2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39377

# Community-University-Government Partnership to Advance Environmental Justice and Address River Water Quality Concerns

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# Community-university-government partnership to advance environmental justice and address river water quality concerns


## Abstract

This paper presents a community-university-government partnership to advance environmental justice and address river water quality concerns for the Mill River of south-central Connecticut (USA) through an undergraduate student research experience. Community engagement was initiated with the Fair Haven neighborhood of New Haven, CT (USA), an environmental justice community, through a series of steering committee meetings. The meetings brought together over 50 different individuals, community groups, environmental organizations, universities, and municipalities. A concern of river water quality adjacent to a decommissioned power plant was identified. Ball Island is home to a retired power plant that is currently being remediated for PCBs (polychlorinated biphenyls), an endocrine-disrupting, persistent pollutant. Testing for PCBs in the river water was important as PCBs may be transported and pose a risk to community members who recreate and fish for sustenance in the river. Through an undergraduate research experience, a total of 48 water samples were taken from the Mill River around Ball Island and one upstream control. Samples were analyzed using GC-MS (gas chromatography–mass spectrometry) after a hexane extraction following ASTM D5175-91. Mass spectra were evaluated in comparison to known standards to determine whether PCBs were present. PCB levels were below detection limits (0.14 to 1.10 ng/L) for all samples. The project offered a valuable undergraduate student research experience and benefit for community members addressing their water quality concerns.


## Background

### *Community-university-partnerships*

Community-university partnerships are collaborations between communities and universities to achieve shared goals through community-engaged scholarship [1] [2, pp. 463–469]. Key tenants of community-university partnerships and community-based research involve genuine reciprocity, mutual benefit for communities and participating students [1], building connections within and between organizations [3, Vol. 4], generation of knowledge to meet a community identified need, involving the community throughout, from problem definition to results dissemination [4, pp. 412–428] and funding [3, Vol. 4].

Community-university partnerships are embraced worldwide [5, pp. 121–138] addressing a wide range of topics. Examples of engineering and water related projects include urban design [6, pp. 48–56], geography and urban studies [7, pp. 43–57], water supply in rural communities [8, No. 15], groundwater contamination on reservations [9], and sustainability and water conservation [10, No. 2]. Organizations like EPIC-N and Campus Compact serve to foster community-university partnerships and civic engagement [11] [12].

### *Environmental justice*

Community-university partnerships have played a role in advancing environmental justice since the inception of the movement in the 1980's and continue to do so through community-engaged scholarship [13, p. 412] [14, p. 173]. Environmental justice is the, "fair treatment and meaningful involvement of all people…[such that]…everyone enjoys…a healthy environment in which to live, learn and work [15]."

Environmental justice (EJ) communities are broadly recognized as communities that bear disproportionate environmental burden. EJ communities, for example, may be proximate to transportation/highway related sites that cause air pollution, existing or proposed landfill and hazardous waste sites or discharge from poorly managed wastewater treatment plants [15]. Multiple factors contribute to the existence of EJ communities. The US Environmental Protection Agency EJ indices consider environmental indicators, such as ozone levels, traffic proximity, hazardous waste proximity, and wastewater discharge, in combination with socioeconomic information, including percent low income, percent unemployed, and percent of population with lower than a high school education [16]. In Connecticut, similar metrics are used by the CT Department of Energy and Environmental Protection to classify EJ communities [17].

### *Water quality and polychlorinated biphenyls (PCBs)*

Polychlorinated biphenyls (PCBs) are manmade, endocrine disrupting, persistent compounds made up of biphenyls ($C_6H_5C_6H_5$) attached to multiple chlorine ions. PCBs have permanent and irreversible effects to humans, especially pregnant women and children [18, pp. 378–384].

The presence and concentration of PCBs in surface water bodies has been evaluated globally, such as in the Mississippi River at New Orleans, Louisiana (USA) [19, pp. 1057–1069], river water in Madrid and Burgos, Spain [20, pp. 1913–1924], in Daya Bay, China [21, pp. 373–384] and Ontario, Canada [22, pp. 1841–1848].

