Video Title:	Civic Bioremediation: Building a Grassroots Network of Soil Practitioners
Student Names:	Annika Hjelmstad, Ariane Jong-Levinger, Ashley Green, Alexis Guerra, Caroline Nguyen, David Christopher Banuelas, Tim Schütz
Community Organization Name(s):	Orange County Environmental Justice (OCEJ)
Faculty Advisor(s):	Connie McGuire

A. Strategy Proposal

In our Phase I video, we demonstrated how historical mapping can be used to better understand the sources of soil-lead contamination in Santa Ana, California. This approach widened the range of potential sources (from lead in paint and consumer products to leaded gasoline) and the scale at which clean-up of contaminated soil will be necessary (not just houses with lead-based paint, but entire census tracts). The strategy that our group proposes to address this lead crisis is to train community members in the science and practice of bioremediation. Bioremediation methods use a combination of plants and fungi to treat contaminated soil. Unlike conventional remediation methods like "dig and dump" – a costly and inequitable solution by which contaminated soil is moved to other communities – bioremediation is safe, inexpensive, and efficient. Bioremediation methods are also more technically accessible and can be executed by the residents of the affected areas. The implementation of a bioremediation program can further yield much needed data on soil contamination mitigation, shedding light on how civic actions can address environmental health disparity issues.

Our **vision** is to create a city-wide network of community leaders (called "soil practitioners") who will be trained in collecting soil samples, measuring soil-lead contamination, and conducting bioremediation using native plants and fungi. The creation of such a network is especially important in light of the newly uncovered scale and extent of contaminated soil, including numerous residential locations such as front and back yards. We will build the network in partnership with the ¡Plo-NO! Santa Ana Coalition described in the Phase I video. The coalition includes Orange County Environmental Justice (OCEJ) as well as public health and bioremediation experts at the University of California. The coalition will lead a series of training workshops on how to measure lead levels, build and maintain a bioremediation site, as well as manage and analyze the collected data. These workshops will take place at OCEJ's offices and at a pilot bioremediation site in Downtown Santa Ana ("pilot site"). Upon graduation, the initial cohort will engage in a coordinated outreach campaign to teach other Santa Ana residents to perform bioremediation in their homes ("affiliated residencies'') and encourage the use of these methods in the broader community.

The campaign will unfold in **three stages** over the course of four years. In **Stage I** (Jan 2024 – Jan 2026) the ¡Plo-NO! Santa Ana Coalition will acquire bioremediation equipment and prepare the pilot site where soil practitioners will participate in a series of hands-on workshops. An initial cohort of 25 resident trainees will enroll in these workshops as paid soil practitioners. The initial cohort will be recruited from OCEJ's existing membership and through canvassing efforts in vulnerable census tracts. Community members will learn how to implement the different stages of bioremediation, including soil preparation, irrigation, inoculation, planting, monitoring, harvest, and disposal. The workshops will also address the use of portable X-ray fluorescence (XRF) machines for measuring soil-lead on site (Clark et al. 1999; Markey et al. 2008). XRF technology is simple enough to operate such that non-experts can be trained to use them correctly and interpret their results. The initial cohort's attendance will be registered and their learning progress will be assessed through initial, mid-term, and final surveys carried out by members of the ¡Plo-NO! Santa Ana Coalition.

In **Stage II** (Jan 2025 – Jan 2026), the soil practitioners will conduct outreach and enroll at least 50 additional households across the eight most affected census tracts in Santa Ana. This part of the program will consist of several visits paid by soil practitioners and OCEJ members to the affiliated residencies, in which the basic know-how and materials are provided to residents to allow them to engage in a bioremediation project on their own properties (especially child play areas). During every visit, soil practitioners will measure lead levels in the soil using a high-quality, portable XRF machine, explain the different stages of bioremediation, and provide the needed materials for each stage (woodchips, mulch, seeds, fungi mulch, and demarcation tools). This outreach process will be documented through surveys, as well as photographs and video recordings of the sites.

