3-24-2021

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Abstract
The purpose of this engaged public sociology study was to use social science to bring resident stakeholders into the process of governing pollution production in a rural community. The community has cancer clusters. Residents have concerns about direct exposure to pollution production in their neighborhood by a steel recycling plant that has been cited numerous times for environmental violations. The facility has been under voluntary remediation since 2009, but neighborhood residents were marginalized from the governance process. This case study details how social science was used to bring neighborhood residents' concerns about direct exposure to toxic air pollution into remediation governance. A curricula-as-research model was developed to provide an engagement framework that guided the case study as it progressed through a series of six stages over five years. The Principle Investigator maintained this collaboration by integrating the project into courses, securing small grants, developing an affordable air pollution monitoring method, and convening multiple community meetings. The air monitoring results are analyzed and discussed. Finally, the impact of the case study on the company, the state environmental management agency, local government, the non-profit partner, and residents' sense of human agency is evaluated.

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Keywords
Engaged research, public sociology, public health, environmental regulation, stakeholder governance, governance

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[1]**Recommended Citation:** Steiner, Sherrie M., Jordan M. Marshall, Atefeh Mohammadpour, and Aaron W. Thompson, "Applying Social Science to Bring Resident Stakeholders into Pollution Governance: A Rural Environmental Justice Public Health Case Study" (2021). *Journal of Applied Social Science* 1-26https://journals.sagepub.com/doi/10.1177/19367244211001751. First published online: March 24, 2021.

Non-governmental interventions directed at building neighborhood-based social capital to facilitate recovery from community disasters has stimulated an interest in community disaster resilience assessment and tools in recent years, but less attention has been given to the assessment of neighborhood stakeholder's perspectives outside the disaster management sector (Cutter 2016; Kwok, et al. 2019). Residential exposure to toxic pollution production is not a natural disaster, but the uncertainty associated with elevated cancer risk factors shapes residents' experiences in analogous ways that stimulate active investment to activate social capital to plan for future events and procure necessary resources for response and recovery. Unlike disaster risk reduction research, the political ecology tradition of geography has well documented how toxic exposure disproportionately affects those who are marginalized in everyday life and who lack access to resources and means of protection which are available to those with more social power (e.g., Pulido 2015). Age, poverty, and minority status place some groups at disproportionately high risk for exposure to environmental toins in ways that the general population does not experience (Gochfeld and Burger 2011; Landrigan et al. 2017). The very populations most in need of the resources required to identify and address their toxic exposure are least equipped to do so (Abel and White 2011). These areas are referred to as Environmnental Justice Communities because they are disproportionately impacted with increased risks of adverse health consequences associated with exposure to multiple environmental and social stressors (Linder, Marko, anad Sexton 2008). However, there is yet another similarity between national risk reduction research (Gaillard and Mercer 2013) and toxic remediation governance research: Studies disproportionately rely on command-and-control and top-down frameworks. Local people and communities are largely overlooked as stakeholders in the governance process (Chiapella et al. 2019). Residents often do not even become aware of the environmental risks until enough harm has accrued to elicit a social response (Silbergeld, Mandrioli, and Cranor 2015). There is a need for research to identify how people work with non-governmental organizations to involve those affected by toxic exposure with what Long and Long (1992) have referred to as the 'battlefield of knowledge and action' to improve outcomes for those most vulnerable. One way of measuring neighborhood resilience is to evaluate the

effectiveness of resilience interventions, and track progress made toward desired resilience goals (Cutter et al. 2013).

Systemic interventions are transdisciplinary and they make pluralistic use of diverse methodologies in ways that challenge the coherence of theoretical frameworks (Midgley and Ochoa-Arias 2001). At the heart of systemic intervention is the problem of subject-object dualism that identifies boundaries to distinguish what is included or excluded from the analysis (Midgley 2000). Critical reflection upon the close connection between boundaries and values overcomes the problem of subject-object dualism underpining intervention strategy frameworks to explore multiple understandings of the system in question (Rajagopalan and Midgley 2015). For example, Justice Clapp and colleagues (2016) conducted interviews of people involved in community responses to environmental toxicity from asbestos in Ambler, Pennsylvania; they found that the perspectives of laypeople and experts were so divergent that they could no longer be presumed to be varying perspectives of a singular toxic reality because "lived experience constructs multiple toxic realities" (Clapp et al. 2016:149). When taken-for-granted boundaries are critically reflected upon in the community, the negative effects of maintaining those boundaries can be more productively challenged and revised.

Studies of power and the empowerment of marginalized stakeholders have promoted community participation in research as a non-dualistic intervention strategy that puts community empowerment at the center of the theoretical model (Stack and McDonald 2018). Most models, however, focus on empowering marginalized individuals with rare consideration given to how collaborations influence the perspectives of those in power (McDonald and Keys 2008). For example, Jewell and Owens (2017) used experiential learning techniques in partnership with community agencies and the American Civil Liberties Union to train citizens at-risk of experiencing policy brutality to know and advocate for their rights under the law. This participatory research approach empowers citizens, but it also continues to reify the subject-object dualism associated with the existing boundaries between police and citizens of color. The model thus fails to address the negative effects of maintaining those boundaries.

Another model for empowering marginalized citizens using participatory research and experiential learning might give consideration to influencing the

perspectives of those in power to become aware of the negative effects of maintaining existing boundaries. A measure of impact would be the degree to which the collabortion succeeds in eliciting a behavioral response from those in power to take action to address the negative effects of the existing boundaries.

We report here on how social science was used to bring residents who are on the frontline of preparedness and response as stakeholders into the process of governing pollution production in their neighborhood. Critical to this case study was the development of a body of research on residential exposure to toxic air pollution that became compelling evidence that residents used to influence government officials. The case study is an example of engaged environmental sociology (Cordner, Richter, and Brown 2019).

A similar community-driven pilot study was conducted in two industrial-adjacent neighborhoods in Seattle, Washington. They referenced our first collection of moss study when we used citizen science (Steiner 2020), and took it to the next step to determine whether or not the method using students produced high-quality and replicable samples. Local urban youths (8^{th} grade-12^{th} grade) participated as civic scientists in an educational program about environmental health, environmental justice, and urban forestry that was a place-based, urban-oriented environmental research project (derrien et al. 2020). Youth collected moss samples to explore the spatial distribution of air pollutants in two industrial-adjacent neighborhoods where vulnerable populations reside. Researchers from the Department of Environmental and Occupational Health Sciences and the Pacific Northwest Research Station of the United States Department of Agriculture Forest Service worked with a core collaborative group – the Green-Duwamish Learning Landscape – consisting of community leaders and local government officials to evaluate the quality of youth-collected data through analysis of replicate samples. They determined that youth scientists collected usable samples that had acceptable precisions among repeated samples, they learned project content in ways that were statistically meaningful, and they appraised their engagement in the project favorably (Derrien et al. 2020).

Our research team is a collaboration of environmental sociology, natural, engineering, landscape architectural, and biomedical scientists along with their students. We have been working in collaboration with the community since 2014 to identify the extent and health effects of toxic exposure by tracking new cases of heavy

metal exposure; dialoguing with community groups and local and state governments about research, remediation and regulatory action, and educating the broader public to build awareness and strengthen cooperation between residents, scientists, and regulators. A curricula-as-research model was developed to provide an engagement framework that guided the case study as it progressed through a series of six stages over five years. The principle investigator (PI) integrated the project into a series of 11 undergraduate courses, and our research team successfully funded 11 projects using small grants totaling $36,066 to sustain the collaboration. Our grant-writing capacity allowed our non-governmental partners to sponsor 10 public gatherings that were used to identify priorities in the demarcated community. This enabled us to direct our research questions to address the concerns that came directly from the impacted communities.

In this paper, we demonstrate how social science was applied to create compelling evidence for residents to present to regulators as an intervention-oriented action strategy for improving public health. Sociologists have been encouraged to get publicly engaged to strengthen civil society since Burawoy's (2005) Presidential Address at the American Sociological Association's 2004 annual meeting. This case study is consistent with the model of public sociology that Cordner et al. (2019) have described as appropriate for the current moment.

