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Superfund Sites in North Carolina: Analyzing Income Disparities in Designation and Remediation

Finnigan Ellis Digman
Environmental Governance: Ecology and Legal Studies
The University of North Carolina Asheville
One University Heights
Asheville, North Carolina 28804 USA

Faculty Advisor: Dr. Dee Eggers

Abstract

A Superfund site is defined under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as "any land in the United States that has been contaminated by hazardous waste and identified by the US Environmental Protection Agency (EPA) as a candidate for cleanup because it poses a risk to human health and/or the environment." Previous studies suggest Superfund sites are more likely to be located in lower income areas, and sites in wealthier areas are likely to be identified and mitigated at a more rapid pace. This study analyzes both income equity in distribution and time to ROD of Superfund sites in North Carolina by comparing three variables to median household income. First, median household income is compared among 22 North Carolina counties containing 37 NPL-listed sites and 78 counties that do not contain such sites. In order to account for confounding factors present on the County scale (i.e. large cities), median household income is then compared between census tracts containing Superfund sites and census tracts without such sites for each of the 22 counties individually. Finally, among the 37 Superfund sites, the time span between official listing on the NPL and publication of the ROD is compared to median household income in the surrounding census tracts.

1. Introduction

The History of the Superfund program begins with Love Canal, a working-class neighborhood in New York, just south of Niagara Falls. From 1942 to 1953, Hooker Chemical Company disposed of approximately 21,800 tons of hazardous chemical waste, including twelve known carcinogens, into an incomplete canal once destined to connect the upper and lower Niagara Rivers. [1, 2] In 1953, after filling the canal with hazardous waste and covering it with soil, Hooker sold the land to the Niagara Falls Board of Education for one dollar. A State Health Emergency was declared in 1978 when chemical residues began visibly seeping into homes in close proximity to the site. The area was evacuated, and the State of New York sued the Hooker Chemical Company claiming reckless or wanton disregard for the health and safety of others. [3, 1] Hooker asserted a "warning" included in the property deed was sufficient to absolve the company of any future liability. [3] While litigations were underway, Congress enacted the Comprehensive Environmental Response and Liability Act (CERCLA). CERCLA established a strict, joint and several liability system for releases of hazardous substances and created a "Superfund" to finance the remediation of such releases. Under CERCLA, the United States Environmental Protection Agency (US EPA) is given power to address uncontrolled and/or abandoned hazardous waste sites by identifying potentially responsible parties (PRPs) and developing comprehensive management plans to reduce the risk associated with hazardous releases into communities and the environment

The new regulations imposed by the CERCLA and the Toxic Substances Release Act (TSRA) placed more burden and more cost on private polluters. To avoid the cost of compliance, some companies began illegally disposing waste. One such company, the Ward Transformer Company, began dumping polychlorinated biphenyl (PCB) onto highways in northern North Carolina night. PCB is a potent carcinogen, which causes cancer of the skin, liver and digestive tract. [4] During the 2 week duration of the crime known as "the midnight dumpings", a black tanker truck drove down rural Piedmont highways in northern North Carolina and disposed of the hazardous waste. Hooker Chemical Company was eventually discovered, and the EPA began site assessment to determine the extent of the contamination. Testing revealed contamination of topsoil putting nearby communities and roadway travelers at risk. As a result, the EPA listed 243 miles in 14 counties as the "Roadside PCB Spill" Superfund site in 1983. [5] The EPA did not publish an ROD for the site, but the site was considered sufficiently clean to be eliminated from the NPL in 1986. [5] For many sites, the timespan between NPL listing and ROD publication may exceed 3 years; deletion may take decades. Previous studies suggest the cleanup pace may be influenced by socioeconomic status in neighboring communities. [6, 7] This research analyzes the cleanup pace by measuring the timespan between NPL listing and ROD publication as well as analyzing median household incomes between counties and census tracts with sites and those without to determine if environmental inequity is occurring in North Carolina.

