Sustainability Studio Presents:

Environmental Wellness and Health

A report developed by the ENVIR 480: Sustainability Studio class of Winter 2018
Acknowledgements:

- **Kristen Dotson**, Miller Hull Partnership, Sustainability Services Director
- **Aris Efting**, Environmental Policy and Sustainability
- **Chris Helstern**, Miller Hull Partnership, Living Building Challenge Services Director
- **Peter Kahn**, UW Department of Psychology, Professor
- **Rick Keil**, UW Environmental Studies, Director
- **Monali Patel**, UW Environmental Studies, Communication Specialist
- **Teri Thomson Randall**, UW Livable City Year Program Manager
- **Hillary Sanders**, Puget Soundkeeper Volunteer Coordinator
- **Deborah Sigler**, UW Center for Integrated Design, Discovery Commons Program Manager
- **Ana Wieman**, UW Environmental Studies, Adviser
Student Groups:

**Duwamish Cancer Alley: Health Impacts of and Solutions to Industrial Pollution** (in collaboration with the Miller Hull Partnership)
- Tiara Adler, John Ericksen, Ankush Puri, Anneliese Smyth, Kaelyn Thede

**Supply Chain Impact Analysis: Concrete vs. Wood** (in collaboration with the Miller Hull Partnership)
- Julia Chiado, Nazmah Hasaan, Joshua Jones, Eli Maesner

**Microplastics in UW’s Drinking Water** (in collaboration with the Puget Soundkeeper Alliance)
- Gigi Dawn, Madison Hoiland, Perla Moran, Lauren Neroutsos, Ann Samson

**Vinyl Windows** (in collaboration with the Miller Hull Partnership)
- Minghao Gao, Joy Shang, Uyen Tran

**Composting Toilets** (in collaboration with the Miller Hull Partnership)
- Rori Kirkpatrick, Lauren Campbell, Gina Durst, Erika Gertsen, Rori Kirkpatrick, Josephine Wu

**A Look into Tacoma’s Communities: Values, Concerns, & Barriers** (in collaboration with UW Livable City Year, Tacoma)
- Meghan Avila, Gabriella Chilczuk, Anna Mckee, Katie Ort
Introduction

This winter quarter, our class explored the topic *Environmental Wellness and Health*. This means understanding the relationship and interaction between people and the environment. Today, humankind has quite the reputation for harming our natural surroundings, whether through resource exploitation, pollution, and even climate change, which has many other downstream effects. Additionally, we have created a man-made environment that harms, not only our natural surroundings, but human health as well. Poor air quality, hazardous building materials, contaminants in our drinking water, and even a sedentary lifestyle all affect our long-term physical and mental health.

As we learn more about our impacts on the environment as well as the many benefits a healthy environment has on us, major efforts are taking place to restore that symbiotic balance between us and the place we live. How can we create healthier surroundings for ourselves? How can we lead a lifestyle that is respectful and responsible toward the environment and its natural resources?

Our class explored possible solutions by partnering with Miller Hull Architects, the Puget Soundkeeper Alliance, and the University of Washington Livable City Year on a range of projects, including mapping pollution & health impacts along the industrialized Duwamish River, comparing the sustainability of several commercial building materials, measuring the level of microplastics in our drinking water, exploring the feasibility of composting toilets and conventional toilets for water-saving purposes, making a case against the cost-effectiveness & health impacts of vinyl windows, and preserving green open spaces in Tacoma, Washington.

The success of our class would not have been possible without the support of our guest lecturers, Peter Kahn, a professor from the UW Department of Psychology, Kristen Dotson, the Sustainability Services director at Miller Hull, and Chris Helstern, the Living Building Challenge Services director at Miller Hull. Additionally, thanks to Deborah Sigler for providing a tour of the Bullitt Center, considered to be the most sustainable commercial building in the world given its environmentally-friendly design and its efforts to increase occupational health within.

Our class report demonstrates an important need to promote environmental wellness and health, not only for our generation but future generations as well. The following student reports will elaborate in more detail these challenges across the UW and Greater Puget Sound region and will highlight recommendations to optimize sustainability.
# Table of Contents

Acknowledgements ...................................................... ii

Student Groups ...................................................... iii

Introduction ........................................................ iv

Duwamish Cancer Alley: Health Impacts of and Solutions to Industrial Pollution ........................................... 1

Supply Chain Impact Analysis: Concrete vs. Wood ............................................................ 19

Microplastics in UW’s Drinking Water ................................................. 35

Vinyl Windows ....................................................... 49

Composting Toilets ................................................... 64

A Look into Tacoma’s Communities: Values, Concerns, & Barriers .................................................. 81

Conclusions .......................................................... 94
Duwamish Cancer Alley: Health Impacts of & Solutions to Industrial Pollution

Group Members: Tiara Adler | John Ericksen | Ankush Puri | Anneliese Smyth | Kaelyn Thede

Client Partner: Chris Hellstern | Miller Hull

Figure 1. Lower Five-Mile Stretch of the Duwamish Waterway: displays the most heavily polluted section of the Duwamish River (Brown, 2013).
Table of Contents:

Introduction 3-5

Methods & Findings 6-7

Results 8-12

Shortcomings of Data 13

Conclusions 14

Next Steps 15

Main Points 16

Works Cited 17-18
Introduction

The Duwamish River and surrounding lands have been crucial to shaping the history and ecosystems of Seattle. As an indigenous spiritual and resource epicenter, this waterway was used for hunting, fishing and harvesting marine species, gathering plants, and transportation until its colonization in the mid-1800s.

Amidst Salish erasure and industrialization, spaces for refining production materials and manufacturing became highly desirable. The dredging and straightening of this meandering river throughout the early-1910s established these spaces by providing access to the region for barges and larger vessels, shown on the right. Industrial manufacturing along the Duwamish has since provided countless jobs, numerous material goods, and massive economic growth for the greater Seattle area.

For decades, these industries have utilized the Duwamish for the production, storage, and distribution of various industrial commodities. While providing these resources, however, industrial processes have instigated tremendous environmental stressors. Toxic pollutants have leached into the river, surrounding groundwater, sediments, wildlife, and peoples, provoking a myriad of environmental, social, political, and economic challenges. Our focus for this investigation engages directly with how each of these adversely affect human health.
Highest concentrations of pollutants are located in the lower five-mile stretch of the Duwamish Waterway, shown on the right. This expanse is densely industrialized, contaminated by toxins produced by former factories and present-day operations. The Environmental Protection Agency (EPA) declared the Lower Duwamish Waterway a Superfund Site in 2001. Superfund Sites are the most toxic hazardous waste sites in the nation, and are identified to pressure future cleaning in the region (WA Department of Ecology, 2018). Projects similar to the Duwamish River Cleanup Coalition have been working to remove toxins since its superfund proclamation (Duwamish River Cleanup Coalition; Technical Advisory Group, 2018). Their efforts have made progress in building community and fostering feelings of ownership, but there is still much work to be completed regarding industrial pollution and human health concerns.

Georgetown and South Park, marginalized communities neighboring this waterway, are among the most affected populations. Indigenous peoples, including the Squamish, Duwamish, and Muckleshoot tribes, are also disproportionately impacted by this pollution, as this river is one of few migratory paths used by native salmon. The Squamish and Muckleshoot tribes were allotted treaty rights to fish in the Duwamish, and continue to do so despite toxin presence in marine species (Daniell, Gould, Cummings, Childers, & Lenhart, 2013). Warning signs surrounding fishing zones are in English, establishing significant barriers for the diverse populations living and working near the Duwamish. South Park is inhabited by over fifty percent people of color, whereas Seattle is comprised of only twenty-five percent (US Census Bureau, 2015). For many minority populations, English, especially as a second language, may be difficult to read with fluency. Thus, we are posed with a significant question: how can we inform diverse populations of Duwamish toxicity?
Our group partnered with Chris Hellstern of Miller Hull, an architecture firm bearing an extensive history of commitment to sustainability. This project was guided by a combination of class, group, and client objectives.

**Guiding Questions:**
1. What are the specific human health impacts of the Duwamish Waterway?
2. How does industrial manufacturing influence these impacts?
3. What specific industries and associated chemicals are contributing to this pollution?

**Hypothesis:**
Industries along the Duwamish Waterway are contributing to human health concerns by emitting toxins leaching into surrounding air, soil, and water.

**Project Goals and Objectives:**
1. Determine the impacts of producing materials along/near the Duwamish and establish how manufacturing materials affect neighboring communities.
2. Learn more about chemical pollution associated with industrialization.
3. Suggest steps for improving these communities, e.g. mitigating exposure, treating conditions for affected populations, and utilizing alternative materials.
4. Create approachable and tangible infographics with engaging material. Results and findings, especially infographics, will be used to inform Miller Hull clients and colleagues about human health impacts of manufacturing construction products, as they are an architecture firm employing local materials in their buildings.
Methods and Findings

Our first step in exploring human health impacts of the Duwamish Waterway was to visit this river and visualize described pollution with our own eyes. We intended on visiting CertainTeed Gypsum, touring local industries, and collecting qualitative data through interviews with employees of manufacturing companies. Unfortunately, we were turned away by many due to privacy, health, and safety concerns. After several failed attempts, our group decided to explore in order to view the lives of individuals working in this region.

We were able to interview two people working at a fish distribution business. They discussed their experiences, identities, and perspectives of industrial pollution. Nick, on the left, was appalled by the abundance of garbage and murky water. They mentioned still seeing people fishing and swimming in the waterway despite various warning signs. They expressed disappointment with local authorities, and said they did not see visible progress in clean-up efforts.

One other industry we were able to communicate with was R90 Lighting, a concert light distribution center. The owner of said business remarked, “it’s just a cheap space,” when asked why they work along the Duwamish. They did not seem to care about toxin effects on human health. When asked about their knowledge and opinion of pollution in the area, they mentioned having to kill a few rats in the building upon moving in, but did not comment on river contamination or if they were even aware of Duwamish toxicity.

In continuing our investigation, we contacted experts within our communities. Unfortunately, we were unable to schedule meetings with Public Health Professors at UW. After communicating with Professor Bill Daniell, we instead had to use information from a UW Public Health Report. We spoke with Amy White from the WA Department of Ecology, and they presented us with ecology research that assisted in detecting health impacts of pollutants emitted
by specific industries. Additionally, they provided us with contact information of working professionals able to contribute their perspectives on our research.

After conducting a comprehensive literature review, gathering important and relevant articles, we determined the most common pollutants, locations of specific industries responsible for pollutant emission, industrial sources, associated health effects, and affected populations living near or depending on the Duwamish Waterway.

We focused on two detailed reports: “Lower Duwamish Waterway Source Control Status Report” and “Health Impact Assessment: Proposed Cleanup Plan for the Lower Duwamish Waterway Superfund Site.” The former was used to define industrial pollution by chemical, industry, and industry type, as well as explore how said chemicals impact surrounding soil, sediment, air, and water. The latter was used to further research pollutant impacts on and demographics of neighboring communities.

Health data and pollutant statistics were complex, and scattered among various sources. As per our objectives, we designed and created three infographics using the graphic design tool Canva to portray our findings in a simple, informative, and engaging manner. These will be used by sustainability consultants at Miller Hull to inform their clients, co-workers, and the public of human health impacts linked to manufacturing building materials. They were created with the intention of cohesiveness: matching color schemes, modest text, concise wording, and color coding and bolding for emphasis.

One of our largest barriers was transparency and locating accessible information. Many of these industries do not have records of their pollutant emissions, contributing to the public perception of their negligent environmental practices. As these pollutants directly impact residents of Georgetown and South Park, our research aids in establishing public transparency by synthesizing complex data into approachable and tangible infographics.
Results

There are thousands of toxins and pollutants present in the Duwamish River. We chose to focus on the five most common and harmful chemicals produced by industrial building material manufacturing along the Duwamish. These include:

1. Polychlorinated Biphenyls (PCBs)
2. Phthalates
3. Dioxins/Furans
4. Arsenic
5. Petroleum Hydrocarbons

We discovered that there are more than twenty industries currently emitting these five pollutants, in addition to other chemicals, including: Ash Grove Cement, Boeing, Cadman Construction, Duwamish Shipyard, and Independent Metals.

The following table summarizes our findings by pollutant, industry, common sources, and human health risks:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Polluting Industries</th>
<th>Common Sources</th>
<th>Human Health Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCBs</td>
<td>Crowley Marine Srvc.</td>
<td>Surface coatings</td>
<td>Probable human carcinogen; increases rates of digestive system cancers</td>
</tr>
<tr>
<td></td>
<td>Rainier Commons LLC</td>
<td>Paints</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ash Grove Cement</td>
<td>Adhesives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duwamish Shipyard Inc.</td>
<td>Flame retardants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cadman Inc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>And others (see map)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phthalates</td>
<td>Ash Grove Cement</td>
<td>Wall-coverings</td>
<td>Exposure can cause acute toxicity, irritation and sensitization</td>
</tr>
<tr>
<td></td>
<td>Northwest Glacier Inc.</td>
<td>Paints</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crowley Marine Srvc.</td>
<td>Adhesives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Independent Metals I + II</td>
<td>Cosmetics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>And others (see map)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxins &amp; Furans</td>
<td>Northwest Glacier Inc.</td>
<td>Vinyl windows</td>
<td>Human carcinogen; leads to increased cancer risk, neurodevelopmental delays, and skin lesions</td>
</tr>
<tr>
<td></td>
<td>J.A. Jack &amp; Sons</td>
<td>PVC piping</td>
<td></td>
</tr>
<tr>
<td></td>
<td>United Western Supply</td>
<td>Industrial processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cadman Inc.</td>
<td>&amp; incomplete combustion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manson Cnstr.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To illustrate these findings in a more accessible manner, we created our map infographic, “Tracing Seattle’s Cancer Alley: Polluters and Pollutants,” that correlates industry with pollutant. Though there are more, we chose to map only the five chemicals listed above, combining arsenic with other heavy metals, and notable companies within the construction industry. We then created our pollutant infographic, “Industrial Pollutants in the Duwamish River,” highlighting the five key pollutants connected to industries in our map. The culminating infographic, “Seattle’s Cancer Alley: The Duwamish River, A Report on Human Health,” contextualizes information from all infographics.

See below for all infographics:
Manufacturers:
- Ash Grove Cement
- Manson Construction Co.
- Cadman Inc.
- J.A. Jack & Sons
- Art Brass Plating
- Capital Industries Inc.
- Seattle Iron and Metals
- Boeing Field + Plant
- Independent Metals I + II
- Gary Merlino Construction Co.
- Northwest Glacier Inc.