We begin by describing how our public sociology model combines community-based participatory research (CBPR) with environmental sociology in accordance with the approach taken by Cordner et al. (2019). Reciprocal collaborations evolve over time. Sustainable collaborations survive the test of time. For this reason, we discuss how the case study, using the curricula-as-research model, progressed through a series of six stages over a period of six years. The collaboration culminated in the social scientific discovery of four airborne heavy metals and a series of documented explosions. We have integrated the traditional division of research articles (Materials, Methods, Results and Discussions) into the developmental stages so that readers of this case study can understand how teaching, research and engagement ebbed and flowed throughout the collaboration. At times, teaching was dominant. At other times, research was dominant. At key moments, engagement was dominant. It merits mentioning that our research team was involved in the community for several years before enough trust and understanding existed to make effective research possible. The

social science component to our research team became very important at this strategic moment in the case study. Trends in the adjudication of toxic torts have been changing in ways that are effectively decreasing citizen access to the law for those injured by toxic substances (Cranor 2016). We knew that our community biomonitoring evidence would most likely be judged inadmissible in court for using an innovative method; and the Environmental Protection Agency (EPA) would disregard the pollution measurements as legally actionable because regional moss data have not yet been calibrated to EPA standards. We convened a neighborhood meeting where about 50 residents from the immediate neighborhood used the evidence to advocate on their behalf to, and elicit a response from, the Commissioner of the Indiana Department of Environmental Management (IDEM). IDEM is currently using their expensive technical equipment to gather data that would be legally actionable and admissible in court if offsite airborne pollution were found. We conclude by evaluating the impact of the case study on the company, the state environmental management agency, local government, the non-profit partner, and residents' own sense of human agency.

COMMUNITY-ENGAGED ENVIRONMENTAL SOCIOLOGY

We incorporated six principles of CBPR that are identified by O'Fallon and Dearry (2002) into our research program: (1) promotion of active collaboration and participation at every stage of research, (2) fostering of co-learning, (3) ensuring that projects are community-driven, (4) dissemination of results in useful terms, (5) ensuring that research and intervention strategies are culturally appropriate, and (6) definition of the community as a unit of identity.

Promotion of Active Collaboration and Participation at Every Stage

Since 2014, our university research team has partnered with a local citizen's group, Blackford County Concerned Citizens (BCCC), to collaboratively design and implement each stage of the research project. All of the projects were collaboratively reviewed with community members every four to six months before implementation. The Director of Environmental Health and Water Policy for Hoosier Environmental Council (HEC), the state-wide environmental non-governmental organization, reviewed any public health information prior to its presentation to the community. Legal matters were often reviewed by HEC's Senior Staff Attorney. At one point,

residents tended to nine moss stations for a year, and made regular journal entries, some made daily, over twelve-months.

Fostering Co-learning

One way of measuring the degree of co-learning extant in collaboration is to identify who initiated various projects. Out of the 11 projects, creation of pollution maps, videos, newsletters, and mini-gardens were initiated by the non-profit partner; focusing on residents' concerns, using moss as a bio-indicator of pollution, and using the moss-transplant method were initiated by the authors of this paper; using social media, implementing a photovoice project, and redesigning the Facebook and non-profit webpage was initiated by students, but it was neighborhood residents - and only neighborhood residents - who repeatedly brought attention to air pollution in the neighborhood. For example, on October 22, 2016, our research team facilitated a community conversation between Hartford Iron and Metal's (HI&M) engineering consultant and local residents to talk about remediation. The engineering consultant revealed plans to install a permanent storm water treatment system to prevent runoff into the city sewer. Residents raised concerns about fugitive dust and other immediate neighborhood impacts, but their complaints were summarily dismissed. The engineer said that fugitive dust was not where most of the contamination resides. When the group pressed him further by asking "On what basis did you make that decision?", he finally conceded that the insurance company had not asked him to address fugitive dust, but he promised to look into it. Our research team convened two community meetings in October and November of 2017 to discuss the first moss air pollution findings with about 50 residents, and then to present the findings to city officials at a meeting attended by 150 people from Hartford City. In preparation for the November meeting, a resident placed a series of white baby onesies on her porch and then bagged them at regular intervals to indicate the level of dust exposure they have in the neighborhood near HI&M. Over a week period in November, neighborhood residents submitted 59 signatories with handwritten comments asking the government to take the fugitive dust and air pollution seriously. The onesies were laid on the table in front of the Mayor and City Counselors at a public meeting to emphasize that children in the neighborhood have a cumulative dust exposure. During the meeting, students read all of the comments to city officials. Residents specifically asked city officials to relocate

HI&M to the industrial park because of the fugitive dust and air pollution evidence. An additional 20 comments addressing neighborhood conditions were solicited from residents during a two-hour information meeting convened at the local Junior High School on April 21, 2018. These comments were delivered by BCCC to the Mayor shortly thereafter.

Another indicator of co-learning, reciprocity, was demonstrated by student professional presentations and publications. In 2016, a sociology student presented a professional conference paper where he theoretically explored how to empower local residents (Puff 2016). In 2018, another sociology student published a peer-reviewed article in an undergraduate journal that was focused on how the community partner, BCCC, impacted the university, multiplying university partnerships as a consequence of faculty listening to the community partner (LaFontaine 2018). In 2019, a Construction Engineering Technology student presented a professional conference paper describing how sustainable construction designs were developed by students for Hartford City residents as a form of "pre-figurative politics" (e.g., Gordon 2018; Leach 2013) to help the community imagine what could be done with the HI&M brownfield if the company were to relocate to the industrial park (Jimenez, Steiner and Mohammadpour 2019).

Ensuring Projects are Community-driven

The current focus on airborne pollution emerged from ongoing conversations with residents. Until residents repeatedly drew attention to air pollution, none of the involved parties - the research team, BCCC, the EPA, nor IDEM – were paying attention to fugitive dust or off-site fumes. The PI repeatedly engaged with BCCC board members to consider refocusing their community engagement strategy to prioritize residents' concerns. Over time, a new strategy was adopted that made residents' concerns the central focus of BCCC's approach.

Dissemination of Results in Useful Terms

The community partner consistently reviewed how information was presented to the community to ensure that local residents would understand the findings. This often meant creating special posters and visuals that could be easily viewed and readily understood. Our collaborative research team worked with undergraduate students to

create posters that provided technical knowledge to the public in useful terms (i.e., addressing questions such as the public health implications of toxic exposure and what residents could do to reduce toxic exposure). Bar charts replaced tables of statistical analysis on the public posters to assist the community in engaging with the data through visuals that are easier to interpret. Sometimes props were utilized. For example, a photo of a dust cloud blowing off the steel recycling plant's property was enlarged and put on display. Baby onesies were left exposed to the air on a resident's porch and then packaged in sealed containers over regular time intervals; the series of ever-darkening onesies were then displayed in front of the City Council at a meeting where residents presented their air pollution concerns to public officials. After each meeting, a readable newsletter was disseminated to BCCC's mailing list and posted on their Web site.

Ensuring that Research and Intervention Strategies are Culturally Appropriate

A few years into the case study, the PI surveyed the immediate neighborhood using a door-to-door questionnaire, but the approach was not well-suited to the community. The population is racially homogenous (96.8% white) and aging (21.9% 65 or older) with an elevated poverty level (14.1%); only 13.6% of the population have a bachelor's degree or higher (U.S. Census Bureau 2019). Most of the questions had to be extensively elaborated upon by the researcher before residents provided answers to the questions. The introductory consent form was too long, residents appeared uncomfortable having long conversations on their doorstep with people from outside of the tightknit community, and the retrospective pre-then-post questionnaire format was unfamiliar to respondents. Few of the residents were able to read and respond to the questionnaires as written despite their having indicated a willingness to participate. We discontinued the neighborhood questionnaires. Neighborhood canvassing was primarily used to disseminate information and invite residents to public meetings.

Definition of Community as a Unit of Identity

We defined community as a two-block radius surrounding the only business in the community that is under remediation by state and federal authorities: HI&M. Hartford City spans just over 4 mi^2. In 2010, the citywide poverty rate of 16.4 percent was significantly higher than the statewide average of 11.9 percent. In 2017, Blackford

County was identified as the poorest county in Indiana (Carter 2017). Much of Hartford City's poverty is concentrated in the community immediately surrounding HI&M.