Sources of PCBs in surface water bodies have not been definitively studied, though decommissioned power plants represent a potential source. Prior to the ban of PCB manufacture in the United States in 1979, PCBs were commonly used in transformers present in power plants and commonly in the Northeast United States [23]. A decommissioned power plant may have PCBs mobilized and carried to surface water bodies through rain events and surface water runoff. From there, people may be exposed to PCBs in water either through direct contact from recreation or through consumption of aquatic organisms, as PCBs bioaccumulate [24, p. 012031].

## Objectives

The goal of this project is to advance environmental justice through a community-university-government partnership. The specific objectives were to 1) facilitate a valuable, undergraduate research experience and 2) address community river water quality concerns.

## Methods

A community-university-government partnership, implemented in observance of key tenants of community-university partnerships and community-based research, informed scholarly research activities. Research presented in this paper was conducted by a civil engineering student through an undergraduate summer research experience addressing community-identified water quality concerns.

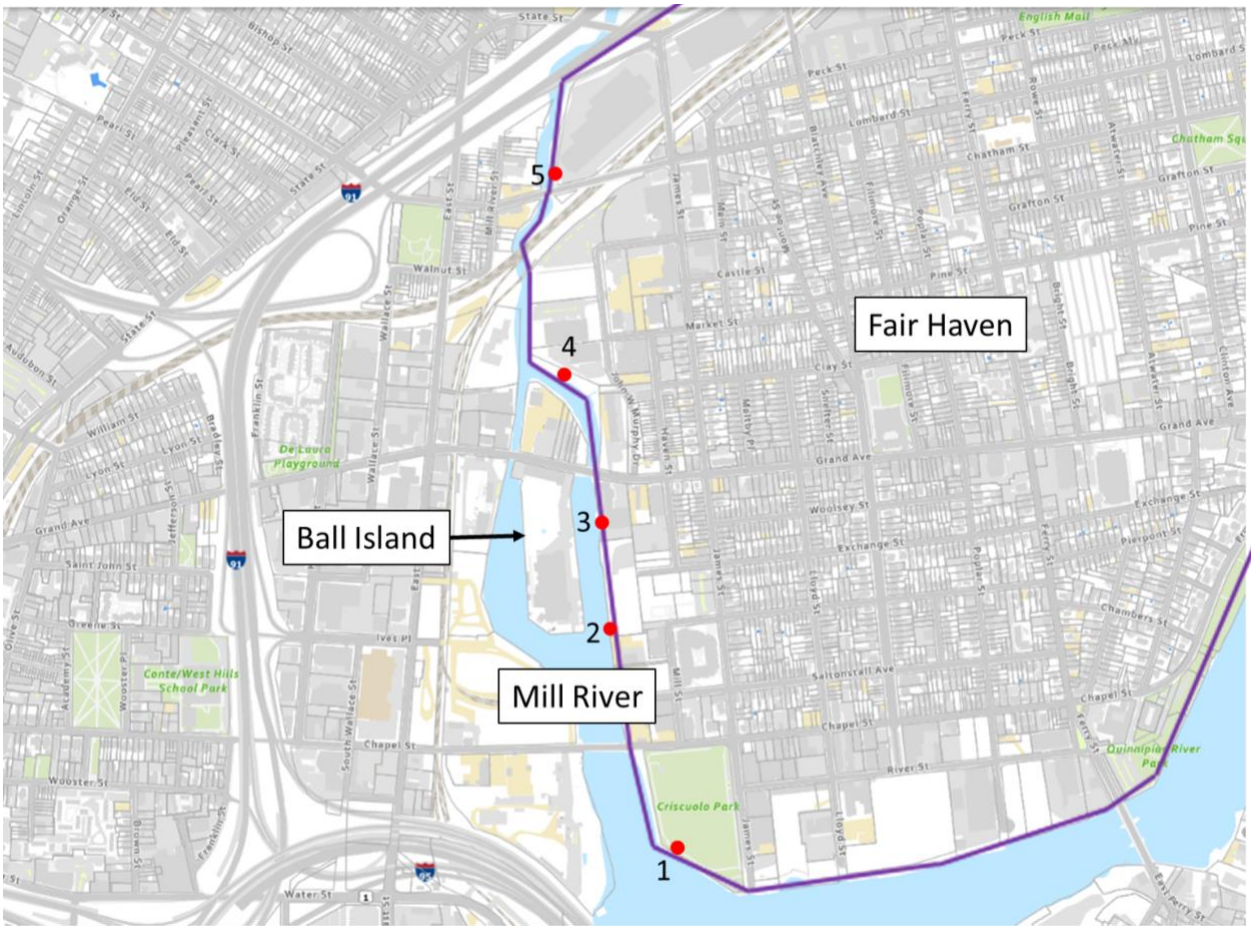


**Figure 1 - Fair Haven neighborhood, bounded by purple, of New Haven, CT (USA) with Mill River and Ball Island to the west. Water sampling locations 1-5. Backdrop image from New Haven GIS.**

### *Community-university-government partnership*

The community-university-government partnership for this paper consists of the urban community of Fair Haven in New Haven, CT (USA) and affiliated organizations, Quinnipiac University and the government partner of the Connecticut Department of Energy and Environmental Protection (CT DEEP). The Fair Haven neighborhood, shown in Figure 1, is an urban community that is approximately one square mile in size and has roughly 16,000 residents within New Haven, CT (USA). Fair Haven is along the Mill River and is classified as an environmental justice community by the Connecticut General Statutes [25] and by United States

Environmental Protection Agency (US EPA) indexes. Fair Haven exceeds the 90$^{th}$ percentile regionally and 80$^{th}$ percentile nationally for all EJ Indexes defined by the US EPA [26].

## Mill River Urban Waters Initiative

The community-university-government partnership was brought to fruition through the Mill River Urban Waters Initiative (UWI). The Mill River UWI is a pilot project for the Mill River of south-central Connecticut, administered through the CT DEEP from a US EPA grant. The Mill River UWI is specifically dedicated to promoting EJ and improving water quality in urban areas of the Mill River. The vision of the Mill River UWI is to facilitate unification around water quality and community participation and engagement in the Mill River, addressing a key tenant of community-university-government partnerships to build connections within and between organizations.