Distributors + Storage:
- ConGlobal Industries
- Rainier Commons LLC
- United Western Supply
- Industrial Container Services
- Crowley Marine Services
- MacMillan Piper Inc.
- Duwamish Shipyard Inc.
INDUSTRIAL POLLUTANTS IN THE DUWAMISH RIVER

Tiera Adler • John Erickson • Ankush Puri
Anneliese Smyth • Kaelyn Theede

PCBs
Synthetic hydrocarbon compounds, produced commercially until 1979. Used in surface coatings, inks, adhesives, flame retardants, and paints, many of which are present in industrial production along the Duwamish. Exposure increases rates of digestive system cancers, and can affect neurological functions of offspring.

ARSENIC
Metalloid produced when smelting metal or burning fossil fuels. Long-term exposure can cause cancer in the skin, lungs, bladder, and kidney; ingestion can lead to severe vomiting, damage to the nervous system, and eventually death.

PHTHALATES
Plasticizers used as additives for malleability and flexibility in floor- and wall-covering, toys, clothing, paints, adhesives, and cosmetics. Not chemically bound, released from consumer products into environments. Exposure can cause acute toxicity, irritation, and sensitization.

DIOXINS & FURANS
Group of chlorinated organic chemicals, formed unintentionally by industrial processes and incomplete combustion, e.g., waste incineration, burning fuels, chlorine bleaching, and pesticide manufacturing. Deposits on water bodies and farmland, bioaccumulating in food chains. Exposure leads to an increased overall cancer risk, and neurodevelopmental delays in children.

PETROLEUM HYDROCARBONS
Group of over 100 organic compounds composed of several benzene rings, commonly formed during the incomplete burning of coal, oil, and gas, and garbage. Released directly into environments from waste and manufacturing sites, and consumer products, e.g., carpets and clothing. Exposure is associated with skin, bladder, and lung cancers.

SEATTLE'S CANCER ALLEY: THE DUWAMISH WATERWAY
A REPORT ON HUMAN HEALTH

HISTORY
In 1913, the meandering river was excavated to create the Duwamish waterway. Deeper, wider waters allowed for vessels to move more easily and established an industrial core of Seattle.

INDUSTRY
Today, the waterway supports more than 25% of all manufacturing in King County. More than 100,000 jobs exist along the river.

POLLUTANTS
In 2001, the Duwamish was listed by the EPA as a Superfund site. PCBs, arsenic, and lead are in high concentration in the surrounding area because of a surge in commercial manufacturing.

HEALTH IMPACTS
Due to high amounts of industrial air and water pollution, residents of this area are at an increased risk of lung disease, asthma, developmental problems.

CANCER RATES
Cancer risk, specifically lung cancer, is 27x higher than the national average. This is directly connected to diesel and wood smoke emissions from industrial processes on the Duwamish.

SOLUTIONS
Education, transparency, policy, and research will be pivotal in cleaning up the Duwamish. Businesses and manufacturers need tools to mitigate their impact.
We identified two populations disproportionately impacted by these pollutants: indigenous peoples, specifically the Duwamish, Muckleshoot, and Squamish tribes, and residents of Georgetown and South Park (see map on right). Indigenous peoples experience increased levels of health problems, such as asthma, diabetes, and high infant mortality rates, many of which correspond to pollutants in the Duwamish Waterway (Daniell et al., 2013). Local residents, mostly immigrants and people of color, have average household incomes significantly below, and poverty rates significantly above the county average. Heart disease rates are forty-seven percent higher, and childhood asthma hospitalization rates are twice the county average. Rates of diabetes, lung cancer, and strokes are all also higher than the county average. Cancer risks in these communities are twenty-seven times higher than the national average (specifically lung cancer). The most daunting of these statistics is an average life expectancy of eight years less than the county average, and thirteen years less than affluent neighborhoods in Seattle. These health risks are directly connected to emissions from industrial operations on the Duwamish (Daniell et al., 2013).
Shortcomings

The main shortcoming of our research was that we were unable to converse with as many professionals and experts as we had intended. We would have liked to connect with more public health professionals, WA Department of Ecology staff, Duwamish River Cleanup Coalition members, non-profit organizations, and industry employees. After corresponding with multiple professors at UW, we only received responses from Professor Bill Daniell, and even so, we were unable to arrange a mutual time to discuss our project. We spoke with Amy White from the WA Department of Ecology, and as informative and thought-provoking as it was to hear from someone whose daily work revolves around similar topics, they did not provide us with any new information. Amy referred us to a member of the Duwamish River Cleanup Coalition, but we could not reach them before our deadline. We were unable to converse with industry employees and employers, as qualitative data would have reinforced our findings, because many industries were blocked to the public.

Another shortcoming was the availability of data on polluting industries, emitted chemicals, and exact concentrations of pollutants. Our reliance on, “Lower Duwamish Waterway Source Control Status Report January through December 2013,” from the WA State Department of Ecology, poses potential biases for this project. It would have been beneficial to have had multiple reports analyzing toxins in order to corroborate our results. Additionally, we were unable to investigate alternative industries from which Miller Hull could purchase materials. With more time and resources, we would have addressed ways to reduce chemical exposure and improve conditions for affected populations.

Health impacts presented in this project could be caused by confounding factors, such as lack of access to adequate healthcare, equitable opportunity, education, etc., and not specifically limited to Duwamish pollution. Conducting studies associating resident health conditions with industrial exposure, separating pollutant health impacts from external health conditions, would have substantiated our conclusions.
Conclusions and Recommendations

The Duwamish Waterway remains one of the most polluted sites in Washington, and the nation. Throughout the past several decades, not only has this waterway maintained its status as the hub of intense materials production, but also pollution has been spreading to affect people living in neighboring areas. Affluent communities often ignore the environmental injustices occurring in their backyards. Our goal was to provide a platform by which people could critically analyze how industrial manufacturing impacts residents of these local communities. Financial limitations bind low-income residents to these cheaper spaces, but at the cost of shortened life expectancies, higher asthma rates (especially in children), and an increased risk of cancer.

Though there have been efforts to remove toxins from the Duwamish and surrounding areas, additional awareness should be directed towards residents of South Park and Georgetown, and firms sourcing their building materials from this region. While local products may be more sustainable, processes used must prevent emitting toxic chemicals and harming nearby peoples. This region needs more advocacy for policies that place stricter regulations on toxic chemical outputs, production methods, and materials discharging high levels of pollution. Albeit many already exist, industries are still able to avoid responsibility by paying fines (WA Department of Ecology, 2014). Contractors and architects must be educated on pollutant damage to human health in order to shift market demand towards more sustainable materials.

We recommend that sustainability consultants at Miller Hull continue to educate their co-workers and clients about the health impacts of building material manufacturing. They should build resilient connections with suppliers working to reduce environmental impacts, and become more involved in clean-up efforts by visiting factories where materials are produced. This will further Miller Hull in their mission to become leaders in green architecture, advocating for equity and sustainability.
Next Steps

From our research, we have exposed the many environmental and human health impacts observed along the Duwamish Waterway. The scope of our project has allowed us to identify the specific pollutants businesses have been emitting, their sources, and effects on human health. Our next steps would be to better understand the connections between specific pollutants and human health concerns, and in doing so, discover ways to reduce the occurrence of pollution along the Duwamish. We believe that education and public awareness, through interaction with officials and affected communities, by way of community meetings and accessible presentations, are key in mitigating exposure, and crucial in ensuring individuals are not drinking water, eating fish, or swimming in the Duwamish.

Mandatory training must be implemented in businesses along the Duwamish in order to condemn negative impacts on local environments and communities. Although baseline research on correlations between pollutants and human health exists, exhaustive research is required to compel changes in emitting habits of businesses on the Duwamish. Only through education on affected populations, pollution management policy reform, and engineering technological advances can we find ways to mitigate pollution along the Duwamish Cancer Alley.
Main Points

- Duwamish Waterway is heavily polluted
- Many pollutants are associated with the manufacturing of construction materials
- Visible and daunting human health impacts caused by these pollutants
- To mitigate production of toxins:
  - Increase public awareness of health risks and pollution sources
  - Industries should be aware of and educated on human health concerns regarding manufactured products
  - Public officials must condemn harmful impacts of these industries


Lower Duwamish Waterway Cleanup Plan Equity Impact Review. (2013, August 30). Retrieved from King County Department of Natural Resources and Parks: https://www.kingcounty.gov/services/environment/wastewater/duwamish-waterway/~media/FA6EDFF1E8D44AC59136D64278797333.ashx?la=en

Lower Duwamish Waterway Source Control Status Report January through December 2013

(Publication No. 4-09-337). (2014, June). Retrieved from WA Department of Ecology:


(Neighborhood). Retrieved from
https://statisticalatlas.com/neighborhood/Washington/Seattle/South-Park/Race-and-Ethnicity

https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Cleanup-sites/Toxic-cleanup-sites/Lower-Duwamish-Waterway


Figure 2: The Waterlines Project (2014). Duwamish River, Then (mid-1800s) and Now.

Figure 3: King County Wastewater Treatment Division (2017). Aerial View of the Duwamish Waterway. Retrieved from
https://www.kingcounty.gov/services/environment/wastewater/duwamish-waterway/supervision-process.aspx

Figure 4: Thede, K. (2018). Two People at Fish Distribution Company.

Figure 5: Office of the Seattle City Clerk (2015). Map of Georgetown and South Park. Retrieved from https://commons.wikimedia.org/wiki/File:Seattle_-_South_Park_map.jpg
Supply Chain Impact Analysis: Concrete vs. Wood

By
Julia Chiado, Nazmah Hasaan, Eli Maesner & Joshua Jones

In partnership with Miller Hull Architecture Firm
Sustainability Studio (ENVIR 480) Winter 2018
University of Washington
**Table of Contents**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>21</td>
</tr>
<tr>
<td>METHODS AND FINDINGS</td>
<td>22</td>
</tr>
<tr>
<td>RESULTS</td>
<td>23</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>30</td>
</tr>
<tr>
<td>NEXT STEPS</td>
<td>32</td>
</tr>
<tr>
<td>MAIN POINT</td>
<td>33</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>33</td>
</tr>
</tbody>
</table>
ABSTRACT

As mounting environmental hazards decrease the viability of traditional building materials, new, eco-friendly means for construction are becoming prevalent. One such material is processed wood in the form of cross-laminated timber (CLT) and glued-laminated timber (glulam). The increase in wood usage is meant to considerably reduce the amount of concrete used in building construction. This work seeks to create a cradle-to-grave Life Cycle Analysis of both concrete and processed wood products to understand the human and environmental health impacts of these materials. Our work showed that concrete is overwhelmingly more impactful in terms of both human harm and environmental degradation. While the barriers to the use of CLT and glulam including permit limitations, misconceptions, and availability of manufacture, we hope that this work will act as an incentive to overcome the barriers for an increased prevalence of wood-based construction.

INTRODUCTION

Our group was assigned to work with Miller Hull and create a supply chain health analysis of one or two common building materials. We were asked to include a material produced in the Duwamish corridor, and research the material extraction, manufacturing, building use, and disposal process of the product(s) with a focus on the environmental health impacts of the industry.

We chose to research 2 materials: wood and concrete. The suppliers we chose were Ash Grove Cement Company and Yakama Forest Products. For wood, we specifically focused on cross-laminated timber (CLT) and glued-laminated timber (Glulam). These are two types of engineered wood, they are created by gluing together layers of wood to make the end product more durable. As for concrete, it is made up of 3 main ingredients: water, aggregate (gravel or sand), and cement. We focused mainly on cement produced by Ashgrove for this project. We evaluated the potential health impacts that each supplier has along its entire supply chain. In addition to health impacts, we also included some research about sustainability of wood vs concrete, longevity of the products, and surveyed for public perceptions about wood and concrete as building materials.
METHODS AND FINDINGS

The first thing that we did was meet with our client Kristen Dotson at the Miller Hull architecture firm. After this we went and did some preliminary research on common building materials that were manufactured in Washington. When doing this research, we came across Ash Grove concrete and Yakama forest products as two major manufacturers of very common materials in Washington. Ash Grove manufactures cement and Yakima Forest products manufactures several types of wood.

After determining what materials to focus on, we had to figure out how to define each point of the supply chain. We decided to divide the supply chain up into four distinct sections: extraction, manufacturing, building use and end of life/disposal. At each point of the supply chain we conducted research surrounding the health impacts of both materials and the effects they had on the surrounding area.

Our next step was to make a map that showed all the areas affected by the materials and the health impact that they have at each location. For this we put both concrete and wood onto the same map. Finally, we decided to create a survey and gather data surrounding public perceptions of these materials to compare to our own research. The survey was created to gather basic information about what people thought about wood and concrete in terms of their health impacts. These questions were asked either by phone or in person.

After we had done all our research both online and through surveys, we compiled the information to form our results for the supply chain analysis. We had determined that concrete overall had a much greater impact on both the environment and humans at any part of the life cycle. Wood, on the other hand, had very minimal health impacts throughout it’s life cycle, with the majority of hazards coming from occupational hazards.
RESULTS

Raw Materials

Raw Material Extraction: Wood

When it comes to logging, there are minimal health impacts beyond occupational hazards. However, logging is considered to be one of the most dangerous occupations in the United States. Many of the injuries and deaths that occur are due to use of tools and equipment, such as chainsaws and logging machines. There have been many cases of broken blades of mechanized tree harvesters penetrating cab structures of the machine and injuring or killing the workers inside. There is also risk of falling, sliding, and rolling of trees and logs. These hazards are particularly dangerous when coupled with other conditions, such as inclement weather or rough terrain (Occupational Safety and Health Administration).

Raw Material Extraction: Concrete

Due to the scope of this project, we decided to limit our focus to the raw materials required to make cement, the powdery substance mixed with water and other crushed aggregates to make concrete. Cement is largely made up of minerals such as limestone, silica sand, and clay. Most of these minerals are extracted through open surface mining (Minerals Education Coalition). This involves the removal, drilling, blasting, and hauling of ore to a crushing and processing plant (Minerals Education Coalition).

Limestone deposits in particular are sometimes located on aquifers, and can yield water to wells. Mining such sites has the potential to lead to groundwater contamination (Bliss, Hayes & Orris, 2008). There is particular risk of increased groundwater salinity and increased fluoride, which has been linked to increased risk for dental and skeletal fluorosis in humans (Misra, 2013). Studies have also shown that release of particulate matter, such as dust from quarrying sites, can increase risk of respiratory and other heart diseases. Soot particles from diesel used in quarrying combustion are also significant. This soot can contain carbon particles, as well as over 40 cancer causing agents (Calo et al., 2009). In humid climates large amounts of limestone tend to dissolve
into rainwater or other sources. In these situations, caves can form, and there is potential for sinkholes and other hazardous conditions (Minerals Education Coalition).