Concentrated poverty makes the residents vulnerable, but it is the lack of response from city and state government that makes them marginalized. Research demonstrates that social practices are not simply a matter of individual choices, but they are a reflection of social conditions that take place within systems of power (Ford 2019). The residents within the two-block radius have been routinely contacted by collaborative teams going door-to-door to disseminate and obtain information since 2014. Over time, friendships have developed between members of the research team and some of the neighborhood residents. This is how the research team learned about the white-outs, explosions, and fugitive dust. Residents consistently claimed that they had reported complaints with IDEM about the explosions and fugitive dust. The PI contacted IDEM and learned that resideents' complaints about fugitive dust and exposions were not logged into the system because there was no air permit file associated with HI&M. Residents sent IDEM photos of fugitive dust emanating over the fence line, asking for IDEM to require HI&M to file for an air permit. IDEM told residents that although that is the type of picture that indicates fugitive dust, it has to be taken by one of their agents to become part of the file. An agent subsequently visited the site on a few occasions, but no violates were noted.

A similar pattern was found in relation to local government officials. Residents sought to be heard, but their concerns were routinely ignored. Community residents organized to express to the Mayor and City Council a desire for HI&M to relocate out of the residential neighborhood to an industrial park that is better suited for their business operations. Residents wanted to begin a conversation. The Mayor and the City Council promised to bring parties together for dialogue, but they did not follow through despite repeated requests by BCCC.

A sense of community identity also began to form as people reflected on the future community they sought to become. BCCC has developed a newsletter mailing list and social media presence over the course of several years to maintain communications. If HI&M should ever relocate, a large brownfield would be left behind. Brownfields can be redeveloped, but if residents want the plot to be anything other than barren, EPA officials have said that the community would be well advised

to plan ahead and prepare landscaping designs to have on-hand. If HI&M were to relocate, the designs could be given to the remediation company tasked with clean-up in order to plant trees and shrubs during the remediation process. Once a brownfield is sealed, it cannot be reopened for planting.

Visual designs can strengthen a community's sense of identity and belonging. Purdue University's Center for Community and Environmental Design connected Shuangwen Yang, a 2020 landscape architecture graduate, with the PI of this project. Yang reimagined the brownfield site with an environmental justice focus. When the COVID-19 pandemic shut-down community gatherings, she used Web conferencing tools to communicate with residents and created several designs that were given to the community as her capstone project. Her designs did more than landscaping. She listened to residents and brought their voices into the project design to drive change and envision the future. Her designs contributed to building a sense of community identity in the neighborhood. Her designs depicted a gallery where the town's history, art, and local bulletins can be displayed, a covered amphitheatre for public gatherings, play areas for children and dogs, interactive activities, a memorial to those lost to illness and, perhaps the feature Yang is most proud of, a public healing garden for meditation and a private community garden where residents can grow produce in raised beds (Ambrose 2020). The next step is to identify within the series of drawings different projects for sponsorship and development.

Actively Supporting the Nonprofit

When Cordner et al. (2019) combined CBPR with an explicitly environmental justice-oriented approach within environmental sociology, they added to CBPR principles and expanded public sociology. They encouraged applied researchers to actively serve the needs of social movement organizations, develop data useful to the public, develop innovative data-sharing platforms, and make the data publicly available for purposes of social change (Cordner et al. 2019). Toward that end, we have provided ongoing personnel, expertise, and grant-writing capacity to support the ongoing work of BCCC whose board has had to function without support staff since 2016. Our research team provided undergraduate students to collaboratively write and deliver content for their newsletters, Web page, and social media for three years. We utilized the university's Architecture Geographic Information System to map the county's industrial legacy to

assist BCCC with the identification of sites for testing private water and soil samples, and we have used the university's greenhouse to grow moss samples and mini-gardens for the project.

THE CASE STUDY

Indiana currently ranks as the highest emitter of toxic releases into the environment out of 56 states and territories (EPA 2020). Hartford City is a rural economically depressed and underpopulated city in Blackford County, Indiana, United States. Hartford City has an elevated Air Toxics Cancer Risk measuring 17 percent above the national average (EPA 2019). The county consistently ranks amongst the lowest in the state for quality of health.

Residents gathered anecdotal evidence suggesting that their community had unusually high rates of neurological diseases. Residents formed BCCC in 2009 to improve their quality of life through citizen education and investigation into the incidence of diseases. BCCC worked with the Indiana Cancer Registry (2014) who identified elevated age-adjusted county-level cancer rates for bladder, colon, and thyroid cancers.

The research team began collaborating with BCCC in the spring of 2015. The purpose of the collaboration has been to develop a mutually beneficial partnership that would (1) strengthen the citizen group's ability to fulfil its mission, (2) contribute to the land grant mission of the university, (3) bring a best-practices teaching engagement strategy to complement the curricula in a variety of the PI's courses, and (4) provide an opportunity for applied research that might suitably address the community's needs. Specifically, BCCC needed help with environmental investigation and community education so that citizens could advocate to have the local disease clusters further investigated to improve the quality of life of Blackford County, Indiana. HEC provides expert consultation on matters pertaining to public health and environmental law. The Blackford County Health Department formed a Tobacco-free Taskforce to reduce cancer risk by focusing on changing individual behaviors. BCCC supported this effort, but given the industrial history of the area, they also wanted to reduce cancer risks through a reduction in exposure to carcinogens. BCCC had access to historical records but they did not have the resources to create maps so that they would know where to test to identify possible carcinogens. The PI was trained as an environmental

sociologist and came to the university with service-learning experience. Upon arrival, she actively searched for a community partner that was interested in collaborating with a sociology focus. BCCC was the only citizen's group appropriate for environmental sociology that she could find within the university's metropolitan service region. The partnership has evolved through a series of six stages between 2015 and 2020.

Stage 1 - Knowing Where to Look

BCCC used its funding to confirm that they had a statistically higher than average occurrence of three types of cancer among Blackford County residents (cancer clusters). They partnered with HEC, the Blackford County Health Department, EnviroForensics and Envision Laboratories to test selected private water wells and soil at some of the old glass factory sites, and found that the Hartford City baseball field would need to address elevated arsenic and lead concentrations before the property could be used for housing. When the PI contacted BCCC's president, he asked if the students would create maps of the county's industrial history using materials archived in the Blackford County Historical Society. The PI's role was to work with students to map the industrial history of the community (Figure 1). BCCC used these maps to guide where to test the soil and water for carcinogens. Initial county-wide testing of water and soil was funded by a community foundation and had been supervised by HEC. The grant resulted in some minor clean-ups that, by themselves, would not suggest a relationship with the cancer clusters. BCCC was unable to renew funding to support staff. Any additional testing would now be conducted by collaboration with the university (with occasional consultative support from HEC).

Stage 2 - Communicating with the Public

BCCC next asked for assistance with communicating the results of their testing to the public. The PI worked with students, with assistance from university support services, to create video shorts on the water and soil results that BCCC used to provide technical knowledge to public. Students noticed that BCCC was not making the most of the resources they already had in terms of social media. Students initiated a photovoice project and supervised two meetings with the BCCC board and residents where they (1) asked residents to take relevant photos of their community, (2) created a BCCC Twitter and Facebook page where residents could tell their stories, and (3) taught

