, we compared the observed number of low-income households and people of color living in each buffer zone to expected values. To calculate the expected number of individuals in each block group, the percentage of low-income households and people of color was calculated for the United States overall. This percentage was then multiplied by the total estimated number of individuals within a buffer zone for a point location, generating an expected number of people of color and low-income individuals. For example, 5.22 percent of US households are recorded as being low-income; therefore, we expect 5.22 percent of households within the buffer zones to be low-income.

These methods were carried out for the United States as well as the state of Michigan. Michigan is the only state that has conducted systematic testing of water sources and may lend insight into the true state of PFAS-contamination in the United States.

Table A-1. Number and Percentages of People in Michigan Living Within Three or Five Miles of a PFAS-contaminated Site

The number and percentage of low-income households, total households, people of color, white individuals, and the total number of individuals living within three-five miles of a PFAS contaminated site in Michigan.

Sources: US Government Census, SSERHI 2019

Michigan						
	Michigan		**3 Miles**		**5 Miles**	
	Number	Percentage	Number	Percentage	Number	Percentage
Low-Income Households	564,192	14.51%	58,792	23.49%	110,411	48.72%
Total Household	3,887,938		250,304		511,608	
People of Color	2,111,638	21.28%	209,096	33.11%	414,572	31.50%
white	7,811,079	78.72%	422,500	66.89%	901,50	68.50%
Total Population	9,922,717	-	631,596	-	1,316,132	-

Table A-2. Estimates of the Number and Percentages of People in the United States Living Within Three or Five Miles of a PFAS-contaminated Site

The number and percentage of low-income households, total households, people of color, white individuals, and the total number of individuals living within three-five miles of a PFAS contaminated site in the United States.

Sources: US Government Census, SSERHI 2019

United States						
	US		3 Mile		5 Mile	
	Number	Percentage	Number	Percentage	Number	Percentage
Low-Income Households	16,943,520	14.11%	140,904	17.76%	298,535	16.23%
Total Households	120,048,514	-	793,166	-	1,839,131	-
People of Color	87,713,703	27.03%	714420	34.59%	1,611,289	33.08%
White	236,759,596	72.97%	1350981	65.41%	3,259,479	66.92%
Total Population	324,473,299	-	2,065,400	-	4,870,768	-

Figure A-1

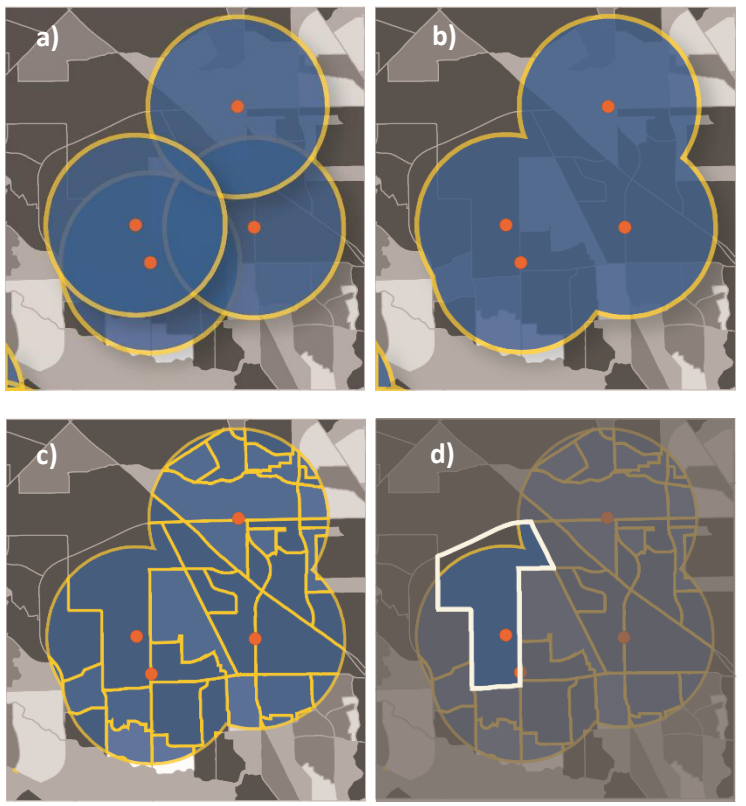

Figure 1a *shows hypothetical PFAS-contaminated facilities with buffer zones drawn.*

Figure 1b *shows the same PFAS-contaminated sites dissolved together in order to eliminate double counting of census block groups that fall within multiple buffer zones.*

Figure 1c *highlights the boundaries of all census block groups within the dissolved buffer zones.*

Figure 1d *shows the outline of a single block group highlighted for purposes of example in white. The blue region within this block group is the region within the buffer zone. In this case, the buffer zone could be said to cover about 90 percent of the census block group. For purposes of population estimate, we would take the total population of the block group and multiply it by this percentage. For example, if 100 people live in the census block group, we would estimate that about 90 people from that block group live within the buffer zone.*

References

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