It was challenging to locate the raw material extraction sites for Ash Grove’s Seattle plant specifically. There was an Ash Grove quarry located on Texada Island in Vancouver BC (Leduc, 2008), but according to an online mineral and locality database, the quarry was suspended in 2010 (Hudson Institute of Mineralogy). The limestone and other aggregates were shipped from Blubber Bay down to Ash Grove’s limestone crushing plant, which is still operational in Rivergate, Oregon.

**Manufacture**

**Manufacture: Wood 1 – Transforming Raw Timber**

This step focuses on the processing of raw timber into wood planks, boards, particle board, etc. (i.e. the physically transformed and untreated wood). The manufacturer of wood that is analyzed for this LCA is Yakama Forest Products (YFP) as they are the only sawmill in Central Washington (McGee, 2017). This step of wood manufacture is very low in of environmental impact and waste products.

In terms of water usage, there is little involved in this part of the manufacturing process. Water is mainly used to spray down untreated timber to keep it fresh and prevent insects from getting into the logs. This water is reused over time and isn’t harmful. Airborne particulate matter is negligible as proper respiratory equipment limits the amount of sawdust inhaled by workers. Most of this sawdust is made into compressed particle board and what floats away from the sawmill is merely just organic material for soil to absorb (FAO). Other forms of airborne pollution mainly include carbon emissions from transport – YFP hauls processed timber 200 miles on average to “other purchasing facilities” (McGee, 2017). This step of wood manufacture has little to no impact on soil and, once a mill is operational, most of the resource usage is power from Columbia River’s hydroelectric dams. Ultimately, the primary processing of wood has moderate to little environmental damage and negligible human health effects.
Manufacture: Wood 2 – CLT and Glulam

This step of wood manufacturing encompasses the transformation of partially processed wood into CLT and Glulam. These forms of wood are relatively rare in the United States – the first company to receive the proper US certification to manufacture CLT was Oregon’s D.R. Johnson in 2015 (Oregon CLT). We assume in this piece that this company is the most viable choice for studying the impacts of CLT and glulam manufacture in the Pacific Northwest as Washington’s only facility capable of creating these products is currently being built (Woodworking Network).

This stage of wood manufacture comes along with notable water quality impacts. Most notable is the risk of eutrophication, the “potential to cause overabundance of nutrient content of water bodies” (Robertson, 2011). As the issues of nutrient runoff are prevalent in local places such as the mouth of the Columbia River, this manufacturer has the possibility to exacerbate regional environmental concerns. This form of hypoxia-forming pollution also lowers fish populations, potentially limiting indigenous access to traditional foods that may play a large role in their nutritional intake. Somewhat less threatening, the process of transformation of lumber requires water and has the possibility to affect manufacturing areas if they are prone to dry weather (IBID).

The airborne effects of CLT and glulam manufacture on a large scale are highly notable. The first two detailed are ozone depletion and smog formation. The potential human health impacts of these effects are most notably cancer formation across wide regions (the latter more regional), possibly creating harms for those that are completely outside of the manufacturing process (IBID). Another wide scale airborne effect is carbon emission and consequently greenhouse gas increases (IBID). This is offset, however, by the basic biological function of wood’s role as a carbon sink. Theoretically, an increase in the sustainable harvest and use of wood can reduce the amount of carbon in the atmosphere.

The main local airborne product of CLT and glulam manufacture is formaldehyde. This exists as a byproduct of the use of certain glues in these products (Scalet, 2015). There are, however, alternative types of glue such as PUR by Purbond that offer high strength without the harms of formaldehyde. The short-term effects of formaldehyde can cause “adverse effects such
as watery eyes; burning sensations in the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation” while long term effects include cancer (National Cancer Institute).

The main consequence of CLT and glulam manufacture in relation to soil is the creation of ecotoxicity that leads to “plant, animal and ecosystem effects” (Robertson, 2011). Toxic outputs can bioaccumulate in biological systems and ultimately reach humans via the consumption of plants/animals or contact with contaminated soil. Additionally, the manufacture of these products can cause acidification in both soil and water – this causes degradation in the natural functions of ecosystems as certain organisms can’t function under abnormal chemical conditions (IBID).

While CLT and glulam manufacture has a fossil fuel depletion factor that is 6% higher than concrete (IBID). This is a sort of red herring, however, as less fuel is used in wood manufacturing; the natural gas used for wood has a 30x higher depletion rate than the less clean and more abundant coal and oil used for concrete.

**Manufacture: Concrete**

For the manufacture of concrete, we analyzed the Ash Grove plant located on the Duwamish River in Seattle. The Ash Grove concrete manufacture, while having the “positive” association with the term local, obviously comes with local harms. It is important to note that, aside from formaldehyde, concrete manufacture has all the same damaging impacts of CLT and glulam detailed above but more so in addition to its own unique set.

The Ash Grove plant is a sprawling facility located along the Duwamish’s infamous Cancer Corridor; the river has 900 times the acceptable amount of highly carcinogenic PCBs for a waterway (EPA) and estimates say that not even $200 million dollars of funding could clean up the hazardous river (One Water). Pollutants don’t stop at PCBs, however, with heavy metals and industrial chemicals also entering from manufacturers such as Ash Grove (IBID). One of the most prevalent metals given off is mercury, a pollutant so insidious that “0.0024 ounces can contaminate a 20-acre lake and render the fish in that lake unsafe to eat” (Earthjustice). Ash Grove in Seattle gives off at least 12 pounds of mercury every year through the air, an amount high enough to pollute 1.6 million acres of water yearly (IBID). Unfortunately, this specific plant
is far below the mercury output of other plants, some belonging to the same company (IBID). This may be a low estimate, however, as their manufacturing plant reports 52 pounds of input with such little output by comparison (IBID). Mercury bioaccumulates through food webs and, when ingested, is toxic to humans (detailed more below).

In terms of airborne pollution, concrete is a heavy hitter. First and foremost, Ash Grove was specifically targeted as one of the top 35 carbon emitting companies in Washington State with an output of at least 100,000 metric tons every year (Crosscut). This carbon emission comes with other forms of particulate matter as concrete has a highly intensive manufacture process that is worsened by the forms of fuel used such as coal, oil, and tires (OPB). One of the byproducts of this process is Sulphur dioxide, an aerial pollutant that creates high rates of asthma amongst disenfranchised groups such as low-income and minority groups (IBID). Mercury is also given off by the burning of “fuels and raw materials” (Earthjustice) and, as stated above, is highly toxic. The metal has a wide variety of effects as it “acts as a neurotoxin, interfering with the brain and nervous system” in ways that debilitate infantile and childhood development and health, increase heart attack risk, cause memory loss, etc. (IBID).

Soil pollution from this Ash Grove plant ties heavily with the previously stated effects. Studies have shown that “sometimes PCBs leach from those PCB manufactured products into attached porous building materials” and can make their way into soils (EPA). Mercury can do the same as it lingers in soil and can make its way into food and water (Earthjustice). Even more, there have been instances of finished cement being discharged into the air (West Seattle Blog). This cement can enter soil and cause acidification that interferes with the health of certain plant species (Home Guides).

**Building Use**

**Building use: Wood**

In terms of how wood is used in the building stages of commercial and residential buildings there are very minimal health hazards or effects. Most of injuries that happen come from occupational hazards that come with construction in general. Many accidents happen with the tools such as hammers, saws and all nails and screws. Other hazards can be from not
following all the proper safety steps. Seeing this shows that there are no actual safety hazards from the wood itself, only from hazards that go along with the job.

**Building use: Concrete**

Concrete is more dangerous than wood in its building use. It has similar health hazards that come from occupational hazards, but it also has some other more dangerous health hazards while in use. The most harmful of these hazards is first and second degree burns that you can get from wet concrete. If this happens you should visit a doctor but should have no serious health impacts after that (Occupational safety and Health Administration). The other big health impact is from dust inhalation while mixing concrete. This can cause irritation in the eyes, mouth, throat and nose but with proper safety equipment should be easily avoidable. Safety equipment is a face mask, glove, coveralls, and just making sure that all your skin is covered while working with concrete.

**Disposal**

In King County, approximately 83% of construction waste is recycled, and the other 17% of waste ends up in Cedar Hills regional landfill in Maple Valley (Ryan, 2010). This is partly due to the Landfill Disposal Ban put in place by the City of Seattle in 2012. This ban encourages salvage and deconstruction before demolition by requiring that all demolition project great 750 sq. feet need a “Salvage Assessment”. The assessment documents how much material is salvaged from the building: this greatly increases the amount of intact materials that can be salvaged from a building set to be torn down. The ban also states that recyclable building materials are not allowed in landfills. The ban began with concrete in 2012, and added unpainted wood in 2015. Seattle Public Utilities will even issue fines to parties that dispose of the banned materials in landfills (“Recycling Required”).

It’s incredibly easy to avoid fines, though. King County has a tool on their website called “What Do I Do With” that allows you to type in a material, and it will suggest a list of recycling companies. There are a number construction, concrete, and wood recycling companies in King County (“What Do I Do With”). Concrete is fairly easy to reuse: it’s crushed into rubble, and
that rubble can be used as aggregate to make new concrete ("Recycling Concrete"). Wood can be reused in a variety of ways, it can be ground or chipped to be made into mulch, interim road bed, hog fuel, or even pulp for paper ("Recycled Wood Products").

Negative health impacts of construction materials we researched were mainly associated with concrete disposal/recycling. Crushing and demolition sites create an occupational health hazard for construction workers. Workers are exposed to dust and debris from concrete, which often contains silica fume. Inhaling silica fume can cause lung cancer, bronchitis, tuberculosis and other health complications. However, there are often OSHA compliant respiratory protections in place to avoid this ("More Than a Nuisance").

As for the 17% of construction waste that does end up in landfills, it’s taken to Cedar Hills regional landfill. It is the only remaining landfill in King County, and receives over 800,000 tons of solid waste a year. In many communities that live near landfills, some common health issues are low birth weight, birth defects, certain types of cancers. An increased prevalence of self-reported health symptoms such as fatigue, sleepiness, and headaches among residents near waste sites has been reported in more than 10 of the reviewed papers ("Landfill Failure").

**SURVEY**

For our survey, we chose to ask respondents three questions:

1. Aesthetically speaking, do you prefer wood or concrete buildings?
2. Which do you think is better for human health?
3. Which do you think is more environmentally sustainable?

For the first question, **11 out of 12** preferred the aesthetic of wood in buildings. For the second, **9 out of 12** thought wood was better for human health. For the final question, **7 out of 12** thought concrete was more environmentally sustainable. We thought that these results were interesting given our findings. Wood appears to be much less detrimental to human health compared to concrete, and perhaps humans can sense that through their aesthetic preferences.
CONCLUSION

It is clear that the effects of concrete on both human and environmental health are drastically more harmful than those of CLT and glulam. Fig 2 shows a simple visual indication of the relative impacts of both materials on human health. Concrete is shown to be more impactful in all four steps conducted in this LCA except for Building Use - the step with the most limited harms for both materials. Fig 3 shows a direct comparison of the factors detailed above in the “Manufacture” section. The graph is a direct side by side comparison of the relative impact of wood in several factors relative to concrete throughout a cradle-to-grave analysis. Among the factors, wood excels greatly relative to concrete.

There are several barriers to the prevalent usage of CLT and glulam. One main issue relates to permitting. In the United States, the first company fully certified for manufacture was only given the ability in 2015 (Oregon CLT) whereas the “green building movement as well as code changes” allowed its manufacture in Europe in the 1990s (Smartlam). Another barrier to the use of these materials is the fact that “hard data about the cost of building with CLT remains just out of reach” (Building Design + Construction). With the ambiguity surrounding specific costs and the limit in purchasing options, it is difficult to fully understand the economic viability of CLT and glulam. Finally, misconceptions regarding the sustainability, safety, viability, and longevity of manufactured wood products limit the ability for these products to be chosen and accepted in construction.
Fig 1. Map showing health impacts associated with each step of the supply chain for both products.

Which Has More Severe Health Impacts? An Overall Comparison of Materials

<table>
<thead>
<tr>
<th></th>
<th>Wood</th>
<th>Concrete</th>
<th>Key Takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw Material Extraction</td>
<td>✔️</td>
<td>Harvesting wood poses greater risks to workers themselves, while concrete creates risk for those mining as well as surrounding communities.</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturing</td>
<td>✔️</td>
<td>Byproducts of manufacturing of cement to be used in concrete are much more harmful to human health compared to wood.</td>
</tr>
<tr>
<td>3</td>
<td>Building Use</td>
<td>✔️</td>
<td>Depends on whether it is being used in residential or commercial application.</td>
</tr>
<tr>
<td>4</td>
<td>End of Life</td>
<td>✔️</td>
<td>Concrete poses more of an occupational health risk due to risk of inhaling silica fume</td>
</tr>
</tbody>
</table>

Fig 2. This chart provides a summarized evaluation of each material at each stage of the supply chain in terms of impacts on human health.
NEXT STEPS

In terms of future research, we believe that conducting a similar analysis focusing on other common building materials would be beneficial in painting a bigger picture of the health impacts associated with our built environments in Seattle. Such materials could include steel, gypsum board, brick or glass. Since concrete appeared to be far worse compared to wood in terms of human health impacts, it would be interesting to see if another material were comparable. Further research to determine the some of the exact locations along the supply chains would also be helpful- for example, we were unable to identify exactly where Ash Grove sources its raw materials, and without this information we were unable to conduct an analysis of the health demographics of the area.

Because of the risks it poses to both human and the environmental health, additional research surrounding alternatives for concrete would also be valuable. It was evident from our
research that use of concrete continues because of its durability and current lack of viable alternatives. There has been initial research on other materials, such as hempcrete, which is a mixture of hemp and lime, Ziegel Blocks, which are clay blocks with honeycomb structure, and straw, but a deeper analysis would be needed to determine if these hold potential to serve as a viable alternative (CNN).

**MAIN POINT**

This work sought to understand the ways that building materials affect humans and environments across the entire supply chain. We chose the ancient materials of concrete and wood due to their deeply significant roles in built environments. It is no longer sufficient to build based on economics or traditional practices - new alternatives need to be made to foster sustainability and responsibility to human health. The potential of wood is almost limitless for building, as long as it is responsibly harvested and protected. Sustainability in construction is unattainable without adaptive, realistic, economically viable, and publicly supported improvements in modern practices.