Once the Roadside PCB Sill Superfund site was cleaned, the hazardous topsoil needed to be safely stored somewhere. Warren County was only one of multiple sites under consideration for waste, and despite reports that the water table was too high to safely support a landfill, the site was ultimately chosen to house the PCB-laden soil. [8] Residents of Warren County protested and sued the state in what is considered a pivotal moment for the field of environmental justice. [9,10] The EPA was accused of issuing waivers that illegally exempted the State of North Carolina from safety protocols designed to protect citizens against environmental damage, failing to perform an Environmental Impact Statement (EIS) required by the newly enacted CERCLA, and of arbitrarily choosing the landfill site. [10] Some argued the site was chosen because the residents were "few, black, and poor." [11] Warren County residents were not successful in stopping the creation of the landfill, but they were successful in garnering national attention and spurring a nationwide environmental justice movement. [12]

Such publicized grassroots efforts gave rise to copious studies examining the equity of Superfund site designation. [13] Many of the results support the hypothesis that racial and socioeconomic inequality exist in connection to the spatial distribution of hazardous sites. [8, 14, 15, 16, 17, 9]

Contradictory studies exist finding no correlation between racial and socioeconomic inequality and spatial distribution of hazardous sites. [18, 19] There is also no consensus as to whether income, race, or homeownership is the primary factor associated with environmental injustice. [14, 17, 20] Maranville et al (2009) suggest these inconsistencies may arise from the variation in methodologies used to the measure the proximity of hazardous sites to the surrounding population; they may also arise from the limited geographic scale on which most such studies have been undertaken. [21] The methodology used to assess the existence of environmental injustice in this study is the unit-hazard coincidence method. [22] This method is most commonly used in environmental justice analyses; it involves the selection of a predetermined geographic area as the unit of analysis. In this case, the units used were County and census tract. This approach assumes the population within the predetermined area is equally affected by the existence of a site regardless of the location of the site within the area (see discussion).

Another method used by social justice researchers is the distance-based method. [17, 22] This method also uses predetermined geographic units, but, unlike the unit-hazard coincidence method, also involves defining radii from the central hazardous site. The size of the radii can be adjusted according to population density, and to analyze areas in varying proximity to the site. [17] There are three variations to the distance-based approach: 1) 50% areal containment, 2) centroid containment, 3) areal apportionment. Both the unit-hazard coincidence method and the distance-based method attempt to parse communities into exposed and non-exposed areas based on some formulation of proximity to the hazardous site.

The process of listing a Superfund site is multifaceted. First, the EPA must be made aware of a potential release of hazardous material. A site must then meet the eligibility criteria for listing on the NPL under Title 40 of the Code of Federal Regulations § 300.425. If contaminated land scores 28.5 or above on the Hazard Ranking System, it is placed on the NPL by the EPA. After official listing on the NPL, a site undergoes a remedial investigation to evaluate the nature and extent of the risk posed to human and environmental health. During this phase, potentially responsible parties (PRPs) are identified and their ability/willingness to pay for cleanup efforts is factored into cost considerations. The length of the investigatory period hinges on the type of hazardous release, the cooperation of the PRPs, and a plethora of environmental, social, and political factors. [7] Once the investigatory period is complete, the EPA issues a Record of Decision (ROD) to define what type of remedial action, if any, will be taken. The proposed ROD delineates the EPA's chosen remedy and is made available for public comment. After the public comment period, the final ROD is published. In certain cases (i.e. the Ram Leather Care site in Mecklenburg County, North Carolina), an interim ROD is released so cleanup can begin while a better determination of the extent and nature of contamination is made. [23] For many sites, more than one ROD is published for various contaminated media (i.e. groundwater, soil, air). Due to the nature of the investigatory period and publication of the ROD, analyses of the duration between NPL and ROD listing (also called "cleanup pace") are difficult to accomplish.

2. Methodology

This study employed the unit-hazard coincidence method. [24] Several influential environmental justice studies have used this method, utilizing either zip codes or census tracts as units of analysis. [18, 25, 26, 45, 27] Other studies have used counties as units of analysis. [6] In some cases, different units of analysis lead to inconsistent results. For example, Taquino et al. (2002) determined the use of counties, zip code areas, census tracts, and block groups yielded differing significance in correlation between sociodemographic factors and proximity to hog farms in Mississippi. [28]

This study used two units of analysis; twenty counties containing Superfund sites were compared to 80 counties without Superfund sites. These 20 counties represent 33 NPL listed sites. There are 5 sites in North Carolina that were removed from the analysis; 2 sites were military bases. Military bases do not issue census information in the same way the general populace does; they also recognize and clean Superfund sites on their premises using different methods than civilian sites. Another 3 sites were removed from the study because they did not have a publicly accessible ROD to use in the duration analysis. To maintain continuity through the study, these three sites were also removed from the spatial location analyses. The second unit of analysis was census tracts; 31 census tracts represent the 33 NPL listed sites. These 31 census tracts with sites were compared to 2,794 census tracts without sites. Median household income for counties and census tracts was acquired from the United States Census Bureau's American Community FactFinder database.