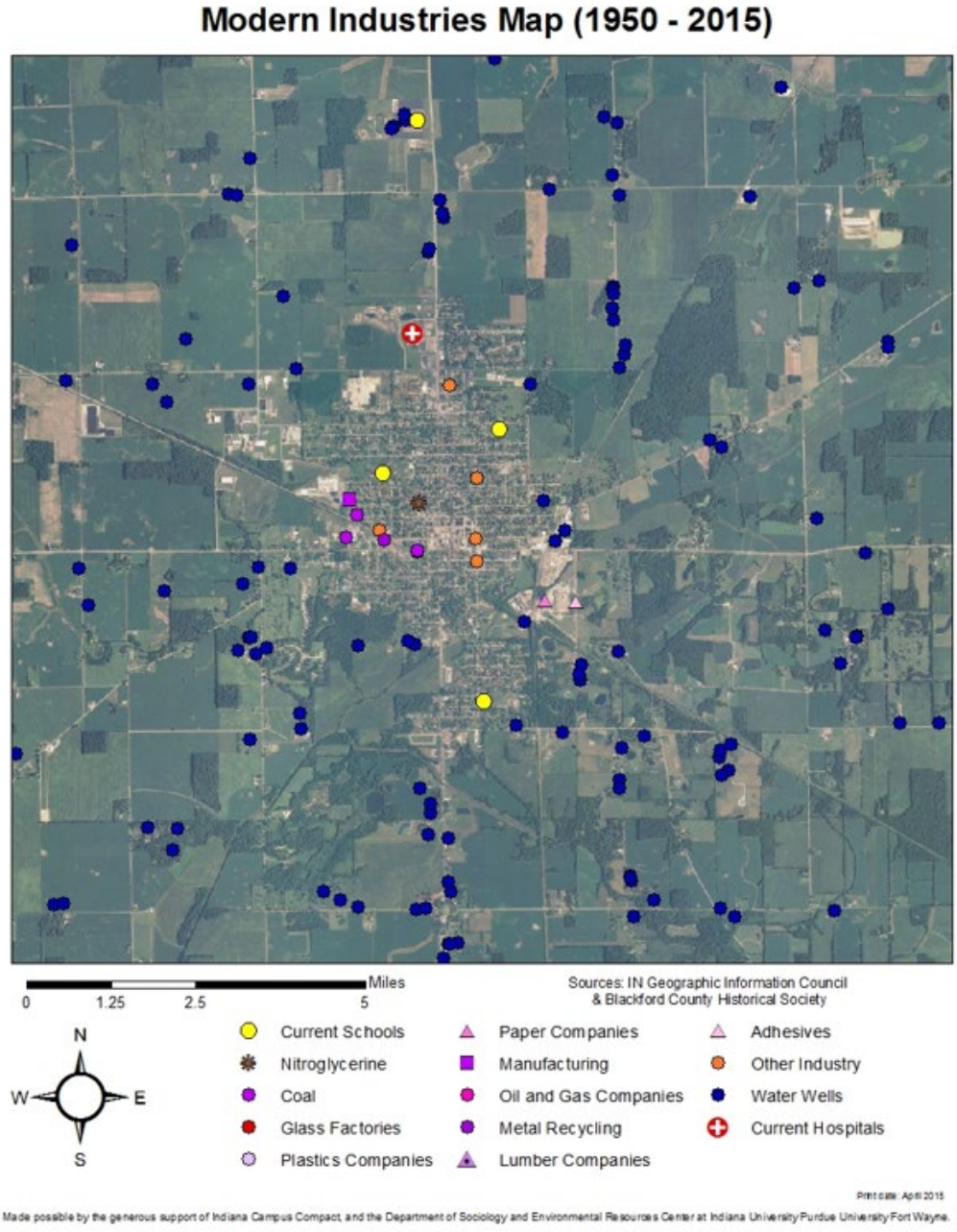

Figure 1. Modern industries map in Hartford City, Indiana (1950-2015).

residents and board members how to use the social media accounts to get their message out to the public. Students have also occasionally assisted BCCC with the creation and delivery of their newsletter that is distributed to over 200 interested community residents.

Stage 3 - Focus on Known Polluters

The research team's PI suggested that BCCC shift their focus away from an all-encompassing county-wide assessment toward testing for contaminants in and around

any facilities that were already being monitored by state and federal agencies for environmental pollution. As it turned out, only one facility in the county was being monitored for regulatory noncompliance by state and federal agencies: HI&M (EPA 2020).

HI&M is a waste management company that buys and processes scrap metal including automotive, industrial, and household items. The steel recycling plant is located in a residential neighborhood that has a long history of industrial activity. They are not the major employer in town, employing less than 10 people full-time. In 2006, HI&M was given a notice of violation by IDEM for mishandling hazardous waste from recycling scrap metals and processing vehicles. In 2009, HI&M entered into a consent decree with IDEM, but compliance has been slow. IDEM has also been slow to enforce the decree. Although the consent decree requires compliance for all off-site environmental impacts (i.e. air, soil, fugitive dust, surface water, and groundwater), enforcement and remediation has focused primarily on surface water runoff. In 2013, HI&M's insurance company paid a fine of $189,580 to the EPA for illegal discharges of polychlorinated biphenyl-contaminated storm water from HI&M into city sewers. In 2016, IDEM fined HI&M $60,000 for contaminated storm water runoff (Hughes 2017). Recently, HI&M invested in significant remediation efforts to address storm water runoff and groundwater pollution.

Our collaboration delineated a two-block residential radius surrounding HI&M. Residents were surveyed for their concerns and repeatedly invited to come to community meetings. Residents complained the most about dust and explosions. The PI oversaw the testing of 12 residential soil samples from this neighborhood. Several pollutants were identified as elevated (e.g., lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, pyrene, etc.), but levels did not exceed the amount allowable by the EPA for soil presumed covered with vegetation.[1]

Stage 4 - Focus on Direct Avenue of Toxic Exposure

At this point, the collaboration began to shift toward environmental research. Residents kept focusing their complaints on fugitive dust and whiteouts. Air pollution affects human health and is considered a direct avenue of toxic exposure (Dockery 2009), but techniques that use sensors to provide calibrated measurements of heavy metal contaminants in the air are a prohibitively expensive monitoring approach that involves

technical equipment that is not easily available or operated (e.g., Gatziolis et al. 2016). As toxicological and epidemiological studies indicate that heavy metal exposure is potentially highly toxic (e.g., Kongtip et al. 2006; Yang and Omaye 2009), scientists in Europe (e.g., Ares et al. 2012; Ryzhakova et al. 2017), Africa (e.g., Abulude and Elisha 2017), and the United States (e.g., Gatzionis et al. 2016) have been developing techniques that use biomonitors as an affordable and useful approach to estimate the presence of toxic elements in the atmosphere.

Outside of the United States, governmental agencies have begun to employ biomonitoring methods to detect environmental hazards (Gatziolis et al. 2016) and supply abundant reliable information to determine the impact of airborne pollutants on physiological processes (de Temmerman et al. 2004). The European Union, in recognition of poor air quality as a leading environmental cause of premature death, has issued two European Air Quality Directives (EU 2004, 2008) that recommend using biomonitoring techniques to monitor heavy metals and polycyclic aromatic hydrocarbons (PAHs) to reduce harmful pollutant concentrations in ambient air (Capozzi et al. 2016). Authoritative researchers in Italy considered the moss transplant technique to be an appropriate methodology for their biomonitoring research program field study in the southern district of Campania to determine the degree of people's exposure to fields poisoned by illegal waste dumping (Capozzi et al. 2016); people in this region are disproportionately poor, have increased cancer rates, and have shorter lifespans (Triassi et al. 2015).

Regulatory agencies in the United States do not yet recognize biomonitoring findings as legally actionable because U.S. mosses have yet to be calibrated to the expensive technical equipment. Biomonitoring findings are only useful for dialogue with government enforcement agencies. Community biomonitoring complements standard agency monitoring efforts by generating information in areas that might otherwise be under-reported (Amano, Lamming, and Sutherland 2016; Hadj-Hammou et al. 2017; Kinchy, Parks, anad Jalbert 2015). The pattern of regulatory enforcement by governmental agencies in the United States is uneven (Pulido 2015), with disproportionate underreporting of environmental conditions in rural areas (Harlan et al. 2015; Rhubart and Engle 2017). Research exploring how communities address toxic waste contamination is an important dimension of air pollution research because community biomonitoring initiatives may be the only means available to citizens for

gathering community-level exposure data in contexts where polluters fail to comply with the law and state agencies tolerate non-compliance as part of the larger regulatory culture (Fredrickson 2013; Pulido 2015).

We collaborated with BCCC to use the biomonitoring method as an affordable means to develop a small data set indicative of residential exposure to toxic fugitive dust that could be provided to regulatory agencies. In 2016, we collected our first set of moss samples from trees in the community and compared the findings of the presence of heavy metals to those from moss collected from trees in a nearby park. We presented the data to the public, obtained local news coverage, and facilitated community engagement with local officials, but we could only estimate the timeline of exposure. What BCCC needed was new evidence of air pollution that used a method with a known timeframe.

The moss-transplant technique is a flexible experimental design that has been increasingly used in the last 40 years to provide a high number of sampling points to counterbalance the lower precision of every single measurement, and to detect the presence of pollutants in the air not routinely measured by conventional monitoring (Ares et al. 2012). Although governments have used the method to provide an affordable means to develop large data sets, citizens may find that the method also provides an affordable means to develop small data sets in support of improving public health. In residential communities, moss bags have been used to monitor heavy metal concentrations in the air outside of homes to measure outdoor exposure at people's residences (e.g., Rivera et al. 2011). In this study, we used the moss-transplant technique to provide data to a social movement organization of toxic exposure within a known timeframe that became useful for dialogue with government officials.