**REFERENCES**

- Hudson Institute of Mineralogy. Limestone quarry (Blubber Bay). Retrieved from https://www.minDat.org/loc-269424.html
Microplastics in UW Drinking Water

2018 UW Environmental Studies 480 Project

Team Members: Perla Moran, Ann Samson, Lauren Neroutsos, Gigi Dawn, Madison Hoiland

Client Partner: Hillary Sanders of Puget Soundkeeper Alliance
# TABLE OF CONTENTS

**Introduction** ................................................................................. 37

Background on what microplastics are ................................. 37

Effect on the environment ....................................................... 37

Effects on humans ................................................................. 38

Current research being done about microplastics .............. 39

Puget Soundkeeper Background ............................................. 39

Main Question, Objective, and Hypothesis ....................... 39

**Methods and Findings** ............................................................. 40

Sample Protocol ................................................................. 40

Sample Data Sheet ............................................................ 40

Prepping ............................................................................... 41

Analyzing ............................................................................. 41

Findings .................................................................................. 42

**Results** ................................................................................... 43

Shortcomings ......................................................................... 45

**Conclusion** .............................................................................. 45

**Next Steps** ............................................................................ 47

**Main Point** ............................................................................. 47

**Sources** ................................................................................ 48
Introduction

Background on Microplastics

As our society starts replacing organic ingredients for plastic materials, we are seeing more and more plastics in our oceans. These plastics are being broken down in the ocean via ultraviolet sunlight degradation and physical degradation from the waves and becoming microplastics. Microplastics are defined as plastics “less than five millimeters in length, or about the size of a sesame seed” but can be all shapes and sizes (NOAA). Microplastics have been found to arise through four separate processes, 1. Deterioration of large plastic objects 2. Direct release of microplastics (ex. microbeads found in face washes) 3. Accidental loss or spills of industrial products 4. Discharge of waste (ex. sewage sludge) (Green Facts). According to NOAA, microplastics have been found in oceans for 50 years but are projected to increase due to societies increase use of plastics. Currently there are around 8 million metric tons of plastic in the ocean, one metric ton is equal to 2,205 pounds so this is a significant amount (Times). This can have detrimental effects on marine ecosystems. The amount of microplastics in the ocean are 37 times higher than expected and the mass of microplastics in the ocean are projected to be equivalent to the masses of 1,300 blue whales (World Economic Forum). The US government has been taking steps to try and decrease the amounts of microplastics in the oceans by banning microplastics in cosmetics with the “Microbead Free Water Act” in 2015 (Green Facts). While these efforts are a good start, we need to continue our efforts to decrease the amounts of plastics and microplastics in our oceans.

Effects on the Environment

Scientists have a pretty good understanding of the effects of plastics on marine life. Marine life often ingest plastics since they are easily mistaken for food or get tangled up in them. Even though these negative effects are well known, scientists are still in the preliminary stages of microplastic research. When marine life ingest microplastics they are also ingesting the toxins and chemicals in them which leads to bioaccumulation. Bioaccumulation is the buildup of chemicals or other toxins in living organisms via the food chain or behaviors. Scientists know that microplastics can lead to illness in marine life and even potential death. Since microplastics are so small, the smallest organisms in the food chain also ingest them. As the larger organisms eat the smaller organisms they are also ingesting those small microplastics, but in larger quantities (this is called biomagnification). Ingestion of microplastics by marine life can lead to “digestive blockage or internal damage from abrasion” (Thought Co). Overall, the effects of microplastics on marine life are still being researched but there is a common understanding among scientists that the effects are undoubtedly harmful.
Effects on Humans

Microplastic research is a fairly new field of study so there is not a lot of data on the effects that they have on humans. We know that we are ingesting microplastics when we eat fish (since they ingest microplastics in the ocean) but not many studies have been done about microplastics in our drinking water. We do not know how frequently microplastics are found in our drinking water or what these microplastics are doing to our health. Scientists believe that “if inhaled or ingested, microplastics may accumulate and exert localized particle toxicity by inducing or enhancing an immune response” (NCBI). If we continue to ingest microplastics through seafood and potentially through our drinking water, they may have irreversible effects on human health. Additionally, “chronic exposure is anticipated to be of greater concern due to the accumulative effect that could occur” (NCBI). If we continue to ingest microplastics regularly, they have the potential to accumulate in our bodies which may have even greater effects on our health. Microplastics could be affecting humans in five different ways. First, they might be leaving our body without harming us. Second, they might be being absorbed but broken down quickly without harming us. Third, the chemicals that are held in microplastics might not be enough to hurt us. Fourth, the plastics are in fact hurting us. And fifth, the microplastics aren’t hurting us yet but once they accumulate in our bodies they will start having effects (Owlcation). Overall, scientists aren’t completely sure about the effects of microplastics on humans but with more research and time we will hopefully increase our understanding.
Current Research on Microplastics

Currently research on microplastics and their effects on humans and marine life is in its early stages. Recently, NOAA has started researching the effects of microplastic and are some of the first in their field. They explain that “eventually field and laboratory protocols will allow for global comparisons of the amount of microplastics released into the environment, which is the first step in determining the final distribution, impacts, and fate of this debris” (NOAA). This will help determine the overall global amount of microplastics and the effects that it has on humans and the environment worldwide. There has been more research done on how to combat the amount of microplastics in the oceans. “The Grantham Institute at Imperial College London in their [July 2016 report](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/526405/gi_report_0.pdf) conclude the best way to reduce marine pollution is to manage plastic waste better at source” (The Royal Society of Chemistry). This means reducing the use of plastic, eliminating littering of garbage on beaches (and everywhere else), and preventing runoff. This also could mean increasing the amount of recycling bins and trash cans in populated areas. There has also been research done about creating a safer plastic, the plastic substitute would have many applications and would be safer for the environment (Owl Cation). Switching from plastic to a biodegradable material could mean less plastic waste in our oceans in the future. Over the course of the next few years we will start to understand more and more about microplastics.

Puget SoundKeeper Background

Puget SoundKeeper was founded in 1984 with the mission to “protect and preserve the waters of the Puget Sound” (Puget SoundKeeper). They organize volunteers to go out every week on boats and kayaks to monitor the health of the waters. They have removed over 145,000 pounds of marine debris from the Puget Sound waterways and continue to collect even more each week. They have also “engaged over 18,000 volunteers in cleanups, outreach events and advocacy projects” (Puget Soundkeeper). They are also involved in government initiatives like the Clean Water Act to help regulate our waters. The company has started testing the Puget Sound waters for microplastics and have found a significant amount. Their next goal is to better understand the amount of microplastics in Seattle’s drinking water which we started to investigate here at the University of Washington (UW).

Main Question, Objective, and Hypothesis

The main question we are trying to answer through this experiment is if there are microplastics in the University of Washington’s drinking water. We know with certainty that there are microplastics in the Puget Sound but we are unsure of their prevalence in our drinking water. Our objective was to collect several water samples from different locations around the UW campus and determine if there were any microplastics in them. We tried to collect the samples in a variety of places around campus to get a holistic look at the water. Our hypothesis was that
there would be little to no microplastics in UW’s drinking water because Seattle’s drinking water is thought to be very clean. Overall, we were very interested in getting a better understanding of the safeness and cleanliness of our drinking water on campus.

**Methods**

Our first step was to collect water samples from different locations around the University of Washington campus.

**Sample Protocol**

1. Assemble needed materials
   - Mason jars
   - Sharpie to write on the lid
   - Data sheet
   - Camera/cell phones to take pictures
2. Find different drinking water sources on the UW campus
3. Write the name of the sample site on the lid of the mason jar using permanent marker.
4. Fill the mason jar halfway with water. Cap and shake the jar, then pour it down the drain. Repeat the rinsing process two more times.
5. After the third rinse, fill the mason jar completely with water and cap immediately.
6. Complete the data sheet to accompany the water sample.
7. Take pictures of the sampling location and nearby surroundings to document the sampling process.
8. Bring sample and data sheet on analyzing day at the Puget Soundkeeper office.

**Sample Data Sheet**

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Faucet type (filtered or not?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishery Science</td>
<td>Fountain (not filtered)</td>
</tr>
<tr>
<td>Health Science</td>
<td>Water fountain (not filtered)</td>
</tr>
<tr>
<td>Wallace</td>
<td>Fountain (filtered)</td>
</tr>
<tr>
<td>Suzzallo</td>
<td>Fountain (not filtered)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Odegard</td>
<td>Water dispenser (filtered)</td>
</tr>
<tr>
<td>McMahon</td>
<td>Fountain (not filtered)</td>
</tr>
<tr>
<td>Forest Service Lab</td>
<td>Sink (not Filtered)</td>
</tr>
<tr>
<td>HUB</td>
<td>Fountain (Filtered)</td>
</tr>
<tr>
<td>Local Point</td>
<td>Dispenser (filtered)</td>
</tr>
<tr>
<td>Sigma Kappa Ice Machine</td>
<td>Dispenser/ice machine (filtered)</td>
</tr>
</tbody>
</table>

**Prepping**

Afterwards, we were responsible for preparing the samples at the Puget Soundkeeper office in Fremont. The lab equipment we used to prep our samples included a hot plate, a magnet, a beaker, mason jars, funnels, tubes, and clips.

**Steps**

1. Rinse the beaker, funnels, tubes, and mason jars with deionized water in order to reduce the probability of contamination.
2. We placed the beaker on the hot plate, dropped the magnet inside, poured the first sample inside, and turned on the hot plate to let it stir for 10 minutes.
3. Once the 10 minutes were up we then slowly began to pour salt into the beaker and let it stir for another 15 minutes.
4. Once the 15 minutes were up we poured the mix into the funnel which had a tube attached to the end that was clipped to prevent it from spilling.
5. We covered it and let it sit for 24 hours in order to finish the prepping process.
6. We repeated these steps for all of our samples.

**Analyzing**

The last step was to analyze each individual sample by pouring the liquid through a filter and then placing it on a petri dish. We placed the petri dish under the microscope and took turns looking at it to see if we could find any fragments, filaments, or pellets. We recorded the amount and the type of plastics we found in each of the samples.
Findings

(Evident fragments/filaments in our drinking water samples)
Results

We found microplastics in every sample. The Fishery Science building had the most microplastics with 5 filaments and 3 fragments. The Odegaard Library and the Sigma Kappa sorority house had 1 filament. Unfiltered water stations had a higher total and higher average of microplastics. There is no clear correlation between total microplastics found in older or newer buildings.

<table>
<thead>
<tr>
<th></th>
<th>Filtered</th>
<th>Nonfiltered</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Microplastics per Sample</strong></td>
<td>2.4</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Total Filaments/Fragments</strong></td>
<td>12</td>
<td>19</td>
</tr>
</tbody>
</table>

There may be possible reasons for different amounts of microplastics in each sample. For example, during the prepping stage, we might have forgotten to use DI water to rinse materials thoroughly. This would leave remnants from past samples or microplastics in the water from Puget SoundKeeper’s sink may have contaminated our samples. Additionally, our work environment was in an open office area. There might have been microplastics in the air from people walking past us or our own clothes might have contaminated the samples. Lastly, there may have been human error during our analysis stage. For example, we might have counted the same microplastic twice, misidentified a filament or fragment, or missed finding one.
### Result Data Sheet

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Date Processed</th>
<th>Date Analyzed</th>
<th>Faucet Type (filtered or not?)</th>
<th>Filtered/Not filtered</th>
<th># Filaments</th>
<th># Fragments</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigma Kappa Ice Machine</td>
<td>2/9/18</td>
<td>2/15/18</td>
<td>Dispenser/ice machine (filtered)</td>
<td>F</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Wallace</td>
<td>2/2/18</td>
<td>2/9/18</td>
<td>Fountain (filtered)</td>
<td>F</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>HUB</td>
<td>2/9/18</td>
<td>2/15/18</td>
<td>Fountain (filtered)</td>
<td>F</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Odegard</td>
<td>2/2/18</td>
<td>2/9/18</td>
<td>Water dispenser (filtered)</td>
<td>F</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Local Point</td>
<td>2/9/18</td>
<td>2/15/18</td>
<td>Water dispenser (filtered)</td>
<td>F</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Fishery Science</td>
<td>2/2/18</td>
<td>2/9/18</td>
<td>Fountain (not filtered)</td>
<td>NF</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Suzzallo</td>
<td>2/2/18</td>
<td>2/9/18</td>
<td>Fountain (not filtered)</td>
<td>NF</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>McMahon</td>
<td>2/9/18</td>
<td>2/15/18</td>
<td>Fountain (not filtered)</td>
<td>NF</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Forest Service Lab</td>
<td>2/9/18</td>
<td>2/15/18</td>
<td>Sink (not Filtered)</td>
<td>NF</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Health Science</td>
<td>2/2/18</td>
<td>2/9/18</td>
<td>Water fountain (not filtered)</td>
<td>NF</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
**Shortcomings:**

We were unable to collect samples from every building of the campus. This would give us a more complete picture of the UW water system. Due to time constraints, we were unable to analyze water samples multiple times for accuracy. Increasing trials during our analysis stage would give us clearer results and conclusions. Additionally, our microscopes were average in power magnification. Obtaining more powerful microscopes can increase efficiency in analyzing and increase visual accuracy of microplastics. Due to lack of space, we were unable to test our samples in a closed, sanitized lab. We also did not have access to appropriate lab wear. Overall better sanitation would prevent contamination. Lastly, our experiment lacked a control. Testing a control of deionized water can further ensure that all samples were uncontaminated.

**Conclusion**

Overall, we found that every drinking fountain sampled on the University of Washington campus had at least one microplastic. Our data suggests that unfiltered water contains more microplastics than filtered water. However, there are other factors that could impact how many microplastics are in our water, such as location of the water source, building type and materials, and anthropogenic activities such as foot traffic or vacuuming. From our background research we found that little is known about the human health implications of plastics in our water, however, much has been found about the impacts they have on the environment and marine life. Based on scientists findings on the possible toxicity and the negative effects that plastics have on marine life, there is cause for concern that microplastics could have the same health impacts in humans.

This could have serious social and health implications, as the access to safe clean water is a fundamental human right. UW has filtered water stations in most of the popular areas on campus and drinking fountains in every building. However, residents outside of UW and around the city of Seattle may not have access to filtered water. This becomes a social justice issue, as some cannot afford to implement water filters, and may not be able to afford healthcare to address possible health effects that may arise in the future. Therefore, more research is necessary to pinpoint the source and the extent of plastics in our water, as well as exploring the implications for human and environmental health.

