Environmental Citizen Science in West Virginia: How Technology Can Increase Scientific Knowledge and Prepare Frontline Communities for Emergencies

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Introduction and Problem Statement

In January 2014, the Elk River, a major source of municipal drinking water for 300,000 West Virginians, was polluted by a chemical used in coal processing (National Toxicology Program, n.d.). In June 2016, the state of West Virginia experienced a “1 in 1,000 year flood” in which 10 inches of rain fell in less than 12 hours (National Weather Service, n.d.). Every year, hundreds of West Virginian deaths are attributable to airborne pollution from oil and gas extraction (Buonocore, et al., 2022). These events have two things in common: 1. their harms were directly attributable to, or enhanced by, resource extraction; and 2. that, with properly trained and equipped citizen scientists, their harms could have been identified prior to disaster.

Citizen science is a relatively young field and defined as “voluntary engagement with science” (Ceccaroni, et al., 2021). Sometimes citizen science is purely educational while other times, the argument of this paper, is that it is a practice of democratic agency and environmental necessity; lay persons actively engaged in scientific knowledge production to better science *and* identify foreseeable environmental disasters.This paper proposes a project of active engagement, training, equipping, and coordination of nascent citizen scientists.

This paper is organized as follows: the first section provides an overview of the management concepts most germane to citizen science and environmental reporting; namely deployment of trained volunteers, collaborations between science practitioners and frontline communities, and ethical management practices; the second section discusses particular practice strategies to most appropriately leverage technology towards environmental justice and citizen science; and the third section analyzes ethical dimensions related to citizen science as a form of knowledge as well as the particularities of West Virginia as a poor, rural state with a geographically dispersed population.

Management Concepts

The management concepts most germane to citizen science and the production of lay scientific knowledge to detect environment disaster are as follows: managing volunteers and influencing their actions; the collaboration of multiple stakeholder groups and frontline communities (of which volunteers are a part) towards a shared vision and goal; the implementation, and efficacy, of technology towards that goal; and, finally, ethical considerations of citizen science, in particular, and how scientific knowledge is produced and management in West Virginia.

Stakeholder Collaboration

The first step of this proposal requires collaboration and buy-in from stakeholder groups. These groups – those most affected by climate change, pollution of all kinds, and other environmental calamities – will have the most sway in their localities, on-the-ground knowledge of where and when pollution events occur, and supply the volunteer force (expanded upon in the next section) that perform the environmental monitoring.

There may be a case in which nonprofit and volunteer groups already exist in the areas of most need. Towers (2000), McGinley (2004), Barry (2008), Young, Teixeira, and Hartnett (2015) all describe significant resistance to environmental degradation in West Virginia over the years; these groups – which range from mountaintop removal watchers to those who organized on social media after the Elk River spill – form out of necessity. It would be wise to organize these disparate groups towards a preventative environmental measurement. While task forces may be appropriate in a government setting, due to the inherently political nature of their fight, it might be best for this to be separate from local or state government efforts. Further, by collaborating with stakeholders groups directly, you foster community engagement.

Volunteer Management

Nascent citizen scientists have to volunteer their time and effort; they do so without pay and, sometimes, without recognition. For this proposal to work, volunteers must be properly trained, oriented towards a shared vision and goal, and, most importantly, placed in the most effective locations. The first part, training, necessarily involves cost. Weinbach and Taylor (2018) reference significant time and expense for “orientation, training, and supervision” (p. 186). Further, Weinbach and Taylor caution against volunteers for their “behavior is […] often more difficult to influence than paid employees” (p. 187). A benefit, though, of unpaid volunteers is that the number of potential volunteers is far greater than the number of people professionally trained in science; meaning, it would be easier to train a volunteer to monitor ambient air pollution near their home in a polluted area than it would be to *hire* a scientist and move them to that same location. Fortunately, as Berry (2008) states, these people are a “small group of thoughtful citizens” located all throughout West Virginia.

Once volunteers are located, the next step is coordination. Rather than the coordination of a number of volunteers in a single place for, say, a blood drive, this proposal suggests the coordination of dispersed volunteers, doing different tasks, at different times. This coordination will most likely require a paid staff member

Technology Implementation

Two recent developments in technology have occurred that allow for this type of proposal: the marked decrease in the cost of communication and sensors. Information sharing, collection, storage, management, and analysis is incredibly cheap. While inexpensive, however, they still require funds but it is undeniable that the internet and small cellular devices have increased the speed at which people communicate and share information. However, as Weinbach and Taylor note, “better access to information transfer may or may not produce better communication” (p. 283). Just because information is cheaper and faster, doesn’t necessarily mean it is correct. The practice strategies discussed in the next section, along with appropriate training, could ensure that proper communication and information management is practiced.

Practice Strategies

The people most impacted by resource extraction live closest to sites of resource extraction. As such, the intervention identified in this paper is to provide training and technical assistance to those frontline communities. This intervention is situated within two fields: environmental justice and citizen science, which are both relatively new fields of inquiry, and come with certain ethical and historical contours. This section will briefly describe the two fields, their nexus, and how the new combined proposal may have mediated the environmental crises in our historical examples.

In his seminal work, Bullard (1983) found that the “siting of solid waste facilities [...] were not randomly scattered over the Houston landscape but were likely to be found in predominantly black neighborhoods” (p. 274). This sociological work – the direct link between environmental policy and race – began what is now known as environmental justice. Environmental policy is not randomly distributed; there is necessarily a spatial component. Bullard found that this spatial component involved race; in the West Virginian context, it is correlated with income (Young. Teixeira, Hartnett, 2015, p. 1). Following Bullard, it would behoove our stakeholder groups to identify volunteers closest to these (im)pending environmental issues.