We developed a small-sample community biomonitoring method to provide scientific evidence that BCCC could present, if relevant, to regulatory authorities. This community biomonitoring method differs from the biomonitoring method used by the U.S. Forest Service (Donovan et al. 2016; Gatzionis et al. 2016) in that we collected fewer samples and substituted statistical analysis for large-scale Geographical Information System mapping. The U.S. Forest Service uses biomonitoring to develop large samples to map pollution "hot spots," whereas the community biomonitoring method uses small samples to identify possible regulatory non-compliance of known "hot spots." The regulatory non-compliance focus of the method incorporated an

additional step from the method used by the U.S. Forest Service: Citizens hosting the moss stations in their yards were provided with journals to record any unusual events associated with the stations and the industry's operations. The community biomonitoring method was intended to provide citizens with scientific evidence that, where appropriate, might motivate governmental enforcement agencies to utilize the expensive technical equipment at their disposal to follow-up with calibrated measurements of any heavy metal contaminants that might be present at the community level.

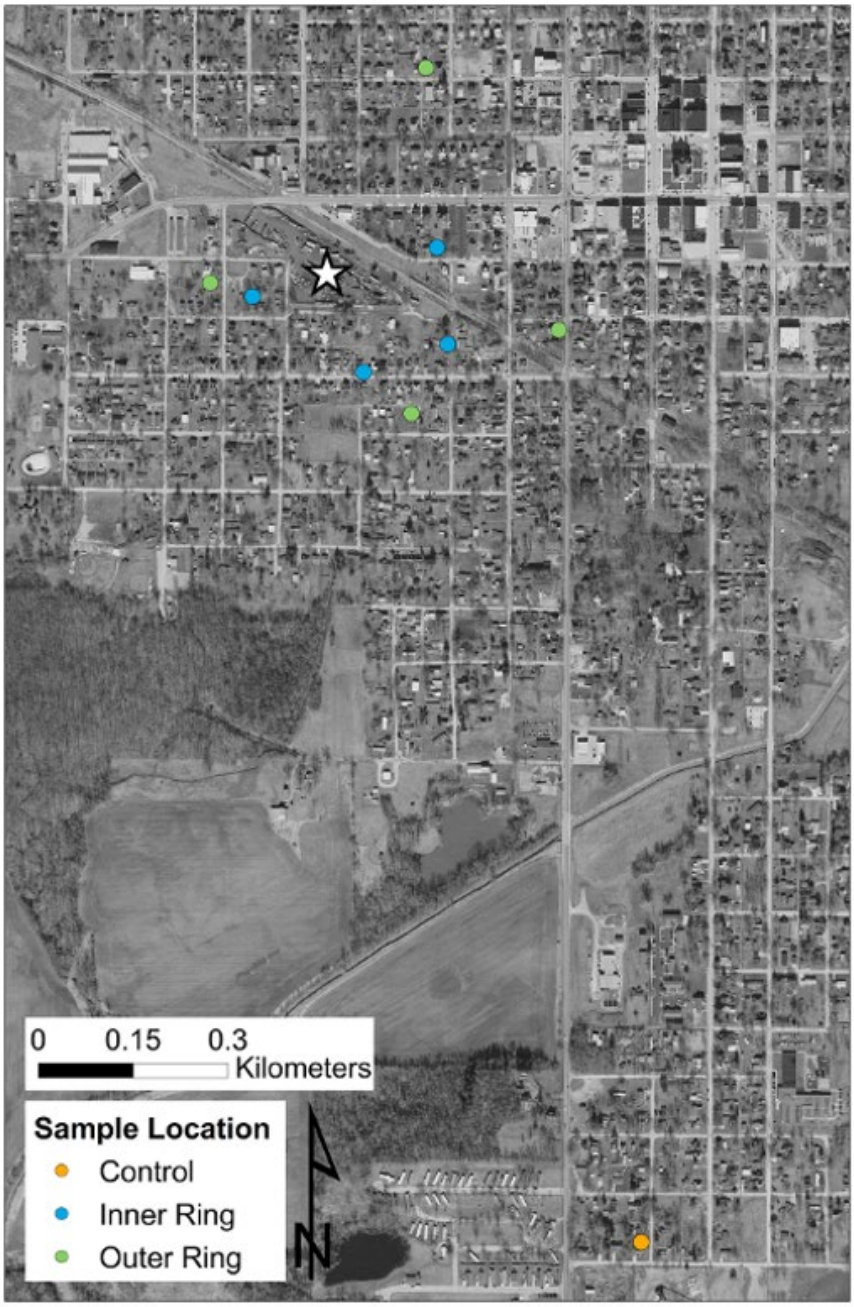

Figure 2. Locations of eight stations adjacent to a steel recycling plant and a control station.

Material and Methods

A community biomonitoring method was developed to grow moss in eight stations located in two concentric rings surrounding HI&M: the immediate neighborhood and the neighborhood just beyond that. A ninth control station was located in a neighborhood of comparable age and socioeconomic conditions across town within Hartford City to take into account other sources of pollution such as lead paint and residential activities (Figure 2). The moss-transplant technique (Ares et al., 2012) was used to monitor atmospheric pollutants in the air outside of homes at individual residences in Hartford City between June 3, 2018 and June 1, 2019. Moss was grown in the Purdue University Fort Wayne Department of Biology greenhouse, identified via DNA sequencing by the Purdue University Plant and Pest Diagnostic Lab as *Brachythecium laetum*, and tested for the presence of cadmium, chromium, lead and nickel, four metals that are known carcinogens and commonly associated with steel recycling, at the time of placement in-field monitoring stations. Three samples of moss were placed at each station at a height above the splash level. The ground-level pollutant concentrations of moss samples were compared between stations and the control using a blocked analysis of variance, with location serving as a blocking variable.

Stations were located on residential properties. Residents hosting the stations were provided with blank journals and instructed to keep a record of any unusual activities regarding the stations. They were also asked to make a record of the time and date of any explosions at HI&M.

Stage 5- Mobilizing Local Governance

By now, residents clearly wanted HI&M out of their neighborhood – a goal that was not entirely unreasonable. Years ago, HI&M had approached the Mayor indicating a willingness to relocate their operations to the local industrial park. A property was available that had direct rail access, better road conditions, and double the size. These three characteristics alone were conducive to expanding business operations. Relocating also created an opportunity to establish operating conditions that would ensure regulatory compliance with EPA and IDEM. Unfortunately, the Mayor at the time was not in a position to facilitate this relocation.

Circumstances were different now, the property was still available, and BCCC

was interested in generating political will. BCCC used the first moss findings of air pollution to pressure local government officials to embrace what they believed would be a win-win strategy of sustainable development. BCCC distributed T-shirts and buttons with the slogan "Relocate Hartford Iron and Metal – Good for Business! Good for Health!" They identified a piece of property owned by the city government in the industrial park and asked the Mayor and City Council to discuss possible relocation with HI&M. Engineering students created posters that demonstrated how this relocation would benefit HI&M as well as the neighborhood. Residents came to the city hall with petitions asking for HI&M's relocation. At the moment, the Mayor and, subsequently, City Council both promised to form a task force that would include residents to consider possible relocation, but no action was forthcoming despite multiple promises. Despite having been open to relocating in the past, HI&M was unwilling to consider relocation to the industrial park now. BCCC's efforts to mobilize local government with the first set of moss evidence failed.

Stage 6 - Asking for Accountability

Everything changed a year later. The Mayor and several City Council members were up for reelection, and the research team's evidence was ready for analysis.