For Puget Soundkeeper, we recommend advocating for further research and education of the public to bring awareness to this issue. With their data, background research, and their power as an advocacy and environmental group combined, they have a compelling case and connections to encourage change to better our health. Having the knowledge that there are plastics in our
drinking water is the first step, but needs to followed by identifying ways to remove the plastics and distribute the knowledge.

The first step would be to share our findings and include conclusions from other sources to encourage UW or other research groups to begin researching the possible health effects. However, this would require significant funds and time for a research project that may take an extended amount of time to conduct.

Along with investigating the health effects, more research should be done on how the microplastics get into our drinking water in the first place. By identifying the sources and whether the plastics come from within the fountain, from the surrounding environment, or the larger water source, the measures to remove the plastics will be more effective.

Furthermore, knowing that the widespread use of plastics has infiltrated our water could be a motivator to use less plastic in our daily lives. This would assist the goal of Puget Soundkeeper of cleaning our waters, if individuals had the knowledge that plastic wasn't just affecting the water, but also their own safety. Tabling at events or in public areas could spread awareness of the importance of decreasing plastic waste as well as provide a platform to share methods to filter out microplastics.

The final suggestion of what could be done with this data would be to indicate solutions to filter plastics out of our water. There are microplastic filters available on the market at varying costs, which is a possible solution to the social issues of having plastics in our home, but more advanced technology to effectively remove them is needed (How to Remove Microplastics).

Because microplastics are so small, most commercial filters don't capture them. These suggestions are important to protect the social needs for healthy water and ensure that we avoid any possible health impacts. Finally, finding solutions now may save economic resources in the future, by avoiding potential healthcare costs and decreasing the amount of plastics that will need to be cleared later.
Next Steps

With the limited amount of time we had to work on this projected, our next steps would be to collect more water samples from the UW campus. Based on the results of our research, future research would focus on:

● Understanding the consequences of using/consuming plastic. Further research should be done to understand the health implication of consuming plastic.

● Encouraging UW to use better water filtration systems and use less plastic materials, as well as reducing amounts of plastic we use in our daily lives. UW can look into better materials used in their piping system and maybe install a filtration system that removes plastic material.

● Bringing awareness to students and general public that there is microplastic in our drinking water. Not many students at UW are aware that microplastics are floating around the water we drink everyday. If we let them know, then they can push for further action.

Main Point

In order for any change to happen at the University of Washington, we need to bring awareness to faculty and students about the issue of microplastics in our drinking water. We need to encourage ourselves and others to reduce our use of plastic, by doing so, less plastic material will end up in the water. Additionally, floating plastics in the ocean have been found to accumulate pollutants which can be considered harmful to our health and the environment. Plastic does not completely decompose, it only breaks up into smaller pieces that end up being consumed by us and other organisms. We need to work to resolve this issue if we all want safe clean drinking water and a healthy environment.
Sources

- “About Us.” Puget Soundkeeper Alliance, pugetsoundkeeper.org/about-us/.
Vinyl Windows

An Analysis of Health Risks, Cost Benefits, and Case Laws

Minghao Gao, Joy Shang, Uyen Tran
In partnership with Miller Hull

March 14, 2018
# Table of Content

I. Introduction .................................................................................................................. 51  
II. Methods and Findings .............................................................................................. 51  
III. Results  
  1. Risks to Human Health .......................................................................................... 52  
  2. Economic Cost-Benefit ......................................................................................... 54  
  3. Case Laws .............................................................................................................. 56  
IV. Conclusions & Recommendation .......................................................................... 58  
V. Next Steps ............................................................................................................... 60  
VI. Main Point ............................................................................................................. 60  
References .................................................................................................................. 61

Figure 1. UltraMaxx® Fusion-Welded Vinyl Windows
I. Introduction

Vinyl windows are the go-to for most construction projects, accounting for 63.6% of the profits made by the window installation industry in 2016 (IBISWorld, 2017). However, as is the case with most building materials, contractors often default to the industry standard when choosing what windows to install rather than examining the consequences of choosing one material over another. Our client, Miller Hull, approached us with the hypothesis that vinyl windows are worse than alternative materials when it comes to their impact on human health and long-term cost over the lifespan of a building. Based on these shortcomings, our client also wanted us to inquire whether any lawsuits have been heard where a tenant successfully sued their landowner or building contractor for health or economic damages they experienced due to living in a building with vinyl windows.

We endeavored to research and synthesis these two arguments against vinyl windows, as well as potential case law, to produce a report and infographic that Miller Hull can share with their employees and clients. The report will provide an in-depth overview of our analysis including extensive references to support our claims. The infographic will present our findings in an aesthetically pleasing and easily digestible format that summarizes the same information and can be quickly presented to others.

II. Methods and Findings

In order to assess the risks to human health, long-term costs, and potential case law regarding vinyl windows we conducted a literature review of the existing research and reached out to experts in these three areas. We found that, overall, there was a sore lack of information on the topic of vinyl windows and resorted to researching the effects of polyvinyl chloride, which is a specific type of vinyl (“Best Vinyl”, 2017).

Polyvinyl chloride is used in many products, including other buildings materials - such as flooring, pipes, and cables (ChemicalSafetyFacts.org, 2014) - and we drew on existing information for these other uses and applied them to theoretical cases with vinyl windows. This was especially the case when researching health effects, as there don’t appear to be any papers specifically looking into the illnesses caused by living in the vicinity of vinyl windows.
However, by coupling our findings on the chemicals released by vinyl windows as they are produced and degrade with separate research on the impact on human health, we were able to construct a picture of the effect vinyl windows have on health. Another challenge we ran into was conflicting information on the effects of polyvinyl chloride, with some sources calling it a “poison plastic” and others touting it for its sustainability (Sevenster, 2003). Ultimately, we learned to distinguish from biased sources, such as vinyl companies, from more reputable sources, such as academic research papers.

We were able to find more sources comparing the cost and durability of different types of window materials, although the majority of websites failed to support their claims with evidence. Many of these sources were window vendors or installers themselves, putting into question the validity of their claims. Information on the insulation capabilities of window materials was more difficult to find, and although we found some sources discussing the issue they failed to provide exact numbers.

In addition, our research found no case law regarding the effects of vinyl windows in buildings, despite emailing and calling seven law firms that specialized in housing or vinyl chloride poisoning and searching through case law databases recommended by the University of Washington Gallagher Law Library. That being said, we did discover lawsuits related to the production of polyvinyl chloride, which we could use to extrapolate to theoretical cases for the residential or commercial installation of vinyl windows.

Overall, the majority of our findings were not based on research directly relating to vinyl windows, but were pieced together from related sources. Furthermore, the experts that we reached out to seemed unaware of the issues surrounding vinyl windows and did not contribute significantly to our research.

III. Results

1. Risks to Human Health

Since polyvinyl chloride it is inexpensive, durable, strong, chemically and biologically resistant, as well as easy to install and replace, it is widely used in various construction applications (Gromicko, n.d.). Vinyl building materials include pipes, windows, plywood,
particleboard, carpet and pads, paints, stains, glue, and etc. The risk of vinyl windows to human health could be categorized as the exposure to two main categories of toxic chemicals: vinyl chloride and dioxins.

To begin with, PVC and other vinyl products are synthesized from vinyl chloride monomers, which are toxic and carcinogenic. However, very little vinyl chloride monomer is present in the finished vinyl building materials. The exposure from consumer products made from vinyl chloride are well below the EPA guideline, which is under 0.003 milligrams per kilogram per day for vinyl chloride and the EPA Reference Concentration (RfC) of vinyl chloride is 0.1 milligrams per cubic meter (“Vinyl Chloride”, 2009). The risk from vinyl chloride are largely limited to 1) occupational exposure to the monomer during production of polyvinyl chloride, and 2) the biological degradation of trichloroethylene (TCE) in the ground that can lead to the formation of vinyl chloride and then find its way into groundwater. However, the latter does not directly relate to vinyl windows (Eaton, 2017).

Furthermore, volatile organic compounds (VOCs) are released due to outgassing of the vinyl products, which contributes to 31% of indoor air quality degradation (“Particulates”, n.d.). VOCs are the additives remaining in vinyl products when they are installed in buildings. Outgassing is a general problem associated with the PVC building materials such as windows, plywood, particleboard, carpet and pads, paints, stains and glue (Khonsu, 2017). At room temperature, VOCs are volatile enough to evaporate and are inhaled by humans. Long-term exposure to VOCs leads to damage to the liver, kidneys, and central nervous system. Short-term exposure to VOCs causes symptoms including eye and respiratory tract irritation, headaches, dizziness, visual disorders, allergic skin reactions, nausea, and memory impairment (“Tox Town”, n.d.). Ways to reduce VOC outgassing is through increasing ventilation or using windows made with non-vinyl materials. For vinyl products, there is no other VOC released besides vinyl chloride. Relative to other sources (carpets, glues, cleaners, paints, etc) vinyl windows add very little to the total VOC load. In other words, there are no health effects associated with vinyl windows (Cleland, 2018). Residents are not affected by the installation of newly produced vinyl windows due to extremely low room concentration and, thus, experience little exposure to vinyl chloride (Eaton, 2018). Despite the inconclusive findings, we believe the
direct effects of vinyl windows on the human health can be studied more vigorously and comprehensively.

Moreover, there is increasing concern about the thermal performance of vinyl windows, since vinyl chloride is highly flammable and heat sensitive. As such, manufacturers often add stabilizing components to prevent the degradation of vinyl building materials from UV radiation and extremely hot conditions. One example of a common heat stabilizer used for ultraviolet protection is titanium dioxide, which also serves as a white pigment because of its brightness and high refractive index. When UV strikes the clear molecules of vinyl chloride, it chemically alters them to polyene molecules. Polyene and titanium dioxide collectively block UV rays and limits chemical reactions only to the exposed surface and extremely shallow depths of .001 to .003 inches (Workman, 2016). Further degradation does not continue when exposure to sunlight is blocked (Workman, 2016). A study by Uni-Bell, a PVC pipe association, found that the exposure to sunlight would only result in a change of color on the vinyl surface as well as a slight reduction in impact strength (Workman, 2016).

Under reactive conditions throughout the life cycle of PVC, dioxins are generated when chlorine-based organic chemicals in PVC are burned or processed. The sources of dioxin emission can be linked to the production of chlorine, synthesis of other vinyl feedstocks, accidental burning of vinyl windows, incineration of hazardous wastes from vinyl production, and arson in landfills containing vinyl solid waste (“Pro/Con: Vinyl is Lethal”, 2009). Byproducts of these reactions, such as ethylene dichloride and vinyl chloride monomer, are associated with skin lesions in short-term exposure and higher rates of cancer in long-term exposure, and pose a risk for workers (“Consumers Association of Penang”, n.d). In fact, dioxin is considered the most potent carcinogen chemical, as well as a cause for developmental and reproductive problems, and damages the immune and endocrine systems (“Dioxins”, 2016).

2. Economic Cost-Benefit

The cost of replacing windows can vary due to geographical regions and the state of the economy; however, drawing from multiple sources, we observed that vinyl windows are the cheapest among the most common materials used in window installation -- wood, aluminum, and
fiberglass (“2018 Window Prices – How Much New Vinyl Windows Really Cost”, 2018). The graph below shows the comparison of price among the aforementioned materials:

<table>
<thead>
<tr>
<th></th>
<th>Vinyl</th>
<th>Aluminum</th>
<th>Wood</th>
<th>Fiberglass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$352</td>
<td>$400</td>
<td>$689.5</td>
<td>$849.5</td>
</tr>
</tbody>
</table>

Figure 2. Costs of Replacement of Window Materials

Vinyl windows are usually about half as expensive as the highest-quality material – fiberglass, and this is the most prominent reason for why vinyl window frames are used extensively in construction projects (Harder, 2004). However, vinyl windows are short-lived and not long lasting (“The Problem with Windows”, 2012). They respond very well to heat and weather conditions -- in fact, they contract when temperature drops and expand quickly when temperature rises. Therefore, the sudden changes in temperature and exposure to harsh weather factors can very likely cause vinyl windows to warp and rot. Once vinyl windows are damaged, they cannot be fixed, but can only be replaced, adding to the cost of maintenance every 3-5 years (“The Problem with Windows”, 2012). In contrast, wood, aluminum, and especially fiberglass windows provide eight times more strength than vinyl windows do (“Window Installation Cost – Compare Vinyl vs Fiberglass Windows”, 2017). Fiberglass windows have much higher resistance to warping and rotting, thus making them much more long-lasting and durable. They can be installed to withstand any weather condition, and since glass has fire self-extinguishing characteristics, fiberglass windows will not release toxic dioxin gas in case of arson.

Furthermore, a lot of windows installation projects on the market with low installation cost do not promise long-lasting quality. When not welded properly, components at the corner of the window frame can pull apart easily, and they are difficult to be welded in the first place (“The Problem with Windows”, 2012). This can lead to damages to the windows, significantly reducing its ability to retain heat and warmth in the winter by letting cold air and moisture penetrate the interior of the building. An anecdotal evidence from Chris Hellstern from Miller Hull states that the builders who worked on installing windows at one of University of
Washington’s residence halls were aware of this characteristic of vinyl windows, thus they designed the frame in a way that could be popped out quickly and replaced entirely. Thus, cheap cost of installation does not equate value added and retained in the long-run for construction projects.

Another incentive for builders to phase out the use of vinyl windows is the growth the wood and fiberglass window segments (IBISWorld, 2017). IBISWorld estimates that from now to 2021, these two segments will see expansion since the construction industry is picking up pace again, and because of the rising demands for alternatives to vinyl windows. This is because consumers are becoming more aware of the impacts and health risks of vinyl windows on human well-being and on the environment.

Lastly, the cost of replacing vinyl windows does not take into account environmental and public health externalities. Since vinyl windows cannot be recycled, and since they pose risks and unstudied negative health impacts on the human body, the economic costs of these externalities should be enough to balance out the seemingly higher cost of installation of alternatives that are recyclable and do not pose risks to human health.

In short, from a comprehensive and long-term perspective, vinyl windows are not economically beneficial for a construction project. They are easily damaged, and once they are damaged, they incur replacement costs, costs to the environment and human health, and energy consumption. Alternatives to vinyl windows are worth considering for builders as they are long-lasting and will add value to the project in the long-run. Construction projects should only be chosen due to its income-generating potential, and “trimming down” on marginal costs such as window installation cost just to make the bottom line is not sustainable from an economic and financial standpoint. If we had more time and resources, we could contact the construction managers to find out the incentives behind choosing vinyl windows consistently for their projects.