Data for temporal variation in NPL listing to ROD publication was acquired from the Superfund Enterprise Management System (SEMS) database using the search query "All Final NPL Sites." Only currently listed Superfund sites appear in this study; 11 other NPL-caliber sites exist in North Carolina, but they are addressed under the EPA's Superfund Alternative Approach Program and were not included in this analysis.

Using Minitab 18, a two-sample T-test was employed to analyze the mean and the median household income between counties with and without sites and to analyze the median household income between census tracts with and without sites in North Carolina. A regression analysis was used to compare the median household income to the days between NPL and ROD listing among counties with sites.

3. Results

Statistically, the median household income was significantly higher in counties with sites versus counties without sites, p-value=0.042). Additionally, mean household income was significantly higher in counties with Superfund sites than those without (p-value=0.031).

The median household income was statistically significantly different between census tracts with and without sites (p-value = 0.000). Superfund sites are statistically significantly more likely to be located in block groups with lower income. The largest measured difference was $20,920.50 in Cabarrus County where the median household income in census tracts with sites was $36,344.00 and $57,264.50 in census tracts without sites.

The regression analysis comparing the limited variable: county-level household median income, to the continuous variable: days between NPL listing and first ROD publication, was not statistically significant. (p-value= 0.083, r^2 = 9.41%). One site, the NC State (lot 86, Farm Unit #1 site) was an outlier (3,765 days between listing, upper bound = 3092.5). Without this outlier, the p-value shrinks, though it is still not significant (p-value= 0.072). The NC State site, therefore exerts disproportional leverage on the regression statistic.

4. Discussion

Environmental justice is typically considered a social movement, but it also operates as a research frame. [9] Environmental justice research aims to uncover trends in policy decisions that affect societal equity. Most policy analysis focuses on analyzing the economic efficiency of public programs rather than their equity. [6] Evaluating equity (in place of efficiency) is objectionable to some scholars for a number of reasons. First, many scholars maintain established working definitions for terms such as "environmental justice," "environmental equity," and "environmental racism" are necessary to inform unbiased research, although some scholars claim such definitions are unnecessarily limiting. [29] Hird (1993) states there are implicit value judgements present when evaluating equity. A lack of working definition, the potential for an inherent moral bias, and a lack of sufficient or accessible data create issues for scholars looking to analyze equity of any kind. Additionally, scholars have not reached an agreement on the primary way to analyze the equity of policy decisions; a mixture of procedure and outcome analyses using an array of variables complicate the literature. [30, 6]

The finding of statistical significance when comparing counties and census tracts with sites to counties and census tracts without sites supports a hypothesis of environmental inequity concerning Superfund site designation. The finding that wealthier counties are more likely to contain Superfund sites is mirrored by similar findings in national analyses. [6] Census tracts with lower median household incomes were more likely to contain sites, suggesting potential inequity in distribution of the population around Superfund sites. The spatial distribution of Superfund sites appears approximately equal throughout the state, apart from some clustering in counties like Gaston County and Buncombe County (Figure 1). So, geographic location does not seem a likely factor in the differences found between units with and without sites.