Results

Prior to station placement all moss was tested for the selected heavy metals and returned no detectable contamination. All 27 samples were collected on June 1, 2019 and tested for heavy metal contaminants. All samples contained contamination exceeding the detectable limits. Station locations were compared to each other and to the control, with adjacent to HI&M (not individual 'rings') and across town (control) as blocks with an ANOVA. Cadmium was greatest at Location 4, significantly different from all other sites, $F(7,18) = 5.06$, $p = .003$. In addition, the blocks were different with adjacent to HI&M greater than the control, $F(1,18) = 15.09$, $p = .001$; (Figure 3a). Chromium was greater at Location 6 than 2, $F(7,18) = 3.51$, $p = .015$, with the block adjacent to HI&M greater than the control, $F(1,18) = 7.99$, $p = .011$ (Figure 3b). Lead at Location 4 was greater than Locations 2, 5, and 7, $F(7,18) = 6.10$, $p < .001$; Location 3 was greater than 7; and the block adjacent to HI&M was greater than the control, $F(1,18) = 17.12$, $p < .001$ (Figure 3c). Nickel values were transformed

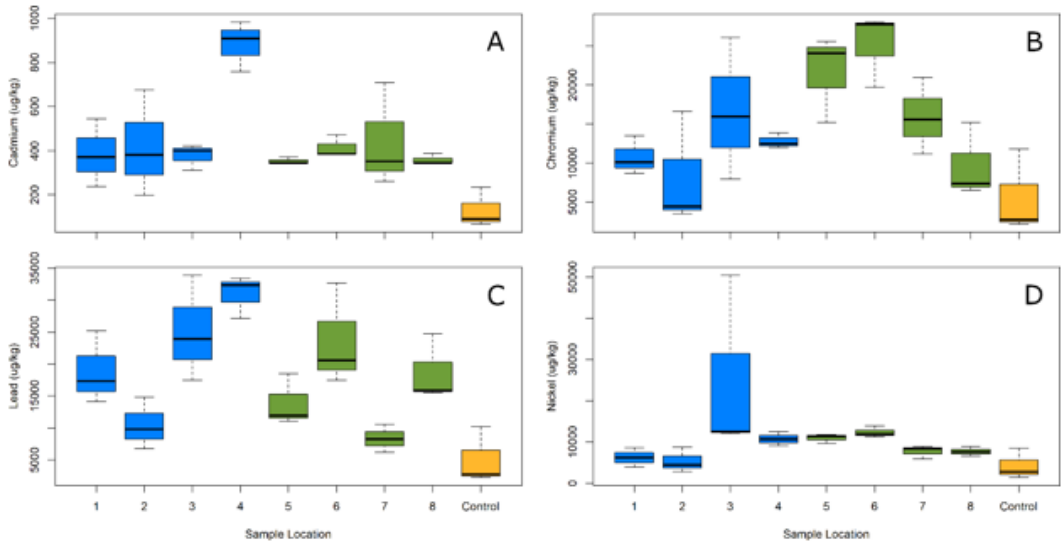

Figure 3. Between station comparisons of (a) cadmium, (b) chromium, (c) lead, and (d) nickel. *Note.* Blue locations = inner ring (Figure 2); Green locations = outer ring (Figure 2); Orange locations = control (Figure 2).

($\log_{10}$) to meet assumption of normality and Location 3 was greater than 2, $F(7,18) = 2.59$, $p = .049$. Additionally, the block adjacent to HI&M was greater than the control, $F(1,18) = 12.40$, $p = .002$ (Figure 3d).

A minimum of 28 explosions was noted by participating residents adjacent to HI&M during the timeframe of moss exposure in Hartford City (Table 1).

Discussion

The research team's results suggest that residents living near and across town from HI&M were exposed to cadmium, chromium, lead, and nickel in the atmosphere, as indicated by all samples being contaminated. In addition, residents living near HI&M were exposed to elevated levels of the four heavy metals tested compared to residents living across town. We were unable to identify a gradient of exposure near HI&M, as there was no clear pattern (i.e. concentric circles in Figure 2). Contamination was equally identifiable in all samples taken from within the three-block radius of homes on every side surrounding HI&M. This contamination has occurred since HI&M initiated a quarterly fugitive dust control remediation program, suggesting that further investigation into their compliance with The Fugitive Dust Rule, 326 IAC 6-4, may be warranted. The fugitive dust rule applies to sites, such as HI&M, regardless if they have an air pollution operation permit as mentioned in a letter to us from L. J. Sullivan,

Table 1. Date, Time, and Count of Explosions Noted by Participating Residents Adjacent to Hartford Iron & Metal.

Date	Time	Count of explosions
July 15, 2018	9:55 a.m.	[a]
July 15, 2018	8:55 p.m.	2
July 31, 2018	3:35 p.m.	2
August 1, 2018	9:00 a.m.	[a]
August 2, 2018	8:36 a.m.	4
August 2, 2018	9:45 a.m.	3
August 3, 2018	7:10 a.m.	[a]
August 27, 2018	4:20 p.m.	[a]
August 30, 2018	12:30 p.m.	2
August 30, 2018	12:45 p.m.	[a]
September 5, 2018	8:15 a.m.	[a]
April 24, 2019	Afternoon	[a]
May 3, 2019	Morning	[a]
May 3, 2019	Evening	[a]
May 6, 2019	Morning	6

[a]Indicate record of explosions without recorded counts.

Chief of Compliance and Enforcement Section 2 of the Office of Air Quality IDEM on September 7, 2018.

Our testing method was unable to distinguish hexavalent chromium from other forms of chromium. This is an important limitation of using a biomonitoring method to monitor a steel recycling plant. Airborn hexavalent chromium is highly carcinogenic and it has been identified as an unintended toxic by-product of certain types of steel recycling processes (Raun, et al. 2013). For example, the City of Houston and the Texas Commission on Environmental Quality have found that steel recycling plants tend to release hexavalent chromium and other carcinogenic metals into the air in ways that were not present in other industrial areas (Lobet 2012). In particular, facilities using processing methods associated with fires and explosions (e.g., improper draining of vehicles, shredding, and torch-cutting metals) were identified as producing hexavalent chromium in the atmosphere. Houston authorities estimated that the steel recycling plants reporting high numbers of fires and explosions were contributing an extra 600 cancers per million people (Lobet 2012), so many of Houston's metal recyclers have subsequently changed how they process steel. Such releases of

hexavalent chromium are possible at this site in Hartford City as numerous explosions were recorded by participating residents during the course of this study.

Our method used an uncalibrated moss (*Brachythecium laetum*) as a bioindicator, but where similar findings in other contexts have been followed-up with calibrated instrumentation, pollution levels have been substantiated (e.g., Gatziolis et al. 2016). At minimum, these results warrant further investigation using calibrated machinery by IDEM and EPA. Of particular concern are the elevated levels of lead exposure, and the need to determine if residents are being exposed to hexavalent chromium in the atmosphere. There remains a limited understanding of how these complex exposures translate to health risk.

Activism

Research into the "toxic exposure experience" indicates that various stakeholders interpret the experience differently in ways that often further influences residents' tendency to publicly disengage. For example, government officials may designate an area as contaminated; residents may want to refute the designation to protect the value of their homes. If pollution accumulation devalues property, residents' "castles" become transformed into "prisons" in ways that undermine residents' sense of freedom, independence and respectability (Fitchen 1989). Rather than leave, residents struggle to remain. They may actively organize and further invest in fortifying their homes despite their high-risk location – which only prolongs their exposure to harmful chemicals (Hernandez 2019). This was referred to earlier as a "consensual community response."

In the case of Hartford City, residents expressed feeling trapped in toxic exposure. They had complained about air pollution conditions, but their advocacy efforts had limited impact. In 2017, residents were surveyed and asked to submit public comments to local government. Residents indicated that they felt a sense of distress due to their proximity to HI&M:

> The extra precautions that must be taken to safeguard health, the stigma associated with pollution, and the lack of support from regulatory agencies…created a negative emotional environment for the neighbourhood residents (Collison, et al. 2019: 6).

Residents' comments indicated that they were emotionally distraught over public

health concerns, HI&M's environmental offending and IDEM's slow regulatory response, but what was most disturbing is that residents' most intense emotional language was associated with the possibility that their concerns might actually be heard and responded to by government officials (Collison, et al. 2019). Residents had become accustomed to being ignored.

BCCC decided to invite both mayoral candidates and local residents to a community meeting to hear the results of the second moss study just prior to the election. Students presented posters illustrating the findings and the PI explained the elevated levels of lead, nickel, and cadmium to residents. The item that drew the most attention was the combination of elevated levels of chromium and documentation of 28 HI&M explosions. Given that HI&M uses torches to cut metal, the PI expressed concern that further research needs to be conducted to identify whether or not the airborne chromium contaminant takes the form of Chromium VI. Unfortunately, this type of research is beyond the means of the university because it requires the type of expensive technical equipment that only agencies such as IDEM and the National Guard can usually afford. At this point, the PI stepped aside and the president of BCCC took the floor.

BCCC's president directed citizens to template letters and envelopes addressed to the state Governor and the Commissioner of IDEM that were inside every attendees' information packet. Writing pens were available in Halloween decorated skull containers for residents to use. Colorful holiday baskets served as table centrepiece receptacles to hold residents' activism letters. The remainder of the meeting was dedicated to citizen activism. Citizens wrote to ask the Governor to direct the National Guard to test the air, and they wrote to the Commissioner of IDEM.