The UWI proposal process focused on creative partnership, fostering collaboration and building connections between groups and organizations. The process included solicitation of local stakeholders to discuss project ideas in a series of steering committee meetings. This was innovative as the steering committee meetings occurred in advance of the proposals for funding. Soliciting local stakeholders involved a substantial and ongoing outreach effort to environmental, community groups, schools, universities, government, and municipal organizations with a special focus on Fair Haven-based groups including cultural organizations, churches, schools, libraries, etc. This effort was largely spear-headed by one of the UWI partner organizations, Save the Sound, that has an existing working relationship within the Fair Haven community. Solicitation of stakeholders and advertisement of steering committee meetings occurred through various mechanisms including social media, email, phone call, and through flyers posted in public spaces like the local library.

Outreach brought individuals and groups together during 2020 and 2021, via Zoom, in a series of six, 1.5 hour long steering committee meetings. The steering committee chair, Kimberly DiGiovanni, a co-author on this paper, facilitated the steering committee meetings with other members to create meeting agendas intended for conversation and exchange about what the current condition of the Mill River is, how people are currently engaging with the river and the future vision for the Mill River. Detailed meeting minutes were taken at each meeting, shared and reviewed with the group. Collaborative tools such as Jamboard were used to coalesce ideas around common themes and funding teams. The Mill River UWI brought together roughly 50 different environmental groups, schools, government and municipal organizations around two central themes 1) Community engagement (augmenting community voices) and 2) Community science (water quality and citizen science) for which funding was awarded.

While concerns around the retired English Station powerplant on Ball Island adjacent to the community were raised during steering committee meetings, they fell outside the scope of funding for the Mill River UWI. These concerns did, however, lead to the development and execution of an undergraduate research experience focused on river water quality testing for PCBs as presented in this paper. In so doing, another key tenant of community-university partnerships was addressed to generate knowledge to meet a community identified need. Actions

around other themes and topics including photovoice method [27, No. 4] to augment community voices, citizen science to test water quality and floatable trash collection/categorization in conjunction with community art projects, are presented elsewhere [28].