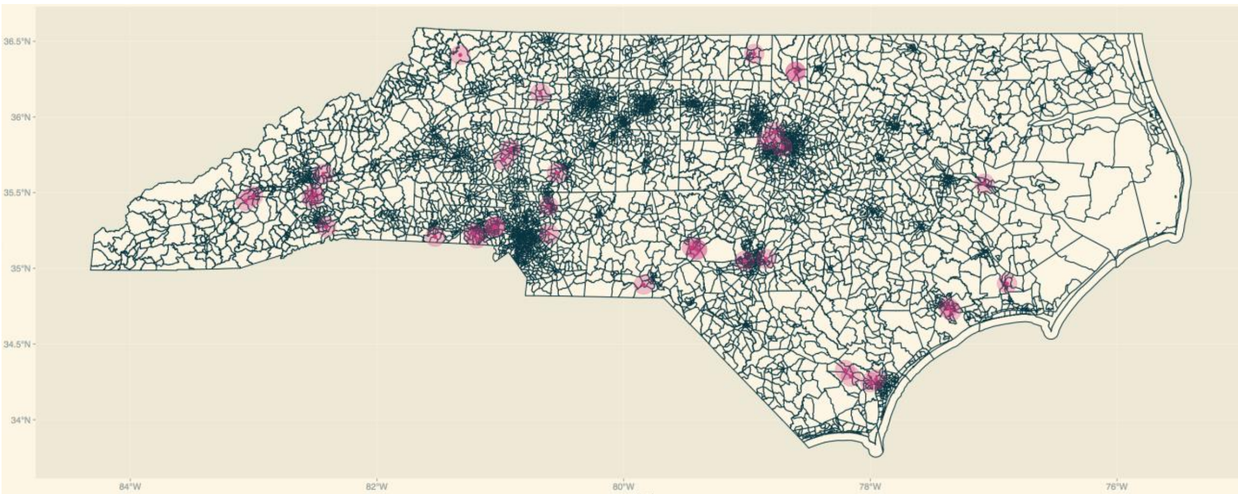

Figure 1. A map of census tracts in North Carolina. Darker areas appear where census tracts are small due to larger population size. Pink dots represent Superfund sites.

The results support the hypothesis that lower socioeconomic communities are more likely to be in proximity to hazardous waste sites, while also finding wealthier counties support these communities. Hird (1993) suggests wealthier counties may support Superfund sites because they have the political power to get the sites evaluated and listed by the EPA. Significantly lower household income in census tracts containing sites suggests poorer communities are either receiving the advantage of cleanup or are disproportionately placed in proximity to hazardous exposure even within wealthier counties.

The research process yielded many opportunities for future research. To explore these opportunities, the discussion will first address the shortcomings of the research methods used in this study. The choice to use the unit-hazard coincidence method is common because predetermined geographic data is readily available. [24, 31] Though it is convenient, the unit-hazard coincidence method is problematic for three reasons. [32]

First, the analytical unit does not account for variations in the quantity of sites within a unit. In both Granville and Moore Counties, a single census tract contained two sites: Cristex Drum and JFD Electronics/ Channel Master in Granville County; Aberdeen Contaminated Groundwater and Aberdeen Pesticide Dump in Moore County. Granville has two sites in total while Moore County has one additional site, Geigy Chemical Corp. in a different census tract than the other two. In the case of Moore County, it seems likely the two sites in a singular census tract are related. The hazardous release at Aberdeen Pesticide Dump may have been partially responsible for the contamination of Aberdeen Groundwater. However, each site is a distinct analytical unit in terms of the proximity of and effect on the surrounding community. The Aberdeen Pesticide Dump is a 37 acre property constituting 5 discreet sub-sites of hazardous contamination. One of these sub-sites is a four acre area where a pesticide formulation plant operated from 1930 to 1987. [33] The other four sub-sites are locations where hazardous waste from the plant was known to be dumped. The disposal at Aberdeen Pesticide Dump is known to have contaminated groundwater in the area. [34] However, according to the EPA’s website, contamination at the Aberdeen Contaminated Groundwater site was potentially caused by Powder Metal Product. The 1.3 acre site is distinct from the groundwater contamination caused by pesticide waste dumping, though the sites are only 3.3 miles apart. The unit-hazard coincidence method does not account for units that contain one hazardous site or several, nor can it analyze potential connections between these sites.