3. Case Laws

After searching numerous federal and state case law databases, as well as reaching out to law firms, we determined that no lawsuits have occurred in the United States of America where a landowner or contractor has been successfully sued for using vinyl windows on their property.
However, we did find several cases regarding vinyl chloride poisoning. For instance, residents of Crestwood, Illinois were awarded $15 million as a settlement from the city for providing water contaminated with vinyl chloride for two decades (Hawthorne, 2010; The Schmidt Firm). In addition, there is a thriving business for lawsuits against polyvinyl factories by their employees who developed cancer and other diseases by being exposed to harmful chemicals on the job. The prevalence of occupational lawsuits over residential lawsuits may be encouraged by the wealth of research supporting it. Indeed, with workers being exposed to significantly higher levels of chemicals within a shorter time frame, scientific research is able to draw a direct line between exposure to vinyl chloride and the rate of developing cancers and other chronic diseases, such as a 20% increase in the chance of developing lung cancer and a 45% increase in developing angiosarcoma, a type of liver cancer (Mastrangelo et al., 2003). Thanks to this research, we have seen cases such as Stillo v. Rubbermaid Inc. where an employee received compensation from Rubbermaid Inc. for developing a rheumatic disease (1990).

Based on this record of successes for lawsuits regarding the production of vinyl chloride, we determined that there is the potential for lawsuits against landowners and contractors in the future. This could be achieved through a tort case for the negligence of the landowner or contractor, as

“If there is an unsafe condition within the tenant’s property that the landlord knows about but that would not be obvious to the tenant, the landlord has a duty to warn the tenant of the unsafe condition. Failure to issue such a warning will result in the landlord being liable for injuries caused by the dangerous condition.”

(Law Shelf)

Applying this law to vinyl windows, a landowner is obligated to warn their tenant of the potential harm that vinyl windows could cause. If a landowner fails to do so and their tenant is injured due to the vinyl windows, the landowner must compensate the tenant for any their injuries.

On a broader scale, our research revealed the encouraging pattern of numerous cities, countries, and companies instituting restrictions and bans on polyvinyl chloride. These include
the city of New York reducing their consumption of polyvinyl chloride in 2005, Sweden restricting their use of polyvinyl chloride in 1995, and many companies committing to phasing out polyvinyl chloride, including Adidas, Nike, Ford, Toyato, IKEA, Microsoft, SC Johnson, WalMart, Apple, Samsung, H&M, as well as Target (Center for Health, n.d). Although these commitments don’t tie directly with the disuasion of vinyl windows, they point to a larger trend of polyvinyl chloride being phased out in all sectors, including construction.

IV. Conclusions & Recommendation

In conclusion, vinyl windows pose serious risks to the human health, not only for workers in the factory but also for residents in building, especially when considering the popularity of vinyl windows, as well as their sensitivity to heat and weather conditions. In case of a fire, vinyl windows can release deadly gas into the atmosphere, and even sun exposure can strip away the layers of paint coating, leaving the PVC components bare and exposed to residents. In the long term, vinyl windows incur high replacement costs, as well as costs of externalities to the environment and human health. Using vinyl windows in construction project with unstudied health impacts can lead to lawsuits and complaints in the long-run. There have been cases involved building materials made out of PVC, and we can expect the same situation for vinyl windows.

Since vinyl windows are the most popular choice for window installation projects on the market, we have a few suggestions for the phasing out of them. We would recommend builders and building contractors to choose different materials for installing windows, instead of following the most conventional and cheapest building material without being fully aware of its negative impacts. For our client, Miller Hull, we would recommend that they keep building the case against vinyl windows as there are a lot of potentials with regards to the phasing out of its usage. More research and surveys can be conducted to further study the impacts of vinyl windows and to educate their internal staffs, clients, and the public. For the policy-makers and regulators of industries, we would recommend more investigation and research on vinyl windows to implement comprehensive laws and policies that will affect the industry as a whole to protect residents and the living environment, instead of just targeting individual contractors.
Below is the Infographic our group created to make distributing information more engaging and efficiently.

Figure 3. Infographic – Vinyl Windows

Vinyl Windows

are the go-to for most construction projects and account for two thirds of the window installation industry. First, take the time to consider what they are doing to the environment and our health.

Toxins in your home and work

Notice that "new air smell" from your windows? The gases coming off your new vinyl windows may be polluting you every time you inhale.

Your health is at risk if:

- You live near a factory for vinyl or one of its chemical ingredients
- You recently installed new vinyl windows
- Your windows have caught on fire
- Your vinyl windows are more than 40 years old

Chlorine in your body

Vinyl windows are made of 60% chlorine, which has been historically used for chemical warfare. Symptoms to exposure includes:

- Headache
- Burning sensation in the nose, throat, and eyes
- Chemically induced asthma
- Hypertension
- Burning pain, redness, and blisters on the skin
- Fluid build up in lungs
- Nausea & vomiting
- ...extended exposure can lead to death

Drain your wallet

Cost of window replacement over years

<table>
<thead>
<tr>
<th>Years</th>
<th>Vinyl</th>
<th>Aluminum</th>
<th>Wood</th>
<th>Fiberglass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$500</td>
<td>$1,000</td>
<td>$1,500</td>
<td>$2,000</td>
</tr>
<tr>
<td>10</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$2,500</td>
<td>$3,000</td>
</tr>
<tr>
<td>20</td>
<td>$1,500</td>
<td>$3,000</td>
<td>$3,500</td>
<td>$4,000</td>
</tr>
<tr>
<td>30</td>
<td>$2,000</td>
<td>$4,000</td>
<td>$4,500</td>
<td>$5,000</td>
</tr>
<tr>
<td>40</td>
<td>$2,500</td>
<td>$5,000</td>
<td>$5,500</td>
<td>$6,000</td>
</tr>
</tbody>
</table>

Although vinyl windows have the lowest up front cost, its susceptibility to warping and damage lead to a higher cost over time as it has to be replaced more often than alternative materials. Typically, vinyl windows cannot be repaired.

Warping windows continue to rack up expenses as:

- Improper sealing encourages the growth of mold
- Heat is lost more quickly and more energy is needed to regulate indoor temperature

Lawsuits & further restrictions

Lawsuits against vinyl factories

Vinyl factories have been successfully sued by their employees, who developed cancer and other diseases associated with vinyl chloride exposure.

Negligence cases against land owners

If a renter can prove that a land owner failed to warn of a threat to their well-being, they can sue through a tort case for negligence.

Global bans and restrictions on vinyl

Vinyl is restricted in the EU and ten other countries. Numerous companies - such as Walmart, IKEA, and Ford - have begun phasing out vinyl in their products in response to growing concern over its environmental impact.
V. Next Steps

Not only did our group work under time restrictions, but we also had limited resources to reference in order to carry out the argument against vinyl windows in terms of its health effects on installers and residents. This section will further analyze the limitations that we encountered in the process of our research, which provides the opportunity for continuing research to be carried out by Miller Hull.

First, there are few pieces of literature specifically discussing the health effects and case law of vinyl windows. We had to filter the information we regarded as most credible based on cross-referencing multiple online articles and studies. Moreover, there is very limited to no resource specifically discussing case laws on the adverse health effects of vinyl on residents and window installers.

If we could continue this research project, we would devote more time to looking at the impact of other chemicals on human health, such as the heat stabilizing components added in the vinyl building materials. It is important to ask more questions regarding the health effects of those chemicals since they have not been well studied so far and further research is necessary to better understand the potential risk of using vinyl windows at home. Moreover, as there is no evidence of successful lawsuits, more anecdotal evidence should be collected to strengthen the case against vinyl windows. Eventually, contractors and the general public will need to make a shift in mentality and take human health, environmental degradation, and long-term cost-effectiveness when choosing building materials.

VI. Main Point

Our research could be considered a pilot review of the risks to human health, long-term costs, and potential case laws of vinyl windows. Additionally, more research question should be pursued to further explore the health and economic implications of all vinyl building materials. In our research, we found that vinyl windows are harmful to both human and environmental health at most stages of its life cycle. Vinyl windows are also a least preferred option when it comes to long-term cost-effectiveness due to the short lifespan and tendency to warp. The
production and demand for vinyl window creates a negative loop that is degrading human and environmental wellness and we recommend that contractors should consider alternative materials for their construction projects.

References


David Eaton, Department of Environmental & Occupational Health Sciences. University of Washington


Todd A. Cleland, Department of Material Sciences. University of Washington


Composting Toilets

ENVIR 480
Sustainability Studio

Prepared for:
Kristen Dotson - Sustainability Services Director of Miller Hull
Rori Kirkpatrick, Lauren Campbell, Gina Durst, Josephine Wu, Erika Gertsen
Introduction

The depletion of the earth’s freshwater sources is among the most pressing challenges humanity will face in the near future. Only three percent of the water on earth is freshwater, and the exponential growth of the human population coupled with rising temperatures will deplete our stores quickly.

In our homes, toilets use more water than any other appliance. Flushing accounts for 24% of our indoor water usage, while showers surprisingly only use 20% (EPA). Depending on when it was built, a conventional toilet can use up to 7 gallons for a single flush. Even the most efficient toilets commonly use over a gallon. Most toilets use clean water to flush waste down, which stresses our freshwater ecosystems. However, the role that commercial spaces could play in reducing this stress is often overlooked. In its latest survey, the U.S. Energy Information Administration estimated that there are 5.6 million office buildings in America (Michaels). With the average worker spending up to a third of their day in the office, change in these spaces could make a meaningful impact.

Partnership

To investigate solutions to the freshwater depletion issue, we were partnered with Miller Hull, a Seattle-based architecture firm interested in finding sustainable alternatives to traditional building methods. Miller Hull designed the Bullitt Center, the world’s first Living Building for office space. To meet the Living Building Challenge and receive certification, a building must meet multiple imperatives within seven areas of performance, including producing as much energy as it uses and being nearly 100% sustainable and non-hazardous in both its construction and its daily use. For the Water aspect of the challenge, the Bullitt Center had to capture and treat rainwater for all its needs. They additionally installed Phoenix composting toilets, from Advanced Composting Systems LLC, to remain independent of the municipal water system. In fact, with six stories, the Bullitt Center is the tallest building in the world to only use composting toilets.
Although the Bullitt Center has been largely successful in its implementation of these composting toilets, they are still rarely found in commercial spaces. Thus, Kristen Dotson, Sustainability Services Director at Miller Hull, enlisted our help to determine if composting systems are a viable solution for future commercial spaces, as well as to identify problems caused by conventional toilets that could possibly be mitigated by the use of composting systems.

**Hypothesis**

We suspect that conventional toilets are more harmful to the environment and human health than composting systems are. To determine this, we have investigated the comparative impacts of composting toilets and conventional toilets on our ecosystems and communities as well as identifying barriers to widespread implementation of composting systems in commercial settings. We decided to explore this hypothesis by dividing our research into three areas of study: water usage, waste treatment, and individual-to-toilet contact.

With individual-to-toilet contact, it is important to first understand how developed countries moved to water-based systems. By learning about water-based toilets, it could help us understand the benefits and drawbacks to a waterless system.

**History**

The invention of some of the first simple toilets are credited to Mesopotamia in the late fourth millennium B.C. (McMahon) These non-flushing affairs were pits about 4.5 metres deep, lined with a stack of hollow ceramic cylinders about 1 metre in diameter. Users would have sat or squatted over the toilet, and the excrement would have stayed inside the cylinders with the liquids seeping outwards through perforations in the rings (Wald). This method eventually evolved into a process of flushing the waste by splashing water to clean the area. Systems to transport the waste were built outside the homes. These systems were only accessible to the very wealthy who could afford the toilets and transport mechanisms. For people who couldn’t afford the water systems, bedpans were commonly used and emptied outside the window onto the
streets. Another option was to use a pit in the ground outside and, “although the pit toilets would have successfully separated people from their waste … studies by the US Agency for International Development say that some 75% of a population must have access before there are widespread improvements in health,” (Wald). As society evolved, buildings got taller, inhibiting the throwing-out-the-window mechanism, and toilets became more commonly used. The flush toilet was invented in 1596 but did not become widespread until 1851 (Stamp). It was mostly common in London to have flushable toilets in public spaces that people would pay to use. From there, they became more accessible and common to the middle class. By the end of the 1850’s, with successful waterway planning, most middle-class homes in London were built with toilets. Mechanisms evolved with design lead by Thomas William Twyford who created the iconic “S” shape of the toilet to trap the smell, methane gas, and dropped objects. From there, inventors and entrepreneurs enhanced the mechanisms and shapes for maximum comfort and profit. European cities had to adapt their city codes and water system plans due to the popularity of these toilets. Although the practice of flushing waste into discrete sewers and septic tanks is more sanitary than excreting waste into pits or near a city’s waterway, modern toilets unfortunately still have some major impacts on human health.

Another issue that is apparent in conventional toilets is plumbing. It creates a number of problems from flooding, to leaking of pipes which can increase risk of exposure if not properly protected. Hazards associated with sewage include tetanus, Leptospirosis, Hepatitis (A, B, and C), harmful bacteria, and parasites. Exposure to these hazards pose a danger to human health and can even lead to death.

On a larger scale, a problem with toilets is the lack of availability. Not only is the hardware inaccessible, but the water for flushing is equally difficult to obtain. The World Health Organization and UNICEF state that 40% of the world — 2.6 billion people — engage in open defecation. Lack of toilets is the cause of an estimated 2 million preventable deaths per year (Koss). Dysentery infections, as well as all other waste hazards, are prevalent in countries such as India where campaigns to end open defecation are active. However, because composting toilets can vary so greatly in design and water consumption, they could be a great aid to ending these issues — especially in developing countries.
What are composting toilets?

Composting toilets are an alternative to water-bowl toilets, which use natural processes of decomposition and evaporation to recycle human waste. The waste is decomposed aerobically as opposed to anaerobic septic systems, which not only prevents methane emissions but also breaks down harmful bacteria quickly and efficiently. Due to the nature of the closed system, these toilets are usually not connected to municipal water lines, further reducing the likelihood of sewer leaks. Additionally, composting toilets are generally designed to consume far less water than conventional toilets, further helping preserve freshwater resources. A comparison between water usage in composting toilets and conventional systems will be discussed further in the Methods and Results section of this report.