### *Undergraduate research experience*

Undergraduate research was supported through the Quinnipiac University Interdisciplinary Program for Research and Scholarship (QUIP-RS) and You Got This Kid! Leadership Foundation. QUIP-RS is an eight-week, full-time, summer research experience where students work with faculty on a student-driven research experience [29]. The civil engineering undergraduate student involved in this research, a co-author on this paper, was intrinsically motivated to work on an environmental justice project. He considered various potential projects based on the needs identified from the Mill River UWI steering committee meetings and developed a proposal for PCB testing in the Mill River.

QUIP-RS invites applicants from all undergraduate disciplines across the university and projects are selected for funding through a competitive application process. The program is advertised each year in various ways including email to all undergraduate students, posting on the university website, in class by faculty members, flyers around campus and word-of-mouth. Information sessions are held in advance of the due date for applications. During the eight-week program, all program participants, students and faculty mentors, come together in weekly meetings to share research and engage in various social, e.g. hiking together and professional development activities e.g. presentations on the peer-review process for publication and how to prepare a poster. QUIP-RS culminates in a poster symposium held during fall semester.

To assess the value of the undergraduate research experience to the student, a selection of Likert-scale and open-ended survey questions were evaluated, specifically:

1. How would you rate the QUIP-RS program overall? (5-point Likert scale with options of Excellent-Very Good-Good-Fair-Poor)
2. How do you feel that the QUIP-RS program has supported your ambitions and/or impacted your future career? (Open-ended)
3. What do you consider to have been the best aspect(s) of your experience with QUIP-RS? (Open-ended)
4. What outcomes (e.g., conference presentations, articles, projects, poster presentations, etc.) do you expect from your QUIP-RS project? (open-ended)

These questions are part of a 20-question assessment survey administered through Qualtrics following completion of the QUIP-RS program. The survey questions solicit feedback from participants, both students and mentors, using a combination of Likert scale questions and open-ended questions. Questions generally ask respondents to rate QUIP-RS overall, the weekly programs, the fall symposium, impact on their future career, support of diversity, equity and inclusivity and expected outcomes. While survey respondents may remain anonymous, the undergraduate research student involved in this project agreed to share his responses for this paper.

***River water quality testing for PCBs***

Sampling Locations

Water quality sampling was conducted in the Mill River (of south-central Connecticut) around Ball Island (41.30895, -72.90696), New Haven, CT (USA). Ball Island is site of the retired English Station Power Plant and has known PCB contamination [30]. Stormwater runoff from Ball Island enters the Mill River directly, representing a potential source of PCB contamination to the river.

There are six (6) total sampling locations, with five locations immediately surrounding Ball Island (Figure 1) and one upstream control. Location 1 is at a fishing dock in Criscuolo Park, New Haven, CT. The fishing dock was chosen specifically because it represents a potential source of direct exposure to people using the dock including Fair Haven residents, some of whom fish and crab for sustenance. Locations 2-5 are located downstream, immediately adjacent and upstream of Ball Island and were selected given their proximity to Ball Island, potential source of PCBs. Also, previous studies found PCBs in the river sediment at those locations [31] [32]. The control location is several miles upstream above a dam where the water is non-tidal and not impacted by Ball Island or other potential PCB sources located in New Haven harbor.

Water Sampling

Samples were collected from the Mill River following a grab sampling procedure adapted from ASTM D5175-91 Section 10.1 [33] and [34, pp. 2477–2486]. The notable adaptation to the ASTM sampling procedure was that a swing sampler pole, as seen in Figure 2, was used in lieu of sampling by hand. Hand sampling was not possible at the study sample locations because direct access to the river was not feasible. Study samples were collected from bridges or docks e.g. Figure 2. Sample bottles were attached to the swing sampler pole which was lowered into the river. Sample bottles were rinsed two times using the river water at the sampling location before a sample was taken. Samples were collected at a depth of approximately 0.5 m consistent with the methodology presented in [34, pp. 2477–2486]. As specified in ASTM D5175-91, 75 µL of sodium thiosulfate (0.04 g/mL) was added to each sample. Samples were stored in a cooler until they were returned to the laboratory and stored in a 4°C refrigerator for extraction and analysis. A total of 48 samples were collected from the Mill River on eight sampling expeditions during June and July 2021. Samples were taken during wet-weather and dry conditions and on incoming and outgoing tides at a roughly one-week frequency.