While Brown (1992, 1997) did not necessarily extend (or use) Bullard’s analysis, he extended the theory from the professional to the lay. Brown’s analysis of the Woburn and Love Canal childhood leukemia cluster case study – a case in which non-professional lay people collected data regarding their own community's health and connected it to chemical waste – was the first to conceptualize the field of *popular epidemiology*. Brown connected lay people's local "way(s) of knowing" with their impetus to "detect and act on environmental hazards and diseases" (p. 268).

Bullard identified the non-random siting of environmental policies while Brown conceptualized lay people's ability (and duty) to identify, preempt, and otherwise mitigate environmental harms. With this intellectual grounding, the next step is moving from the intellectual to the active, the potential to kinetic. Citizen science, then, is necessarily the most appropriate route to connect people harmed (or those with the potential to be harmed) by inadequate environmental policies. The State of West Virginia actually does have programs related to citizen science but these are mostly educational at best and inchoate at worst (See: The Citizen Science Manual).

As discussed, Citizen Science is a young field with certain nuances and ethical commitments (see the second on ethical considerations). Citizen Science defined by Ceccaroni, et al. (2021), is voluntary engagement with science (p. 220). Fraisl, et al. (2022) further defined the six stages of citizen science as follows: identifying the problem; determining if citizen science is appropriate; designing the project; building the community; managing the data; and evaluating the project (p. 4). In each of our historical examples, the problems were visible, citizen science was appropriate, and the community has had a long history of affliction. Further, an added benefit of citizen science is "self-actualization and empowerment" (O'Brien, et al. 2010, via Ceccoroni, et al. 2021).

Finally, Kasperowski, et al. (2023) provide strategies for the citizen scientists to interact directly with the law. Whereas, Ceccaroni and Fraisl discuss the science aspect of citizen science, Kasperowski highlights the citizen aspect. Community-based monitoring – the type of monitoring this proposal suggests – has seen success at “pushing for new regulatory standards (p. 1). Further, Kasperowski highlights citizen scientists' success in getting their data accepted in court and even “advocating for the legitimizing of the practice under the Aarhus framework.” (Note: The Aarhus Convention is a United Nations framework which grants the public rights to public participation and government decision-making).

With our proposal grounded in environmental justice and citizen science, how would these practice methods have potentially mitigated the historical examples?

In the Elk River case, it was residents who initially reported a “sweet, licorice-like smell” after the incident (Jonson, 2014). By then, unfortunately, it was too late: 5,000-10,000 gallons of the contaminant had spilled. How could this have been mitigated? The responsible storage tanks were upriver from the municipal water treatment facility, guaranteeing that any issue with the tanks would have percolated to the faucets of people’s homes. To prevent this, volunteers could have been trained to monitor water quality at specific intervals. Local governments – whose trust and collaboration is established with stakeholder groups – could have used that information to promptly confirm the situation and forced the polluting entity to clean up the spill.

In the 2016 flood case, areas most prone to flooding had no time to mitigate the worst effects of the water while areas (formerly less prone to flooding) were hit for the first time. One underrated aspect of flood risk is current levels of groundwater. In the normal water cycle, rainwater soaks into dry soil and the chance for flooding is low. Now, with the increased magnitude and frequency of “precipitation events”, the soil is still saturated with water which causes rain water to become flood water. This, too, can be identified ahead of time by citizen scientists; in fact, the areas most prone to flooding in West Virginia are already well-known.

Again, volunteers could have been trained to measure groundwater levels at specific locations and intervals, emergency management agencies could have predicted greater flooding risk.

The measurement challenge, however, in the air pollution case, is a more long-term project. These involve more expensive sensors that are installed throughout neighborhoods which continuously monitor ambient air quality over the course of years. While more expensive than their water and soil-related counterparts, they entail less involvement and upload air data to centralized servers.

To mitigate the worst of the damage presented in each of these cases, committed volunteers, buy-in from stakeholder groups, pertinent training and technology, and a shared vision are required. The next section analyzes the ethical dilemmas associated with citizen science as a method for preventing harm from certain environmental policies.

Ethical Dilemmas

Rural Populations:

Following Young, Teixeira, and Hartnett (2015), rural populations do not experience environmental harm equally – their costs, burdens, magnitudes, and experiences are different depending on their location. Due to the nature – and proximity – of the resource extraction industry, rural populations experience “their own unique set of environmental hazard exposures” (p. 2). Over time, various groups have formed to combat these hazards – to varying success. West Virginia, in particular, is a small, rural, low-income state with an extremely geographically diverse population dependent on the very industries that pollute the water, soil, and water. This alone makes it difficult to organize with any regularity.

Citizen Science:

Three such ethical commitments, as identified by Ceccaroni, et al. (2021), are "gaps in the ability to volunteer," "transfer of responsibility," and "privacy" (p. 230-231). Is it fair to shift the burden of scientific research to those most harmed by environmental policy? Does the polluting or regulating entity not have the responsibility to remediate or protect? Further, if lay people are to document these are, do they abide by the same ethical and professional commitments as trained and paid professionals?

Conclusion

This paper has argued that citizen science is a powerful tool for monitoring environmental markers – and increasing democratic agency amongst citizens – with the intent of identifying environmental disasters before they occur. Drawing on Bullard (1983) and Brown (1992, 1997), this proposal uses environmental justice and popular epidemiology as powerful tools to identify, monitor, and mitigate environmental harms. Citizen science, the "voluntary engagement with science" puts those tools in the hands of people closest to those environmental harms. Ethical dilemmas abound, however, as placing responsibility and effort on affected populations may not be just or appropriate. That should not deter hopeful citizen scientists as these environmental markers need to be identified – another Elk River or 2016 Flood disaster could occur. Stakeholder groups should be identified, volunteers should be given the appropriate training and technology, and air, water, and ground quality should be monitored.

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