In **Stage III** (Jan 2026 – Jan 2028) members of the ¡Plo-NO! Santa Ana Coalition will evaluate the data collected in Stage I and Stage II. First, the coalition will assess the impact of Stage I by analyzing survey data collected at the beginning, mid-stage, and the end of the workshop series. The goal is to assess the initial cohort's knowledge, skills, and level of confidence in the use of bioremediation methods. Second, the coalition will study the impact of Stage II by analyzing survey data collected at the beginning and at the end of the outreach campaign. The coalition members will investigate the extent to which household members in the affiliated residences increased their capacity in the use of bioremediation methods and knowledge about the sources and risk of lead contamination. Finally, the coalition will evaluate the effects of the bioremediation on the levels of soil contamination in Santa Ana. They will examine the extent to which the pilot and resident-led bioremediation projects reduced the amount of lead in the soil by analyzing the data from XRF scanner monitoring and soil samples. Phase III will culminate in a written report that includes results from the data analysis, as well as the launch of an open-access, digital archive that documents how we analyzed the data and successfully implemented our strategy. This stage will be leveraged to secure future funding and continue to build capacity by enrolling additional cohorts of soil practitioners in subsequent years.

B. Description of Community Partner Collaboration

We first developed ideas for our proposal in conversation with members of the ¡PloNo! Santa Ana coalition, composed of environmental advocates with OCEJ, environmental and public health scholars at University of California,Irvine (UCI) (Prof. Jun Wu, Dr. Shahir Masri), and a historian at Princeton University (Dr. Juan Manuel Rubio). In the past four years, the coalition has collected soil samples in Santa Ana and published several peer-reviewed articles on the distribution, risks, and sources of soil-lead pollution in the city (Masri et al. 2020; Rubio et al. 2022). OCEJ also implemented campaigns dedicated to educating youth of color on the history, science, and practice of environmental justice (Environmental Justice Organizing Academy) and hosted focus groups in which residents shared their opinions on soil-lead policies. Following the release of our Phase I Video, OCEJ partnered with other organizations to advocate for effective policy changes in the City's General Plan, including to improve access to blood lead testing for residents through Orange County Health Care Agency, and to focus on bioremediation as a cost-effective, equitable approach.

While reviewing these ongoing efforts, we learned that the coalition had yet to design and seek funding for a more long-term, community-led strategy to remove contaminated soil. Our student group decided to explore in more detail whether a bioremediation program could be organized in keeping with the coalition's community science organizing approach. We consulted with Danielle Stevenson, an applied mycologist and founder of DIY Fungi at the University of California, Riverside. Stevenson is currently leading a study on the effectiveness of bioremediation at an industrial brownfield in Los Angeles County that includes the participation of community residents. Stevenson provided both a comprehensive list of the equipment necessary for bioremediation and advice on how to effectively train community members in the hands-on work of bioremediation. We have adapted Stevenson's advice to the specific needs of the Santa Ana community using contextual knowledge of the city provided by OCEJ.

C. Description of the Use of Publicly Available Data and Tools

The selection of the **pilot site** is based on findings from the soil-lead research project described in the Phase I Video. Based on the study, we know that the downtown area of Santa Ana has the highest concentrations of soil-lead, ranging from 11.4 to 2687.0 parts per million (ppm) (Masri et al. 2020). The California State recommendation for maximum lead concentrations with children present is 80 ppm, a level which was exceeded by 52.7% of residential soil samples according to the coalition's prior work. Further, the oldest roadways are in this area, suggesting that the source of most of the lead in the soil is historic leaded gasoline.

We will use **CalEnviroScreen 4.0** and the coalition's **lead vulnerability index** (Masri et al. 2020) to guide our selection of census tracts and affiliated residencies. The lead vulnerability index is based on both lead pollution burden and population characteristics, including the percentage of residents who identified as Latina/o/x or Hispanic, immigrant non-native residents, residents who reported speaking no or limited English, residents who did not have health insurance coverage, residents under five years of age, renter-occupied housing units, and residents with a college education level or higher. The latest version of the CalEnviroScreen mapping tool features a score for lead pollution, calculated based on the age of buildings and proportion of low income households with children. Based on data from our bioremediation project, we will compare the CalEnviroScreen lead pollution variable (focusing on paint) with the soil-lead levels and see how they correlate with each other. Our data can be helpful for updating the CalEnviroScreen lead index in the future.