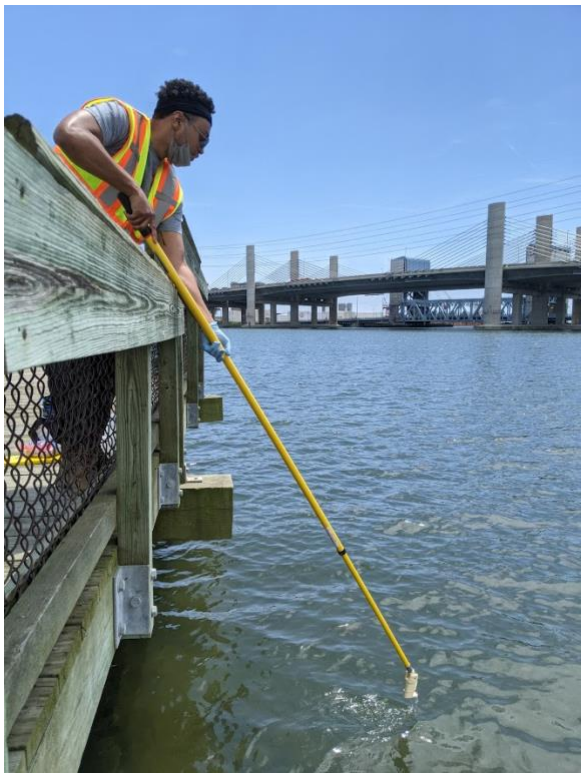

**Figure 2 – Undergraduate student researcher, Connor Becerril, sampling at location 1**

**Figure 3 - Undergraduate student researcher, Connor Becerril, performing a hexane extraction in the laboratory**

GC/MS (gas chromatography–mass spectrometry) testing

Sample preparation and extraction (Figure 3) followed ASTM D5175-91 Sections 13.1 and Section 13.2. All samples were analyzed within one week of collection. GC/MS testing was performed using a Thermo Fisher ISQ7000 single quadrupole gas chromatograph-mass spectrometer following the protocol outlined in Thermo Scientific's Analysis of Poly Chlorinated Biphenyls (PCBs) by GC/MS [35]. TriPlus RSH autosampler was used. Four PCB standards were used, PCBs with seven, eight, nine and ten chlorines respectively. The limit of detection for four PCBs from the PCB standard mixture was estimated to be between 0.14 to 1.10 ng/L. For reference, detection levels were well below the United States Environmental Protection Agency National Primary Drinking Water Regulations for PCBs of 500 ng/L. Each congener had a slightly different response within the instrument, hence the range in limits of detection.

## Results

### *Undergraduate Research Experience*

The undergraduate student researcher's responses to post-participation survey questions are listed below in Table 1.

**Table 1 - Undergraduate student researcher responses to survey questions**

| Survey Question | Response |
|---|---|
| How would you rate the QUIP-RS program overall? (5-point Likert scale with options of Excellent-Very Good-Good-Fair-Poor) | Excellent |
| How do you feel that the QUIP-RS program has supported your ambitions and/or impacted your future career? (open-ended) | The QUIP-RS program has directly impacted my career in a positive way. The research conducted with QUIP taught me how to work on a project that required precision and technical abilities that I did not have before. In addition to this, the program also helped me connect to a community that I want to work with. |
| What do you consider to have been the best aspect(s) of your experience with QUIP-RS? (open-ended) | The best aspect of the QUIP-RS was the balance between conducting an independent study while having supportive faculty to assist as needed. If the program allowed me to conduct the experiment without guidance, I would have likely collected poor data. The faculty also gave me freedom to decide how the experiment would be conducted. Overall I was given a chance to make my own decisions while having effective assistance. |
| What outcomes (e.g., conference presentations, articles, projects, poster presentations, etc.) do you expect from your QUIP-RS project? (open-ended) | I would like to see that the research project will be used to assist a community that has faced environmental based injustices. Additionally, I expect that the paper would have an opportunity to be published by a peer-reviewed journal. |

Importantly, observing key tenants of community-university partnerships, the findings of the research were shared, involving the community from problem definition to results dissemination. Results were shared directly with Mill River UWI partners and through presentations at meetings of the Mill River Watershed Association and partner organizations. There was generally relief that PCBs were not found in the water, suggesting that they are not readily transported from Ball Island into the river water. Though, there was skepticism that PCBs may still be transported to the community in other ways including atmospheric transport and deposition.

