### Thesis Prospectus 2022-23

**Name: Marlene Melchert**  **ID Number: A00129222**

**Email: mlm1@evergreen.edu**

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**Faculty Reader Approval (date):**

**MES Director Approval (date):**

1. **Working title of your thesis**[[1]](#endnote-2).

Evaluating Tire Rubber Microplastics emission sources: Implications to Urban Streams

1. **In 250 words or less, summarize the key background information needed to understand your research problem and question.**

Tire rubber is the second largest contributor of microplastics to the environment with known toxicological effects to aquatic ecosystems (Lou 2021). Tire rubber microplastics (TRMP**)** act as an indirect source of toxic chemicals and heavy metals that are transported via stormwater into urban streams (French 2022; Lou 2021). The identification and quantification of tire rubber microplastic (TRMP) primary sources like tire tread wear particles (TWP) can act as an indicator of urban streams at risk for urban runoff mortality syndrome. When tire additive N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD) undergoes environmental reactions with ground-level ozone it produces acutely toxic N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine-quinone (6PPD-quinone) the casual toxicant for urbanrunoff mortality syndrome, formerly known as Coho Mortality Syndrome, that has been observed in the Puget Sound since the 1980’s (Tian 2022). 6PPD-quinone has one of the highest aquatic life toxicity ratings with a lethal concentration of 95 ng/L and is prominently found in stormwater and roadway runoff (Tian 2022). As TRMP accumulates along the roadside TRMP particles react with ozone where 6PPD-quinone is formed and absorbs to TRMP particles (French 2022; Tian 2022) There are several factors that increase 6PPD-quinone inputs to urbans streams such as increased impervious land coverage to stream size ratio, road use frequency, snow melts and rain/storm events (French 2022; Tian 2022). The identification of the prevalence and abundance of TRMP emissions sources can act as an indicator of streams at risk for 6PPD-quinones toxicological effects.

1. **State your research question(s).**

Is there variation in the size of tire rubber microplastic particles depending on the source of emission?

* If time allows, I will investigate how can road frequency and impervious land coverage indicate TRMP density.

1. **Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?**

The theoretical framework for my project consists of sourcing TRMP hotspots near streams with that have stormwater/roadway runoff susceptible salmon species. Each year as salmon make their journey to their natal streams, they travel through a diverse set of waters impacted by a variety of land practices and stormwater/roadway runoff inputs (French 2022). Stormwater and roadway runoff bring a caveat of toxins into freshwater streams and rivers that have acute mortality effects on Coho salmon (O. *kisutch*) and steelhead trout (O. *mykiss*) (French2022). Coho and steelhead trout show unique sensitivity to stormwater and roadway runoff; however, coho showed the highest sensitivity displaying mortality with a 5 % stormwater concentration exposure limit (French 2022). Since tire rubber is the source of the 6PPD the parent product of 6PPD-quinone it’s crucial to account for all tire rubber related sources to gain insight on the prevalence and abundance of tire rubber microplastics in the environmental.

In theory urban runoff mortality syndrome risks increase as the number of tire rubber microplastic emissions sources and impervious land coverage percent increases the amount of toxic stormwater and roadway runoff inputs to streams (DOE 2022). If we identify regions with increased tire rubber microplastic emission sources, we can highlight areas that need mitigation efforts to alleviate the toxic effects of 6PPD-quinone inputs to streams (DOE 2022). Current studies for 6PPD-quinone characterizes its presence in roadway and parking garbage dust, stormwater runoff, stream surface waters, fish tissues, and human respiratory pathways. 6PPD reacts with ozone at the surface of the tire rubber particle to become 6PDD-quinone (Tian 2022). This suggests that as the TRMP becomes smaller in size the particle increases the available surface area for 6PPD to react and generate 6PPD-quinone. Studies also show that 6PDD-quinone can accumulate in tire rubber particles which enhances tire rubber microplastics toxicity (French 2022; DOE 2022). This means that as tire rubber on roadways accumulates it can become saturated in 6PPD-quinone because 6PPD-quinon absorbs to particles where it is transported to aquatic systems. The source of tire rubber wear emissions comes from the mechanical abrasion of tires on roadway surfaces (Gehrke 2020). The size and quantity of car tire wear particle emissions depends on several factors such as roadway frequency, pavement types, climate (temperature), driving speed and style, as well as the composition and age of the tire (Gehrke 2020). This is why my study will compare and analysis any differences TRMP particulate size from a variety of roads with varying traffic counts (frequency) in Thurston County.