For soil samples with lead levels over 400 ppm (EPA standard for child play areas), community leaders will be able to take **dust swabs and paint chip samples** from the homes (built before 1970) and send them to a lab for isotopic analysis. The goal will be to determine potential dust-related lead exposure and to identify the isotopic fingerprint of lead paint in order to determine the origin of lead in the soil. This data was missing from the ¡PloNo! Santa Ana coalition's prior isotopic analysis and therefore would fill an important gap.

Data used in and collected for the project will be stored in the digital Santa Ana Environmental Justice Archive hosted on the Disaster-STS Network, an open-source data infrastructure developed by researchers at the UCI. The digital infrastructure was designed in keeping with the theory and practice of intersectional environmental justice, bringing together community, academic, and media expertise. The data infrastructure will 1) help preserve heterogeneous data (from historic maps to interview transcripts and video recordings), 2) enable intuitive use by local activists to support their campaigns, and 3) support cross-site comparisons in research and cross-site advocacy initiatives. Collaborative analysis of the data is supported by a set of analytic structures (see data resources or environmental hazards, for example), rendering findings open and available for re-interpretation. Our proposed "Santa Ana Soil-Lead Archive" can be developed and preserved over the long term on the Disaster-STS Network. The Disaster-STS Network also has capacity to support digital environmental justice archives developed by other communities (see St. Louis "lead garden" video). We will thus build a model archive, while also starting the process of developing robust digital infrastructure for diverse, interlinked urban communities dealing with soil-lead contamination.

D. Resource Needs for Strategy Implementation

Resources	Cost estimate
Training and Compensating Soil Practitioners: A total of 25 soil practitioners will be recruited for the bioremediation activities planned. Soil practitioners will be trained in the bioremediation techniques and safety protocols, including Hazardous Waste Operations and Emergency Response (HAZWOPER) training at $250 per person. The training will be co-facilitated by scientists from the ¡Plo-NO! Santa Ana Coalition at UCI and through paid consultation by Danielle Stevenson at UC Riverside.	**$50,000**

XRF Machines: The project will require acquisition and maintenance of two high-quality XRF machines, one stationary (for the common site, $10,000) and one portable (for affiliated residencies, $15,000). XRF scanners will be used to collect spatially relevant, quantitative data about soil-lead levels in the areas selected for bioremediation. Under supervision by OCEJ staff, community members will use the XRF scanners once per year to measure the levels of lead in the soil around their residences. Maintenance and repair of XRF scanners will cost around $15,000.	**$40,000**
Plants and Fungi: California Buckwheat (*Eriogonum fasciculatum*) and California Telegraph Flower (*Heterotheca grandiflora*) are native plant species that will be used for this project. Plant seeds are anticipated to cost $1,000 for each of the 50 household sites ($800 for native plant seeds and $200 for mycorrhizal fungi). The plant species are sold from S&S Seeds who will provide seed stock adapted to Santa Ana's microclimate. Since plants alone cannot absorb lead, fungi will be added to increase the plants' lead uptake from soil into the root biomass. Prior to establishing plants in project plots, seedlings will be raised in a greenhouse and amended with mycorrhizal fungi. The commercial inoculum ($2,000) will be purchased from Tree of Life Nursery, who has developed a mycorrhizal product specifically suited for the Southern California climate. Seeds will be harvested annually to help propagate new seedlings at existing or new plots. Over time seed collections will establish plants highly adapted to lead contamination, reducing long-term costs and increasing community resilience.	**$52,000**
Watering and Irrigation: Equipment for setting up and irrigating the pilot site will cost around $6,000. For bioremediation at affiliated residencies, we will rely on residents' water access and capacity to water the plants. An annual rebate of $1,000 will be issued for each of the 50 affiliated residencies to cover additional water expenses for three years (total $36,000).	**$42,000**
Horticultural supplies and Personal Protective Equipment (PPE): Wood chips, mulch, moisture monitoring devices, and gardening tools are anticipated to cost $800. Flags to demarcate different sections of the remediation site are also required and will cost $200. Personal Protective Equipment will cost around $2,000.	**$12,000**
Sampling and Testing: A small percentage of samples from the XRF scanners will be verified using soil samples, focusing on locations where XRF readings are extremely high (>400 ppm). Testing of the soil for a selected number of samples can be performed by scientists at the UC Riverside lab for about $30 per test. Isotopic analysis of dust swabs and paint chips will be $150 per sample.	**$5,000**
Documentation and Digital Archive: The Santa Ana Soil-Lead Archive will be developed by group member Tim Schütz. Expenses include hourly compensation for software development and data management (soil-lead datasets; photographs, audio and video recordings). Cameras and other multimedia equipment for data collection can be borrowed from UCI.	**$5,000**
Total	**$206,000**