Second, the unit-hazard coincidence method unreasonably assumes hazardous waste will adhere to artificial geographic boundaries. A site could lie in the center of an analytical unit or so close to the border that it affects two geographic units equally. This consideration is particularly important when addressing areas with high population density. In this study, The Ram Leather Care Superfund Site is located in Mecklenburg County. Mecklenburg County contains the township of Charlotte; the city has a mean population density of 2,649 people per square mile. [35] Wake County also contains a city with an urban population; its population density is increasing rapidly, but is currently measured at 1,284 people per square mile. [36] Compare these two urban counties to Person County; the largest township is Roxboro with a mean population density of 321 people per square mile. [35] The unit-hazard coincidence method does not adequately address confounding factors, such as the existence of areas with higher population densities. One possible adjustment to the unit-hazard coincidence method would be to measure block groups within a census tract to account for variations in sociodemographic data over a smaller spatial distribution.

Finally, the unit-hazard coincidence method does not account for the path of exposure. Characteristics of chemicals on Superfund sites vary greatly. Some, like Trichloroethylene (TCE), are heavy compounds not known to migrate. However, TCE can be vaporized under the right circumstances, and such an occurrence greatly changes nearby populations' exposure. For example, at the CTS of Asheville, Inc. Superfund Site, TCE expected to remain on the bedrock volatilized into the air; three families had to be evacuated after their indoor air levels tested 8 times above the allowable limit. [37, 38, 39] In its liquid state, TCE would more likely contaminate water and sediment than air. Depending on the type of chemical, the method of disposal, and a host of environmental factors (e.g., water table, sediment type, proximity to surface water, wind speed, topography), a community's exposure will vary greatly.

To address the issues inherent to the unit-hazard coincidence method; some studies have turned to the distance-based method. There are three variations to this approach. The 50% areal apportionment method uses the hazardous site as a central point then expands a specified distance in a circular pattern from the center. [24] Each predefined geographic unit (i.e. census tract) which is ≥50% captured by the radii will be included as a unit of analysis. A similar approach is the centroid containment method, where only geographic units with centers captured by the radii are included as affected areas. The areal apportionment method is employed by Maranville et al. (2009) as the most advantageous approach. The study involves 1, 2, and 5 mile radii from the central site and shows varying significance among these distances. Indeed, the areal apportionment method reduces the spatial discontinuity present in the previous variations by only treating areas actually within the radii as exposed areas.

This study focused on household income in proximity to hazardous sites as the measurement of environmental equity. Previous research also analyzes race as another salient component of environmental justice, either in combination with, or independent of, household income. [40, 17, 45, 16] Without an exploration of minority populations in proximity to hazardous sites, a comprehensive understanding of the potential inequity apparent near such sites is virtually impossible. Some researchers included homeownership and education as potential indicators of equity within an area as well. [45, 6]

Future research analyzing socioeconomic disparity in North Carolina can be expanded in many ways to account for the shortcomings of the unit-hazard coincidence approach, as well as to encompass more sociodemographic factors than household income alone. The distance-based approach could be focused using chemical plume data to more accurately track proximity to exposure. Using the Geographic Information System (GIS), the projected dispersal pattern (also called "plume") of a hazardous release can be mapped and the communities in proximity to the plume can be analyzed as affected units. The plume-based apportionment method would involve gathering information from more sources than Census databases; it would utilize a variety of environmental factors that would make it more labor-intensive than other distance-based methods. However, it would greatly reduce the risk of neglecting units of analysis actually exposed to the hazard. The Emergency Response and Planning Application Performs Plume Modeling developed by Brian Tomaszewski of the URS Corporation in Buffalo, New York integrates the EPA's Aerial Locations of Hazardous Atmospheres (ALOHA) program with MapObjects and ArcView to provide a model of a chemical plume and the area it is most likely to affect. [41] Chemical plume-based analyses would allow for the consideration of exposure based on hydrological, topographical, geological, and chemical data in comparison to salient socioeconomic factors (Figure 2).

Figure 2. Example of a chemical plume map tracking the contamination of an area from a point-source release of hazardous waste

Such socioeconomic factors include not only median household income as was analyzed in this study, but also race, nationality, homeownership, education, and health. [42]

County and census tract level analyses are affected by confounding factors such as population density, the presence of military facilities, and zoning. The areal apportionment method is adjustable such that high population density areas can be viewed on a narrower scale. The areal apportionment method is more effective for analyzing urban and rural areas for this reason. However, the plume-based apportionment method could all but eliminate these confounding factors by following the precise or estimated path of a hazardous release regardless of other input.