Impact on Student Learning

Students benefited from the community engagement experience in several ways. Qualitative evaluations from students involved in a variety of coursees indicate that student learning improves when the course has an applied focus that connects what students are learning to their community. For example, a student in a 2016 social theory course made the following reflection:

> I have learned that the way to approach a problem in society, such as Hartford Iron and Metal's failure to follow the rules, is to organize and utilize the

> different layers of social, human, and economic capital at our disposal as social scientists to locate and attempt to treat the source of the problem.

A student in an Environmental Sociology coucrse taught in 2017 commented in a reflection paper how community engagement influenced a mind-set change with potential long-term impact on their perspective:

> I began my course with a very narrow and almost closed-off mind. Almost! Left and right it seemed that my self-possessing genius was being defeated by logic. I became more involved and moved from apathetic to empathetic.

Another Social Theory student, this time from a course taught in 2018, clarified how the community engagement experience impacted classroom learning:

> The high level of quality involved with the training I received on civic engagement, in addition to the foundation created by research on the part of Blackford County Concerned Citizens and Hoosier Environmental Council, provided an excellent impetus for me to simultaneously inform individuals about how they may be affected by Hartford Iron & Metal while possessing the knowledge and ability to connect them with potential solutions to the problems that were being discussed. This ability to guide the educative path of certain individual that showed interest in a positive solution is not only inspiring to me because it allows me real-life practice as a social scientist in the field, but it is also using my skills to help people. Most importantly, this service-learning experience has inspired me because I see that I can be effective in utilizing what I am learning during this phase of my education. I cannot express…how anxious I am now to gain more practice navigating and addressing social problems as a social scientist in the field.

A final illustrative student comment, drawn from a Community and the Built Environment course taught in 2020, emphasizes the deep influence culture has on communities. When the student learned that Indiana consistently ranks as the highest emitter of pollutants emitted into the air, water, and soil out of all states and territories in the United States, the student commented,

> This was something that was pretty shocking to me and something I had never heard or discussed. Living in the state virtually my whole life this is something you would think probably would have come up at some point, but that's when it really hit me. It's all about the culture…I started to look back at how

> conservation is viewed and pioritized…[F]or some reason there is this pro-business anti-environment…sentiment in my area of Indiana…It is something that is deep-rooted in people from this area….Looking at the case study, I begin to see several different players sharing that same sentiment…What really shocked me was listening to how people that were actually impacted by the pollution acted. I did not realize that the pro-business sentiment was so powerful it could even extend to people being negatively impacted themselves. There is this deep-rooted fear to even admit that someone else is even harming you.

The PI mentored undergraduate students to work in teams and present 10 posters to the community, publish 3 newsletter articles, obtain 6 grants, and write 6 grant reports. Some students remained involved and became professionally engaged by attending academic meetings or submitting work for journal publication. Six professional presentations were made at regional meetings. Two peer-reviewed journal artgicles were published. Four students referenced their involvement in the community engagement case study as part of their admission process into graduate school.

COMMUNITY IMPACT

The community engagement collaboration benefited students, but how have the service-learning projects impacted the community? We conclude with a cursory assessment of the case study's impact on the company, local government, the non-profit partner, the state environmental management agency, and residents' sense of human agency. The collaboration has been a mutually beneficial partnership that has (1) strengthened the citizen group's ability to fulfil its mission, (2) contributed to the land grant mission of the university, (3) brought a best-practices teaching engagement strategy to complement the curricula in 11 of the PI's courses, and (4) provided an opportunity for applied research to address the community's needs.

Impact on HI&M

HI&M is accustomed to voluntary remediation in dialogue with state and federal agencies; they are not favorably disposed to resident activism. BCCC has invited them to community meetings, but they send, at most, a legal representative. HI&M has

refused BCCC requests for face-to-face dialogue. At one point, HI&M offered to have some residential soils tested for contamination, then withdrew the offer when they learned that BCCC was collecting independent samples. At one point, they were willing to relocate to the industrial facility. Now, they are opposed to the idea. They have made a significant investment in the current site by building two remediation ponds to address surface water runoff. When the first set of moss results were presented to the community in 2017, HI&M initiated a quarterly fugitive dust control program. When the second set of moss results were presented to the community, HI&M additionally removed massive dirt piles from the property. They have become simultaneously somewhat responsive and more intransigent. This development is consistent with studies that explore how those in positions of power decide to engage with those at the margins of society. In particular, if marginalized groups have little social value, instances of dismissive practices toward them emerge (e.g., Bond 1999; Foster-Fishman and Keys 1997; McDonald and Keys 2008; Messinger 2006). That such practices remain unchecked by governing authorities is a reflection of what Chiapella and colleagues (2019) refer to as the toxic chemical governance failure in the United States. Standard risk analysis tends to normalize the production of toxic by-products by treating risks to public health as end-of-pipe problems and unplanned toxic releases as public relations problems (Beck 2008).

The research team did not interact with HI&M employees out of safety concerns for the students and the research team. HI&M management and supervision are armed at all times and transactions are done on a cash-only basis. That said, one person did self-identify as an employee of HI&M on an anonymous questionnaire that was distributed to the residential community in the two-block radius surrounding HI&M. The comments from this employee were supportive of HI&M and negative toward further involvement with BCCC. This is not surprising inasmuch as employees have an invested "stake" in HI&M's ongoing profitability. What is even more interesting, however, is that residents living closest to HI&M were often supportive of the recycling company's operations so that they could be on "good terms" with the owners even if they were themselves physically suffering from cancer or other illnesses. As HI&M continued to expand, residents who had been supportive of BCCC's organizing efforts changed their attitude once HI&M became adjacent to their property. Conflict and controversy do not always surround community contamination;

sometimes public outrage is defused and citizens do not demand remediation with what Valerie Gunter, Marilyn Aranoff, and Susan Joel (1999) refer to as "consensual community responses." Certainly, more research needs to be done on the complex relationship between toxicity and complicity (Zavestoski and Mignano 2002).

Impact on Local Government

Shortly after the evidence was presented to the community, the incumbent mayor lost the election. A new Mayor and several new City Council members have just taken office in Hartford City. A new economic development coordinator has expressed initial interest in meeting with the Mayor and representatives from BCCC, but the COVID-19 pandemic has put meeting with the new government temporarily on-hold.

Impact on BCCC

Because of this collaboration, BCCC has identified soil and air contamination in the residential area surrounding HI&M and made this information available to the community. BCCC, without staff, has been able to keep the community updated about their mission through 10 community meetings, regular newsletter publications, and occasional social media updates. When surveyed mid-way through the collaboration, BCCC board members strongly agreed on a 5-point Likert-type instrument (where 1 = *strongly disagree* and 5 = *strongly agree)* that the community and their organization benefited from the activities of the service-learning students (mean score of 4.67). The response rate to the questionnaire was 100 percent, but given the size of the board members actively involved with the student projects, the sample size was quite small ($N = 3$). All respondents strongly agreed that they wanted the relationship developed with the university research team to continue (mean score of 5.00). Two of the handwritten (anonymous) comments speak to impact: "The projects have advanced our work in the county" and

> We have experienced progress from [the university's] involvement in solving a long-existing problem for our community. This progress, in addition to future progress, would not have been possible without the assistance of [Purdue University Fort Wayne]…Citizens who previously have felt helpless in solving the existing problems now have some hope and a more positive outlook.

Impact on IDEM

In September 2018, IDEM requested HI&M to submit a complete air permit application. HI&M has appealed this request to the Indiana Office of Environmental Adjudication where it is being reviewed.

In November 2019, the Commissioner received residents' letters asking him to use IDEM's capabilities to determine whether or not the neighborhood is being exposed to airborne hexavalent chromium. On December 3, 2019, Bruno Piggott, Commissioner of IDEM, indicated that IDEM purchased a machine capable of testing for airborne hexavalent chromium in the residential area next to HI&M. The machine has been installed on residential property adjacent to HI&M and is currently monitoring the air for hexavalent chromium and other possible airborne pollutions. IDEM has indicated that they plan to evaluate the data at the end of summer in 2020. The data may become useful in the adjudication process involving the air permit.

Impact on Neighborhood Residents

There are multiple ways in which the impact on neighborhood residents might be measured. Do they feel more optimistic and empowered as a consequence of being involved in this process? Have they become more involved? Have they organized their community? Have they succeeded in changing the neighborhood? Certainly, any assessment of the impact on neighborhood residents needs to take into account not only residents' self-reports of feelings of empowerment but also observations of behavioral changes and achievements in community outcomes.