E. Barriers to Strategy Implementation

Through focus groups and a preliminary survey (*n*=33) conducted by OCEJ, we have learned that residents are in favor of bioremediation as opposed to traditional remediation. However, residents have concerns about the bioremediation process since plants can become biohazards after absorbing the lead out of the soil. Residents are concerned about the safety of people working with the soil and the possibility of releasing lead into the air. Residents also felt that practitioners should be adequately financially compensated for their labor and provided with necessary protections while performing this work. A way to address these concerns is to have an extensive safety and training process to ensure that workers are both adequately compensated and protected from the lead in the soil.

Members of the core cohort will likely be unfamiliar with soil-lead research practices and remediation technologies used, requiring substantial training to address concerns about handling of equipment, and data collection protocols. The training will also need to build capacity among residents to teach the remediation methods to others, including family members and friends. A related barrier could be effective outreach to non-English speaking communities, including Latinx, Vietnamese, and Cambodian residents. In prior projects, OCEJ has developed outreach materials in multiple languages that communicate the soil-lead campaign. Ensuring broad community outreach and participation in different languages will be a key goal for recruitment of the core cohort, training, documentation, and evaluation of the project in the digital archive and related publications. Data collection and collaborative stewardship of personal data stored in the digital community archive will require approval from UCI's Institutional Review Board (IRB).

The large number of residential sites to be remediated could present a limit to the scope of the project. Prior studies suggest that at least eight census tracts (753.03, 754.01, 751, 750.03, 750.04, 744.05, 746.01, and 746.02) are highly impacted. Depending on participation, the project team could decide to prioritize the census tracts with the highest concentrations of lead (750.03, 750.04, 751, and 753.03). Before bioremediation activities on the pilot site in Downtown Santa Ana can occur, approval from the City of Santa Ana is necessary.

F. Measures of Successful Strategy Implementation

Program success will be measured as follows:

- **Bioremediation training effectiveness** will be measured through a pre-training, mid-term, and post-training survey administered to each trainee to assess how much their understanding of how to implement soil-lead bioremediation has improved over the course of the training.
- **Success in training and program retention** will be measured by the number of trainees who (i) enroll in the first cohort, and (ii) graduate from the program.
- **Outreach effectiveness** will be measured by (i) the number of community members to which trained leaders reach out, and (ii) continued enrollment numbers in subsequent cohorts.
- **Soil-lead bioremediation** will be evaluated by (i) decreases in soil lead measurements over time at each site, and (ii) observations showing that soil lead levels fall below relevant EPA thresholds.
- **Dissemination** will be evaluated by tracking traffic on the digital archive website and related multimedia outputs (reports, audio documentaries, etc.). The soil-lead monitoring data will be regularly reported to the community in a newsletter and social media posts to foster transparency and to encourage community members to join future cohorts of the training program. We will also quantify the number of Santa Ana residents that attend public events hosted by the coalition about soil-lead remediation. Another important measure of success will be the extent to which we can grow our network to include community partners outside Santa Ana..

By implementing our Civic Bioremediation Strategy, publicly available data and community voices will become an integral part of environmental governance in Santa Ana, supporting regional, cumulative environmental injustice analysis and building the capacity of essential community organizations such as OCEJ.