At the Bullitt Center, Advanced Composting Systems LLC were brought in to work on the challenge of setting up the world’s first office completely outfitted with composting toilets. The Phoenix composting toilets — manufactured by Advanced Composting Systems LLC — were chosen. Each toilet is a waterless bowl that becomes coated by a foaming agent when triggered by a user entering the stall. Upon use, waste falls to the bottom of the bowl and down a pipe leading to one of the Bullitt Center’s 10 composting systems. Each of these units is the size of a Fiat — 84” tall x 40” wide and 61” deep” (“Waste Not”). Wood chips are added to the composters and mixed. Handles on the outside of the tanks turn tines on the inside allowing the mixture to aerate. The manufacturer recommends turning these tines weekly for optimal decomposition. “Liquids are separated from solids through a drain at the bottom of the tank and either resprayed over the pile or removed” (Nelson). In this case, the liquids are drained into leachate tanks, where they are collected regularly, treated, and integrated into a local natural wetland. Solid waste remains in the tanks until it has composted. The ‘biosolids,’ as they are called in this stage, are then taken to a treatment plant for final processing. After this, the mixture can then be sold as garden-safe compost, known in the King County as Loop®. Further discussion on Loop® can be found in the Results section.
Methods

To explore our hypothesis, “Conventional toilets are more harmful to the environment and human health than composting systems,” we focused on four areas of research; individual-to-toilet contact, water usage, and waste treatment, and public perception.

Individual-to-toilet contact

Even in developed countries, normal contact with conventional toilets can impact human health and the environment. A study conducted in 1975 by Dr. Charles Gerba discovered a phenomenon now commonly referred to as “the toilet sneeze.” This is the aerosolization of harmful bacteria and particles from toilets when flushing with the lid open. The study brought attention to bacterial exposure and encouraged people to lower the toilet lid before they flush. It is a subject of continuing study, and potential risks are still unknown.

To determine whether composting toilets are more sanitary, we contacted John Scott Meschke with the University of Washington Department of Environmental and Occupational Health Sciences. We hoped to compare E. coli swab tests of Bullitt Center toilets to that of a building of a comparable size and traffic level. However, Scott’s department had conducted similar swab test studies and we were told they can take up to six months. In public settings, bathrooms are cleaned regularly and thoroughly, so any bacteria that may be deposited by toilet sneeze is often cleaned before it can build up to unsafe levels. Given the scope of this project, setting up a thorough survey that includes swab testing, as well as air particle readings, would take a significant amount of time, money, and resources, in order to get a truly accurate reading of bacteria levels.

Water Usage

In 1992 the US implemented a federal standard limiting the maximum amount of water used per flush to 1.6 gallons. Since then, inventions such as the dual-flush toilet and labels like WaterSense (an EPA-sponsored partnership program) have further reduced water to 1.28 gallons per flush in high-efficiency toilets. To examine water usage by composting and conventional
toilets, we compared the per-use water consumption of a Bullitt Center toilet to the amount of water used in 1992 federal standard toilets, as well as in modern day highest-efficiency toilets.

Interestingly, we discovered how important it was to compare number of individuals versus comparing these systems by office square foot space. This is due to the fact the Bullitt Center follows ASHRAE regulations as well as a ‘natural light policy,’ which encourage each individual’s workspace to be within distance of a window to benefit from the mental health boost of natural light. This is unlike many other office spaces, which are happy to squeeze in workers “like sardines,” as one report claimed. Shockingly, offices in America “will average 151 square feet per worker,” much less than the “225 square feet in 2010,” (Peterson). Additionally, in order to ensure our numbers were correct, we averaged out the number of bathroom visits each user would hypothetically make in one day. “For most people, the normal number of times to urinate per day is between 6 – 7 in a 24 hour period,” so with an 8-hour workday, office workers would typically visit the bathroom three times (“Normal Urinary Frequency”). After researching these numbers, we calculated the amount of water each system uses in a year and how much water is saved by composting systems.

![Fig 1: Copy of the Excel calculations for both 1992 federal standard toilets and high-efficiency toilets.](image)
Waste Treatment

Toilets can be a major cause of pollution. We assume that our blackwater is effectively treated, but 860 million gallons of untreated waste is leaked from American sewer systems annually. In fact, “3.5 million Americans get sick each year after swimming, boating, fishing, or otherwise touching water they thought was safe,” (“How Sewage...”). Even the blackwater that manages to make it to treatment plants then undergoes harsh chemical processing before being released into our natural waterways, unlike the natural composting process which relies on bacterial interactions. Only a fraction of our water is UV treated, so indigestible pharmaceutical chemicals such as hormones additionally affect aquatic life.

Public Perception

To better understand personal opinions of composting toilets in a “forced” environment, we hoped to interview students and staff at the Bertschi Elementary School, which possesses another Living Building in the Seattle area. As part of the Living Building Challenge, their Science Wing has one composting, vacuum-flush toilet on the premises. Unfortunately, due to parental permission issues, we were not able to directly communicate with students. However, we were able to interview Julie Blystad, the Bertschi School science teacher, as well as Jory Lum, the facilities manager in charge of the composting toilet.

Results

Individual-to-toilet contact

As swab testing proved to be out of the scope of this project, we cannot provide conclusive results when discussing individual-to-toilet contact. It can only be said that it is comforting to know that common cleaning practices are upheld in all areas where users would typically interact with their surroundings, regardless of the type of system.
**Water Usage**

The most compelling aspect of the “commercial versus composting” argument was certainly the dramatic reduction in water usage. Below is a smaller version of the infographic that was designed for submission.

![Commercial Toilet Water Comparison](image)

**Fig 2:** Above is the infographic created for Miller Hull to show to future and existing clients.

**Waste Treatment**

When looking at composting and conventional systems, waste treatment is where the two differ most. Although both systems have hazards, we discovered that there are additional added benefits of composting toilets. In conventional toilets, waste is flushed out of the user’s space and into the municipal pipe system. It is then carried to the wastewater treatment plant, during which time leaks could occur in the complex journey. Upon arrival, non-organic trash is filtered...
out. Further on, gravity settles large solids to the bottom of tanks. The cleaner water is piped onwards for further chemical processes and treatment to ensure that it can be released back into natural spaces (in our case, Puget Sound). Whatever conventional system biosolids can be rescued are taken out towards a digestion tank, which, over the course of several weeks, aerobically “digests” and kills off 95-99% of the disease-causing organisms in the same way that the composting system does. This is then transported to the same treatment plant as the composting tanks go to. In King County, these biosolids are taken to GroCo, in Kent, where the biosolids are mixed with sawdust and he mixture can then be sold as garden-safe compost, known in the King County as Loop®. Loop® batches are laboratory tested to meet Washington State composting standard and are then used as fertilizer and soil amendment for commercial forestry and agriculture, and as an ingredient in compost for landscaping and home gardening (“About Loop”).

In looking at this process, we realized several things. Firstly, Loop comes from both conventional and composting sources. However, composting toilets cut down on many aspects of the journey that waste from conventional toilets have to take. Instead of going through pipes and risking leaks, composting toilets put waste straight into the equivalent of the digestion tanks. Additionally, they allow the waste to sit for a much longer period of time — up to two years before removal at the Bullitt Center, ensuring that the disease-causing organisms are killed off (“Waste Not”). Finally, in composting systems the liquid waste is separated and is drained into a wetland for natural filtration — no chemical processes needed.

Unfortunately, neither conventional toilet and wastewater systems are currently able to filter out artificial compounds like steroids or estrogen from birth control. Although we cannot say that one is safer than the other, composting toilets do provide advantages that conventional systems do not, such as decreasing water usage. Each batch of GroCo is also tested for disease-causing microorganisms such as bacteria, viruses and parasites. The treatment of bio-solids kills more than 95% of such organisms and the composting process destroys any that may remain. The use of these materials in the production of crops for human consumption when practiced in accordance with existing federal guidelines and regulations, presents negligible risk to the consumer, to crop production and to the environment.
**Public Perception**

In our talks with the Bertschi school science teacher, Julie Blystad, she explained the setup of the unit and was also able to give some insight to the students’ reactions to the composting toilet. Due to an older, vacuum-flush system, their toilet isn’t as quiet or as odorless as the Bullitt Center’s toilets. Below are some of the paraphrased answers of our interview with Julie Blystad:

*Do the students think the bathrooms are clean?*

Yes, but the bins sometimes make the bathroom stinky.

*How do students feel about having to use the composting toilets?*

Some of the younger kids can find it a little bit scary due to the vacuum-flush system and sometimes choose to walk to use other bathrooms! However, the older students encourage each other to use them. We teach the students how the toilet works and what benefits it gives us, and they really understand it, even the kindergarteners.

*Do they think more people should use them?*

Yes! They know the toilets are good for the environment and better for humans too because they save water.

Julie was quick to emphasize the Bertschi School motto of creativity, confidence, and compassion. “The last one is the most important,” she clarified. Compassion for others as well as for the environment has lead Bertschi School students to have a generally positive opinion on the toilet, especially after being educated on the composting process that occurs after use.

After speaking to Julie, we were able to get in contact with Jory Lum, the Bertschi facilities manager. He explained that unlike the Bullitt Center, their composting product remained on the school grounds and the finished product is “only used in a section of plants that is inaccessible to [Bertschi] students.” Interestingly, as a facilities manager, Jory had a different opinion on the worth of the toilets. The following is an excerpt from our email exchange:
What are the main issues you have with the composting toilets? Do you ever have to deal with leaks of any kind?

The toilet uses the grey water from our sinks in the science room along with rain water if needed. Because it does use the grey water, that is where we have some issues. Either with the pumping system to the toilet or with the lines that run to the toilet. Since I have been here (1 year), we have had issues with the pump twice and repaired the water line to the toilet once.

Have you personally used them? If so, how do you like them?

This is the first time that I have ever dealt with them and personally, I wouldn't install them if I had the choice.

Do you feel like they're cleaner than conventional toilets? If not, is it still worth it to use them for the environmental aspect?

Environmentally they are fantastic. They're a great idea and get the job done. The maintenance however is another story. Therefore, coming from a maintenance viewpoint, I don't really like them. Sorry.

Is there anything else we're overlooking about them that you would like to say?

As I mentioned, for the environment they are great. If they can figure out a better way to maintain them and service them, then I might change my mind, but for now they are more of a hassle then I feel is worth it.

As a takeaway, Jory seemed frustrated by their need for maintenance. In looking at this conversation, we were unsure whether or not it was the same story at the Bullitt Center. With a newer system, the maintenance might be easier. However, he did not mention that they were “unclean,” which further bolstered our hope that people would warm to them if given the opportunity to interact and better understand their benefits.
Conclusion

Implementation of composting toilets is currently very expensive, with the toilet systems at The Bullitt center costing around $900,000 after purchase and installation. The market for composting toilet systems is still not large enough, which is one of the reasons that The Bullitt Center holds one of the largest commercial composting systems in the United States. In order to implement these types of systems on a mass scale, there needs to be a greater public demand of composting toilets for the market to manufacture large enough systems. An increased market will also bring lowered installation and material costs to make these systems feasible for the average business. Traditional sewer systems continue to pose many human health and environmental impacts that must be addressed. However, without increased education surrounding these systems, interest in finding waste management alternatives will continue to lag. Large scale implementation may be possible as the market for these products expands, and changes will be necessary in the future as water resources become scarce. In addressing our four areas of research, individual to toilet contact, waste treatment, water usage, and public perception, we were able to conclude that the long-term benefits of composting toilets outweighed the costs of conventional systems.

Next steps

Given the immense scope of this project, we were unfortunately not able to carry out our original plan of gathering data from swab testing in the time frame allotted. Moving forward, the next steps would be to conduct a study to detect the presence of potentially harmful bacteria in various public restrooms containing composting toilets, as well as public restrooms with conventional toilets.

In order to conduct a thorough study, the setup would need to include swab testing, as well as air particle readings, for the detection of certain major pathogens commonly found in public restrooms. Suggested testing locations would include 1 multiple stalled women’s restroom, 1 single private women's or all gender restroom, 1 multiple stalled men’s restroom, and one private men’s or all gender restroom (1 for each conventional and compostable settings).
testing of 2 larger spaces, in addition to 2 smaller, tightly enclosed spaces, would allow for comparison between bacteria levels found as the result of the air particle readings. We recommend the study start by thoroughly cleaning each of the restrooms being sampled with a bleach solution, to rid surfaces of any existing bacteria. A sample size of around 80 swabs minimum, is recommended for the most accurate results. The cost of swabs and processing is about $50 per swab. Over the course of hours, days, and weeks, periodic swabbing of the toilet bowls, seats, rims, and base would be gathered for bacterial microbe sampling. Microorganism selection would be determined by the most common pathogens found in restrooms, and bacteria that pose a greater potential threat to human health and safety. These pathogens include *Staphylococcus, E. coli, Salmonella, P. alcaligenes, and Norovirus.* (Flores, Gilberto E. et al) In addition to the swab collection, testing and analysis, the use of an air particle reader would allow for the detection of pathogen laden aerosols, commonly found after the flushing of a conventional toilet. In order to gather a thorough analysis of the amounts of various microorganisms found in the air, flush emission levels should be taken into account, that is the strength of the actual flush, as compostable and conventional toilets will vary greatly. After isolating each of the bacteria collected from the swab tests, and determining the average amount present for each sample, the study would then compare the bacteria levels measured by the air particle reader in each location. This would allow for bacteria level comparison between conventional and compostable toilets in smaller, more enclosed spaces, versus bacteria disbursement in larger more open restrooms.

We would also suggest conducting more surveys with individuals who have had less contact and experience using composting toilets. This would allow for a comparison of public perception between individuals who have regular contact with compostable toilets, such as the students we surveyed from the Bertschi school, versus those with very limited or no contact or experience with composting toilets. These surveys would help to gain a better understanding of some of the limitations with implementing composting toilets on a mass scale surrounding public perception, aside from the extreme cost barriers associated with these alternative systems.

In addition to the next steps previously addressed, we would also suggest a cost comparison analysis of an office building of similar size, and foot traffic amounts, to that of The
Bullitt Center. The analysis would allow for a more in depth understanding of the cost limitations that implementing composting toilet systems on a mass scale still pose.

**Main points**

A common theme that came up during our research was the lack of information on large scale composting systems. Despite our research being limited, we were able to conclude the numerous health, cost, and environmental benefits that composting toilet systems would bring. Conventional toilet systems have a multitude of human health problems associated with waste treatment and sewer leakages. Many of these issues can be solved by implementing composting toilets but steps will need to be taken before the application of these toilet systems due to the various factors addressed in the report.