### *PCB Testing*

PCB levels in all the 48 samples collected and analyzed were below detection limits. Figure 4 shows the mass spectra of a PCB standard, Aroclor 1242, used in the study. Notable signatures of PCBs are identified on the mass spectra including the presence of "double spikes", differences of 35 m/z corresponding to the molar mass of chlorine and alternating intensities.

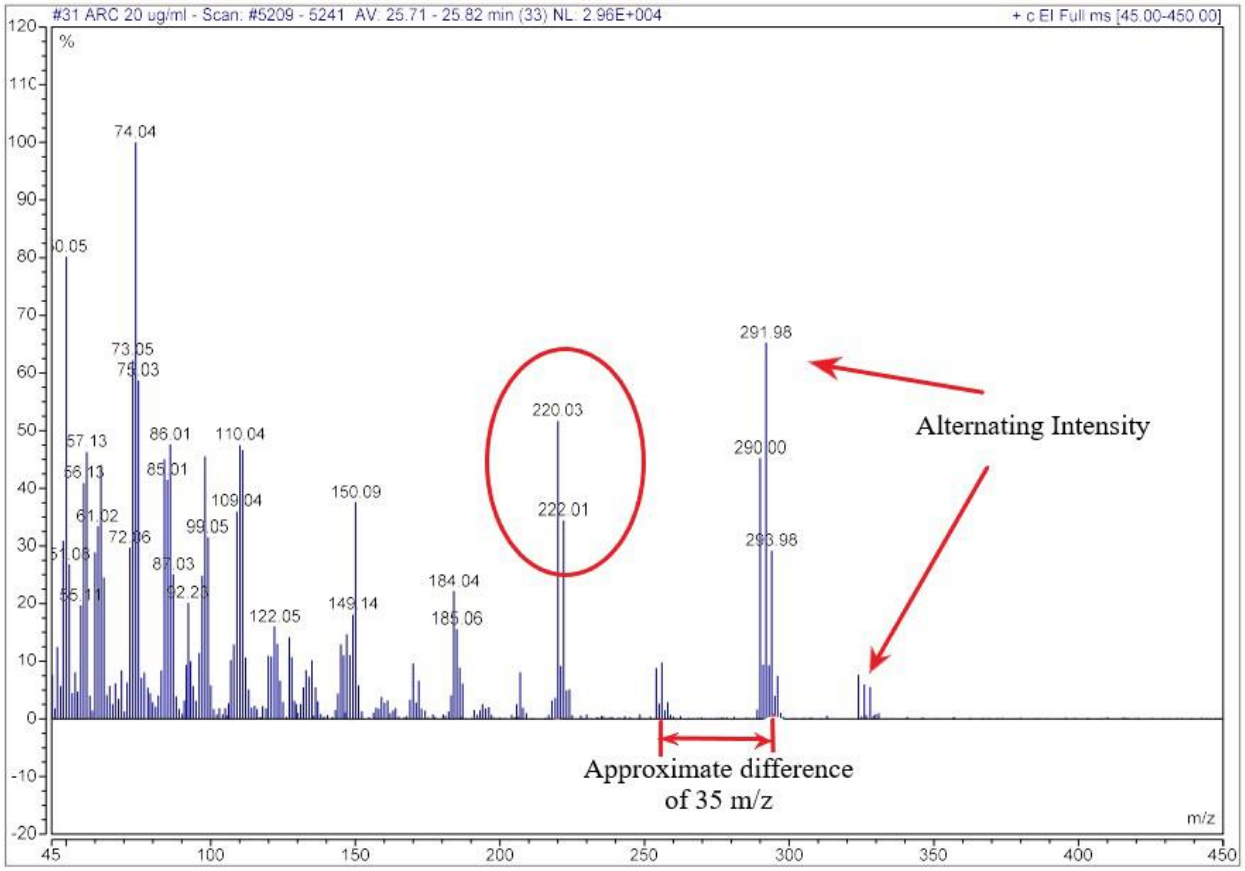


**Figure 4 - Mass Spectra of a PCB standard (Aroclor 1242)**

Figure 5 and Figure 6 below show the spectra for samples which substances were present within the range anticipated to find PCBs but were concluded not to be PCBs due to a lack of signature characteristics. The unknown substances were run through the mass spectrometer database with no results found.