Thirty three sites in North Carolina were examined in total. Five NPL listed sites were excluded from the study because they are located within military installations or do not have accessible published RODs. Future research could also be expanded to include a more comprehensive analyses of the universe of hazardous sites. These sites include NPL-caliber sites addressed under the Superfund Alternative Approach, proposed and deleted NPL sites, RCRA sites, brownfields, sites on military installations, and other hazardous waste sites. Brownfields (sites of hazardous concern not requiring remedial action under CERCLA) are particularly interesting when examining exposure rates because, after they are declared sufficiently safe from the preexisting hazard, they are frequently put to public or private use. [43] An analysis of these uses could prove illuminating for the field of environmental justice.

Lack of a significant finding for the timing of the ROD fails to support the hypothesis that higher household income correlates with faster time to ROD. The addition of certain variables in future studies may yield different results. Political pressure, either from lobbyists or the public, could be factored in to adjust for their potentially confounding effect. Political pressure by lobbyists could be measured using dollars donated for assessment, litigation, or cleanup funds. It is possible such funds could be tracked using the “follow the money” approach applied by Inclusive Development International (IDI). A measure of pressure from the public would be multifaceted; a study could account for this effect by measuring the number of articles devoted to the designation and remediation of a site, the attendants at public meetings addressing the site’s designation and remediation, and the public comments submitted during the public comment period before the publication of the final ROD.

Additionally, analyzing the time from ROD listing to deletion from the NPL could yield further information on the equitable distribution of funds for Superfund cleanup. It should be noted, the cleanup of a Superfund site resulting in the deletion from the NPL does not mean a site is “clean.” Remediation, monitoring, and restoration efforts may remain in effect after a site is deleted from the NPL, but frequently such sites are zoned for limited use. [44]

County	mean no sites	mean w\ sites	Median no sites	Median w\ sites	# sites
Beaufort	41,773.97	27,302.00	39,862.50	27,302.00	1
Brunswick	54,393.52	40,276.50	53,556.00	40,276.50	2
Buncombe	50,236.90	38,567.00	47,563.00	42,220.00	3
Cabarrus	60,210.96	36,344.00	57,264.50	36,344.00	1
Cleveland	41,049.55	37,788.00	39,479.00	37,788.00	1
Cumberland	44,821.34	58,020.50	43,289.50	58,020.50	2
Gaston	47,587.44	40,077.00	44,186.00	40,278.00	4
Granville	54,701.86	36,486.00	51,074.00	36,486.00	2*
Haywood	45,743.53	42,518.00	48,200.00	42,518.00	2
Henderson	50,253.32	31,397.00	51,875.00	31,397.00	1
Iredell	58,979.40	46,056.50	51,667.00	46,056.50	2
Mecklenburg	69,962.42	71,354.00	62,285.00	71,354.00	1
Moore	55,434.02	45,997.33	51,250.00	43,021.00	3**
New Hanover	57,129.00	36,149.00	54,293.00	36,149.00	1
Onslow	47,973.30	32,230.50	48,250.00	32,230.50	2
Person	44,065.08	61,250.00	48,984.00	61,250.00	1
Richmond	34,772.95	38,367.00	34,211.00	38,367.00	1
Rowan	48,169.40	44,730.00	46,185.00	44,730.00	1
Wake	80,066.62	84,046.50	74,236.00	84,046.50	3
Yadkin	39,929.27	42,340.00	41,062.00	42,340.00	1

Table 1. Median and mean household income for counties with sites and those without.
* Both sites are located in the same census tract, the tract was double weighted in the statistical analysis
** Two of three sites are located in the same census tract, the tract was double weighted in the statistical analysis.

5. Conclusion

This study suggests poor census tracts within wealthier counties in North Carolina are disproportionately proximate to Superfund sites. Inequity surrounding Superfund sites is an area of particular concern because of the health risks hazardous waste poses to humans and the environment. As was the case in Warren County, the remediation of one area may become the contamination of another area; environmental justice hinges of the belief that no one group should be the target of excessive exposure. Further studies pertaining to disparities present in Superfund site designation and remediation will ensure a better understanding to the field of environmental justice. Understanding is the first step towards an actionable outcome of environmental equity.

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