While it is in fact a “forced” environment, the students at Bertschi have been given extensive education on the mechanics and benefits of composting toilets. Although they are still in elementary school, Bertschi students are strong proponents of increasing sustainability within their school systems, as well as within our society. As we shift toward more sustainable practices, implementation of alternative waste systems will only continue to grow. The Bullitt Center is a great example of how alternative wastes systems have a place in public settings.
Works Cited


A Look into Tacoma’s Communities: Values, Concerns, & Barriers

City of Tacoma: Aris Efting
Livable City Year: Teri Randall-Thompson

Authors:
Meghan Avila
Gabriella Chilczuk
Anna Mckee
Katie Ort
Table of Contents

Introduction…. 83
Methodologies…. 83-86
Results…. 86-89
Conclusion…. 89-91
Next Steps… 91-92
Main Points…. 92
Introduction

Our group partnered with the University of Washington’s Livable City Year and the City of Tacoma’s Open Space Program to answer the two following questions:
1. What are the best strategies to increase awareness in demographics that have historically been underrepresented at Open Space restoration events?
2. What are the barriers that prevent people in the community from volunteering at these events?

Our objectives as a group were to speak with community members to get a better understanding of their barriers and where they felt underrepresented, if they did, take this information and compile recommendations for the City, and initiate conversation between the Open Space Program and community partners.

Methods and Findings

For our study we wanted to determine why certain demographics were underrepresented within the Passive Open Space volunteer program, what their barriers may be to volunteer, and how the City might address said barriers. We determined that the best way to gather information from the individuals and communities that have the lowest numbers of volunteer engagement, was through school and community group outreach. This was done through email, phone calls, and in person meetings with the goal of organizing focus groups to discuss volunteer barriers and conduct the survey. The initial emails that were sent out explained who we were, what the Open Space Program and Livable City Year is, and what we were hoping to achieve by contacting the schools and organizations. If we did not receive a response to the email, we would call on the phone and attempt to talk with people directly. If there was no response we would leave a voicemail explaining our desire to connect with their club, community center, organization, or group.

We contacted several student groups through the University of Washington, Tacoma. These groups included the Black Student Union, South Asian Student Union, Desi Student Alliance, Filipino American Student Organization, Khmer Student Organization, Latinxs Embracing Education, Muslim Student Association, and Somali Student Association. We were given a list of contacts that was created by the City of Tacoma’s Office of Equity and Human
Resources. This list included the Black Collective, Latinx Unidos, Asian Pacific Cultural Center, Associated Ministries of Tacoma and Pierce County, and Hilltop Action Coalition (Neighborhood Leaders Programs, Community Outreach). All groups were contacted. We also obtained contacts through the Tacoma Public Schools homepage, internet research, and word of mouth. These included, Christine Cooley through Pierce County Conservation, Lynnete Scheidt, a McKinley Park Volunteer, Emily Pinkney the Citizens for a Healthy Bay Program Manager, Tom Eben, Jordan Burman, and Samantha Lake who are members of the New Tacoma Neighborhood Council, Top Gorospe, the Director of Social Activities/Support Groups Tacoma YMCA, and the People's Center Tacoma.

In total we received six responses from the community organizations, individuals, and groups, with one, People’s Center, resulting in an in-person meeting. A second group, Latinx Unidos of South Sound (LUSS), contacted us after we had concluded our research and showed interest in future communication. We were able to interview Christine Cooley, a community organizer who works for Pierce County Conservation District, who was referred to us through another contact with the Hilltop Action Coalition. She connects people in the community with volunteer opportunities, centering around environmental projects. Our hope coming into this interview was that we would be able to better understand the relationships within the different communities in Tacoma and learn about how successful volunteer groups are typically organized. She stated that there were several groups that organized similar volunteer projects as the Open Space Program; we asked how the City might be able to replicate this success. While she was unable to pinpoint what would be needed in order to achieve similar results, she provided us with some suggestions on where to start and some people that the City may consider contacting.

Our group was able to get in contact with the People’s Center in Tacoma, a popular community center that is in the Hilltop neighborhood, to inquire about having a table there for conducting surveys. We were told we could come any day we would like, and also advised that there would be a free community dinner on the second Friday of that month and would likely be a lot more people than usual at the center. Our group decided to this would be the best day to conduct our survey.
For our community survey we took questions that were pre-written by the City and altered some of the questions to be somewhat more readable. We did not want to diverge too much from the City’s survey as these were the questions they were interested in finding the answers to. As a group we read through the questions and decided how we might be able to make the survey and its questions more concise so that we could parse through the data and that people would not lose interest. We also wanted people to feel free to express their opinions and elaborate on certain issues. We left most of our questions open ended, rather than multiple choice, and our multiple-choice questions included at least 6 options, of which people could circle more than one option, including a space for other, in which people could write their own answer. Our survey included 14 questions about participants feelings about volunteering and open, natural spaces; their current status as a volunteer; as well as incentives and barriers to volunteering. Our survey also included three questions about demographics and was seventeen questions long in total.

To incentivize people to take the survey, we offered each participant a raffle ticket in which they were entered to win a $50 gift card. We had five participants in total. Several people who we spoke with did not complete the survey but preferred to speak with us one on one about their concerns. This data was not included in the survey results but was considered while writing our recommendations to the City.

In regard to the schools that were contacted, we had a total of 9 initial responses. This was out of a total 44 individuals that were affiliated with either one of the 5 high schools or 8 middle schools. Of these initial responses, 6 were consistently communicated with us and two resulted in school visits. The following were the schools who showed interest in the program: Bettina Stanley, Multicultural Student Union at Wilson High School, Patrick Erwin, Principal, Ms. Schuler, Latino Club & Pacific Islander Club, and Ms. Higgins, Outdoor Adventure Club at Lincoln High School, Bonnie Smith, Youth Leading Change Club at Gray Middle School, YMCA Panther Center at Stewart Middle School, Mr. Walz, Builders Club at Truman Middle School, the Bobcat Learning Center at Jason Lee Middle School, and Amber Evans-Wynn, Baker Bulldog Center at Baker Middle School. The two groups that we were able to visit were
the students in the YLC club at Gray Middle School, and the Bobcat learning center at Jason Lee Middle School.

Our student surveys were very similar to our community surveys with questions about attitudes towards volunteering, open, natural spaces, and incentives and barriers to volunteering. Our student survey differed from the community survey in that the language used was geared towards younger people, and that it had questions specifically aimed at school-aged children. For instance, one of the questions asked if the participant would be more willing to volunteer for environmental projects if they were sponsored through their school. The student survey was twenty questions long, including three demographic questions. Our student survey had thirty-two responses in total.

Results

We reached out to a variety of community groups and schools and had a lower response rate than anticipated. In our one-on-one interviews with community members and organizers we found that there is a general apprehension to working with the City, given past negative experiences. The trepidation towards the City stems from a perceived sense of ineffectiveness and investment in the underserved communities of Tacoma. Others expressed fatigue with the engagement of focus groups and surveys, which they felt did not address their concerns or values or implement solutions to better serve their community. Some community groups required compensation given their extensive participation in similar surveys in the past, which proved to be an issue for our group’s small budget. In addition to monetary compensation for their participation, there was a request for child care and translation services which would also require additional payment as well.

In conducting the written surveys with middle school students, we found a general consistency with the responses, but many of the short answers were left blank. We found that the short answer questions were difficult for the students in this age group to understand and successfully answer. The student survey was written with high school students as our target audience but was only administered to middle school students which could account for the unanswered questions. We also found that students responded better to the survey and post survey discussion when engaged with some type of activity or game.
What would make volunteering more fun and likely for you to engage in?

- Help
- Animals
- Educational/history
- Community/Friends/Connections
- Art
- Money
- Music
- Games/Activities
- Food
- Nothing
- Uncertain

Number of Respondents

Would you be more likely to participate in volunteer projects or environmentally focused projects if there were more clubs or support through your high school?

- Yes
- No
- Not Sure
Post survey discussions were held with the students, which provided us with a lot more qualitative information about their interests and what might encourage them to volunteer with the Open space program. Generally, students said that incorporating fun aspects at work parties would increase their likelihood of participation, such as: food, music, and the presence of their friends. Providing transportation to and from the event as well as holding the event on a holiday such as Earth Day would also increase their likelihood of attending. Most of the students were unaware of what passive open space where prior to the survey, but conveyed concern that these spaces would be used for illegal activities, vandalism, litter, and homeless encampments.
Time was another major resource that prevented us from gathering data from both community center groups as well as the schools we contacted. A majority of community groups only met up once a month, making it difficult to find a time to connect with them within the time frame of our project. Time was also a constraint in coordinating with the schools because of the lengthy requirements for approval prior to us meeting with the students.

In meeting with Christine Coolie from the Pierce Conservation, we gained further information regarding community apprehension of working with the City and possible ways of creating more reciprocal relationships within the community. She suggested the City participate in community networking events to gather information regarding community values and needs, compared to focus groups and surveys. This type of inclusive engagement from the City would be received with more positive feedback from community members, who want to be heard by those from the City who can make a difference. This sentiment was reiterated to us by a community member at the Peoples’ Community Center, who expressed a desire to have one-on-one conversations with City employees who can implement change.

**Conclusion**

In conclusion we determined that the City of Tacoma may consider utilizing groups that are already doing similar work, engage youth with fun aspects at events, and focus on weekends and holidays for events.
We recommend that the City begin by engaging other local organizations and programs, such as Hilltop Urban Gardens, Tacoma Needs Trees, and Tacoma Roots. Hilltop Urban Gardens is a community-based urban agriculture, justice, and equity organization in Tacoma. H.U.G. focuses on inspiring local communities to eat healthy and address economic poverty and systems of oppression in Tacoma. Contacting Dean Jackson from H.U.G. will provide the City of Tacoma with insight into community needs and values, as well as connecting with residents that are actively working towards a healthier community. Tacoma Needs Trees, is another resource for further accessing active community members that value environmental health and well-being. Those already participating in the program understand the need for urban restoration in passive and active spaces. Tacoma Roots is an anti-racist environmental justice group that can best be accessed on Facebook. Their online forum is a platform to discuss the intersectionality of environmental issues, as they pertain to race, health, and income. The City of Tacoma may also utilize events such as Tacoma Green Drinks, which provides social and networking opportunities to those in the community who are interested in environmental issues. Tacoma Green Drinks has an event once a month and is open to all residents, not just environmental professionals. Safe Streets is another organization in Tacoma that focuses on building safe, healthy, thriving communities. Safe Streets works frequently with youth groups as well; Grace Eichner is a youth mobilization specialist for Foss H.S., Lincoln H.S., Stadium H.S., gray M.S., and Giaudrone M.S.; Rob McAfee is a youth mobilization specialist for Wilson H.S. and Mount Tahoma H.S.; and Darren Pen is a community mobilization specialist.

Engaging young community members with fun activities at events was a key result of our findings. That may include but is not limited to: warm up games or ice-breakers, incorporating art and music, making the event competitive, raffles and prizes, and providing food and drink. Warm up games can provide a space for youth to become more comfortable with their peers and their surroundings. A result of our research also showed that many students wanted to engage with their friends at these events, games can facilitate the forming of new friendships through team building. Incorporating art and music into these events was another result of our survey. The Nature Consortium, a grassroots community-based organization, already successfully utilizes art and music in their restoration events, with a focus on fun, building community,
modeling sustainable behavior, increasing accessibility, and continuing learning. The Nature Consortium itself can be a resource for further understanding how to successfully incorporate art and music into program events. Amy McBride or the City of Tacoma Commissions, is another resource for art commissions within the City, who may provide additional resources for incorporating local community artists.

Determining the best times for events was more challenging and changes depending on the targeted audience. Students found that they would be more likely to volunteer weekdays after school, given that many of them want to reserve weekends for their own personal use. Students were more likely to participate in events if they were facilitated through the school as well. We recommend further utilizing the Safe Streets youth mobilization specialists, as well connecting with teachers that have shown interest in creating a partnership through our research such as Bonnie Smith, who is a teacher and advisor for the Youth Leading Change club at Gray Middle School. Weekends and holidays were another time students and community members stated they would be able to volunteer. Many expressed an interest in having large events centering around holidays such as Earth Day, Mother’s Day, and Father’s Day.

Next Steps

We suggest for further data collection the City of Tacoma would consider utilizing town-hall style engagement compared to surveys. We gained the most useful information through group discussion and one-on-ones with community members. We found that people were more likely to communicate their opinions, values, and concerns when given the space to speak freely, without the direction of a survey. Since there was trepidation of working with the City, providing community members with an open forum for discussion allowed for more honest feedback and less discomfort about the intentions of the project. Students benefited from more direction in group discussions, but certainly provided more useful information in these forums compared to the surveys. The surveys themselves proved to be somewhat confusing to younger students, as they were written for high school aged youth, but administered to middle schoolers.

Other gaps in our research can be attested to time and money constraints. Although we contacted more than 100 people, programs, and community centers in total, we received very low response rates within our time frame for this project. Had we had more time to follow up in
communication we may have been able to collect more data. We also had an inconsistency in communication, where we received positive responses, but then had no follow through on their end. Being more flexible with our time we may have been able to engage with those who expressed interest in the project. Many of those who expressed interest were teachers and club advisors, who may be a bridge in creating partnerships with the local schools.

**Main Points**

Upon completion of the project, we have learned that many community members are open to volunteering at Open Space restoration events. The primary concern of these members is that the City has not taken the steps to be involved with community-oriented spaces. These spaces would provide the opportunity for the City to engage in networking events, have discussions with members who are interested or hesitant, and understand where the community is underrepresented. Schools are a resource that the City might consider utilizing. Many individuals expressed an interest in restoration events that were set up through their educators. Coordination with specific clubs, after school programs, and administration has proven to be the most effective thus far. Based on our data and the conversations that we had with students, the biggest thing that would contribute to community involvement would be making the restoration events fun. The best way to connect and make the community members feel heard is to listen.
References


“Keeping Our Community Safe.” Safe Streets, safest.org/who-we-are/

Tacoma Roots: Environmental http://www.greendrinks.org/Tacoma

Justice Forum, https.facebook.com/groups/114459102553901/


Conclusions

Within 10 weeks, we examined the environmental and human health implications of items that we come into contact every single day, such as green spaces, conventional toilets, vinyl windows, public drinking water, and even large industrialized goods, such as concrete, wood, and polyvinyl chloride (PVC).

Our class had the honor of working with Miller Hull, the Puget Soundkeeper Alliance, and UW Livable City Year to better understand the effects our surroundings have on us, and in turn, how we affect our surroundings. Needless to say, there are still many things we can do to improve this relationship and make it sustainable for future generations.

Ultimately, our successful work in this class will establish baseline information for decision-makers and stakeholders to act upon, and our recommendations will contribute to the sustainability of across the UW and Greater Puget Sound region.