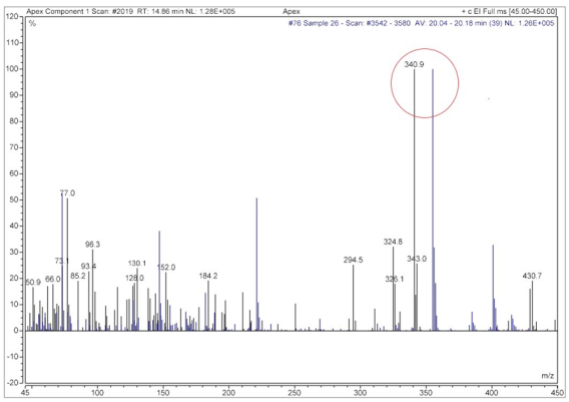

**Figure 5 - Mass Spectra of an unknown substance. Note the lack of alternating intensity.**

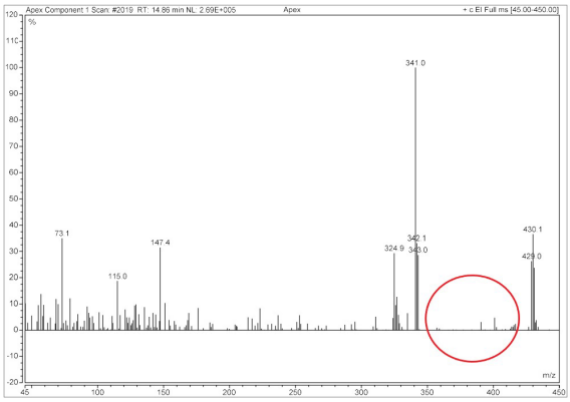

**Figure 6 - Mass Spectra of an unknown substance. Note the lack of double spikes**

## Discussion and Conclusions

Our study highlights a community-university-government partnership that informed a valuable and mutually beneficial undergraduate research experience. Survey responses from the undergraduate researcher highlight the value of the experience, augmenting his technical skills, providing connection to a community, and opportunity for self-directed research with faculty guidance. Notably, the undergraduate researcher was intrinsically motivated to pursue his research project and expressed, "I would like to see that the research project will be used to assist a community that has faced environmental based injustices." Through his work, the community benefited as a community concern was addressed. No detectable levels of PCBs in the waters of the Mill River around Ball Island were found, suggesting that PCBs from the retired English Station Power Plant on Ball Island are not readily being transported from the site into the water of the Mill River. Importantly, the results of these findings were shared back to the community through various avenues including presentation at the Mill River Watershed Association, partner organization meetings and direct communication with individuals at community organizations. Other forms of transport, notably atmospheric deposition of PCBs, are still a concern and provide direction for future research.

## Acknowledgements

We would like to thank the following individuals and organizations for their valuable contributions to this work. The Mill River Urban Waters Initiative (UWI) stakeholders, especially Fair Haven community members and community groups who participated and shared their knowledge and experiences. This work was possible because of their engagement and collaboration. Save the Sound and Southwest Conservation District for their leadership in the community engagement and community science for the Mill River UWI. Mill River Watershed Association for coordination and support of the Mill River UWI. Connecticut Department of Energy and Environmental Protection (CT DEEP) for funding the Mill River UWI, through a United State Environmental Protection Agency grant, participating in the Mill River UWI and providing access to relevant data and information. CT DEEP and Yale School of the Environment for their insight and feedback on the work which enhanced our analysis; we deeply appreciate their efforts. Quinnipiac University Interdisciplinary Program for Research and Scholarship (QUIP-RS) and the You Got This Kid! Leadership Foundation for funding the undergraduate student research experience, fostering a community of scholarship, and supporting environmental initiatives.

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