At the beginning of the collaboration, we wanted to know how our entry into the community was impacting resdents' feelings, so we distributed a questionnaire to obtain self-report measures from the people in the community. In 2016, the PI conducted a retrospective pre-then-post survey to measure the impact of BCCC's educational efforts on residents' sense of human agency (Figure 4). If our activities were unwelcome, we wanted to know earlier rather than later. Results indicated that BCCC's community engagement increased residents' knowledge of HI&M's remediation activities and BCCC's monitoring of HI&M's remediation activities.

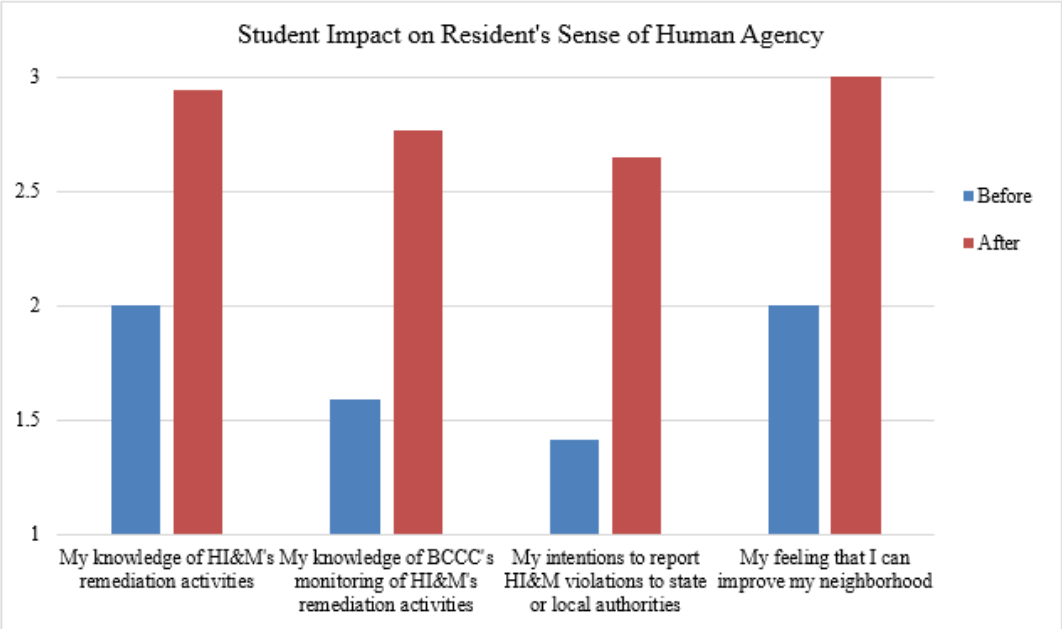

Figure 4. Residents' retrospective pre-then-post self-reports of BCCC impact (2016), graph based on mean score.
Note. BCCC = Blackford County Conerned Citizens; HI&M = Hartford Iron and Metal.

Residents also self-reported increased intentions to report HI&M violations to state and local authorities, and they have increased their feeling of being able to improve their neighborhood. After conducting one door-to-door residential survey, however, the PI decided that this type of surveying was culturally inappropriate. Our measure of human agency considered the combination of all of these questions.

The self-reported intentions to get more involved in 2016 did transform into action over time. By 2017, residents were delivering self-generated comments to local city officials. By 2018, residents were hosting nine moss stations for a year in their yards. By 2019, residents were writing to the Commissioner of IDEM, asking him to take action in their community.

Another indicator of neighborhood resilience is to evaluate the effectiveness of resilience interventions, and track progress made toward desired resilience goals. IDEM is now requiring HI&M to apply for an air permit, and they are monitoring the air for pollutants. IDEM has agreed to make the data available to BCCC and the residents. In this regard, residents' have become stakeholders in the governance process.

Pathways Forward

In time, we hope to build a community-academic-government-industry collaboration to develop a public health action plan capable of improving environmental conditions and residents' health in a manner similar to what the Air Alliance Houston has achieved in four neighborhoods in Houston, Texas (Symanski et al. 2020). Although metal recyclers operating within neighborhoods provide jobs for local communities, increase revenues for local businesses, and conserve resources and energy by recycling metals, they also generate metal aerosol dust, odor, fume, noise, and traffic, and expose residents to explosions and/or fires that may increase their cancer risk (Han et al. a2020). In Houston, some initial studies were conducted and findings were reported in Houston's daily newspapers. City-led initiatives to enforce clean air regulations were subsequently challenged in courts by the Business Coalition for Clean Air, an industry-lobbying group (Mankad 2017). A report by the Environmental Integrity Project found that Texas penalizes only 3 percent of the illegal pollution releases reported by companies (Clark-Leach and Metzger 2017). As tings progressed, a few of the Houston neighborhood recycling companies relocated to an industrial location and one facility closed. However, some of the companies, such as Allied Alloys, took a proactive approach to voluntarily limit emissions (Lobet 2012; Symanski et al. 2020). In response to ongoing resident complaints, a task force was eventually created and a CBPR approach was taken to address the air pollution coming from some of the metal recycling facilities (Han et al. 2020). Despite the failure of governance efforts to regulate pollution, Houston successfully developed a community-academic-government-industry partnership that secured funding from the National Institute of Environmental Health Sciences to conduct a 20-month air monitoring public health campaign. They partnered with a community organization but also expanded upon traditional partnerships to include representatives from the impacted neighborhoods and from industry (Symanski et al. 2020). They gathered information about stakeholder's views and concerns about their neighborhood and environmental health and worked with the Houston Health Department to conduct community air monitoring in four selected neighborhoods that focused on public health. They detected increases in health risks associated with carcinogenic metal emission concentrations at several of the metal recycling facilities even though the facilities were operating within legal limits (Han et al. 2020). Although the collaboration partners were unable to agree

whether or not to include policy initiatives to regulate the metal recycling industry as part of the public health action plan, they did include voluntary actions on the part of the recycling industry partners to change practices, processes, or conditions in the scrapyard to minimize emissions from metal recycling facilities and improve communication with residents. They developed a positive model that built partnerships across different sectors to address the environmental health concerns in four underserved communities near steel recycling plants (Symanski et al. 2020).

As Indiana consistently ranks as one of the highest emitters of pollutants into the environment out of all U.S. states and territories, it is reasonable to assume that the toxic chemical governance failure observed in Houston may likely similarly play out in Hartford City. According to Chiapella and colleagues (2019), regulatory failure to protect human and environmental health is a widespread problem across the United States. The development of an academic-government-community-industry collaboration may be the most promising approach that could eventually be taken in Hartford City. But even that goal might be overly optimistic.

One of the weaknesses of responding to Michael Burawoy's call to engage in public sociology and practice CBPR is the temptation to presume that sociology might be coextensive with social justice- it is not. There may, at times, be moments when the two synergistically converge, but as far back as the founding of the discipline, Max Weber ([1919[1946) explained that the "ethic of responsibility" required understanding the strength of contending powers and often compromising for the good of one's cause. As Steven Bring (2005) has pointed out, one of the hallmarks of mature political sociology is that it can tell us discomfiting truths.

Limitations

The data used in this study collected by the research team in response to citizen complaints of smoke and dust are not the product of a significantly funded research project. Consequently, the data collection and sampling analysis were limited to the collaboration's capabilities. The data were limited to moss samples collected in the proximal neighborhood of one steel recycling plant. Future research should include sampling at more locations and multiple facilities using appropriate air monitoring equipment to better understand the metal-air pollution levels in the community, to

evaluate the feasibility of emission controls, and to identify operational improvements and best management practices for steel recycling facilities located in residential neighborhoods.

Funding

This study was support by grants from the Purdue University Fort Wayne Environmental Resources Center, and the Purdue University Fort Wayne Institute for Research, Scholarship, and Creative Endeavors.

Institutional Review Board

The following Institutional Review Board protocols were approved as part of this project: #1507016294, #1607017903, #1702018769, #1708019528, #1712020000, and #IRB-2019-18.

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[1] EPA levels are more sensitive for airborne contaminants such as fugitive dust because the avenue of toxic exposure is considered direct, but EPA levels are less sensitive for the soil because it is assumed that the dirt is covered with vegetation and any residential avenue of contamination would be, at most, indirect.