A toxic stormwater flush refers to heavy rains or snow melts that send large volumes of toxins from roadway and stormwater runoff into aquatic ecosystems (Peter 2022) As tire rubber microplastic accumulates it becomes more concentrated in 6PPD-quinone where it is washed out to streams via storm events (DOE 2022; French 2022; Peter 2022). Theoretically the percentage of impervious land coverage ratio to the streams size can fundamentally change instream characteristics like water quality, inflow, and velocity (Fiest 2018). Before the discovery of 6PDD-quinone as the casual toxicant to induced Coho mortality, studies showed a direct relation between urban runoff mortality events and increased percentage of impervious land coverage (Fiest 2018). Expanding impervious surfaces increases the negative impacts of land use practices, human activities, and urban growth on stream ecosystems (Fiest 2018). This continuance battle between human expansion and our shrinking freshwater resources provides significant stress to innovate and ensure best management practices in stormwater and roadway runoff mitigation. A geospatial analysis to identify TRMP sources to urban streams with susceptible species is crucial in promoting healthier urban streams for salmon and people.

The practical framework of this study has a 4-step approach to answering my research questions. The 1st step is to identify locations in Thurston County using a map of the county’s urban gradient, road systems, and streams. Road dust samples will be taken from major highways, secondary connector roads, and residential roads. The 2nd step in this practical framework requires field collections of road dust samples for laboratory analysis with the scanning electron microscope (SEM). The 3rd step is the identification of tire wear particle sizes from samples and if time allows quantify tire wear emissions. In this practical approach I will define the distribution of tire rubber emission by visual identification via microscopy, and if time allows the quantification of tire rubber emissions using this equation: (**E) is E = Emissions Factor × Vehicle Km Travelled × Number of vehicles** (Lou 2021; Kole 2017). Following my calculations, I will develop a GIS dataset of Thurston County’s tire rubber microplastic concentration and the measured mean particles size. The combination of predicted tire wear sums and optical measurements of tire rubber microplastics provides a glimpse into the distribution and potential variation of tire rubber microplastics emissions. If time allows the 4th step in this practical framework will include a geospatial and statistical analysis of TRMP emissions risks to urban streams by highlighting any variation in TRMP particle sizes based on sample location. The smaller the TRMP particle the larger the surface area of TRMP particles increases the reaction of 6PPD with ground level ozone increases the production of 6PPD-quinone where it is transported into aquatic environments from the roadways via stormwater and roadway runoff (DOE 2022).

1. **Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?**

My project contributes to the growing research on tire rubber microplastics (TRMP) identification in the environmental. As well as will attempt to contribute to the work on the potential impacts TRMP have on urban streams based on the emission source. In the State of Washington has made significant effort in the assessment and mitigation of 6PPD-quinone effects to aquatic ecosystems (DOE 2022). Currently, there are no studies in Washington that have examined the distribution of TRMP in the environment. The identification of the spatial distribution of TRMP can provide insight on areas that need priority stormwater and roadway runoff mitigation. My study focuses on tire rubber microplastics, the location (i.e., the source) of 6PPD-quinone, to the environment by investigating the distribution of TRMP in Thurston County.

Comparing particle sizes from each TRMP emission source relates to the leachability of 6PPD-quinone to urban streams (Klockner 2021). As TRMP particles decrease in size it gains surface area that allows 6PPD to react with ground level ozone to create 6PPD-quinone (DOE 2022; Tian 2022). This means that TRMP particle size plays a notable role in the generation of 6PPD-quinone and its absorption to TRMP particles. It is my hope that my work will help account TRMP as a prominent source of microplastic pollution in the environment, as well as contribute to the work on the mitigation and assessment of 6PDD-quinone sources to urban streams. Highlighting streams with a high urban gradient index and high road frequency helps to indicate areas of high TRMP concentration. There are several known factors to influence TRMP emissions to roadways: such as speed limits, the topographical design of the road, and the ratio of new to used tires driving on the road (Gehrke 2020). Understanding TRMP particle size can help provide in-depth understanding to the distribution tire rubber microplastics. For example, particle size changes the tire rubber microplastics transport and fate once it enters the environment (Järlskog 2022). The larger TRMP particle are more likely to be transported to soil and sediments, whereas small particles are transported to surface waters by stormwater and roadway runoff (Järlskog 2022). My research has the potential to add significant information in how tire rubber microplastics emissions vary in their contribution to aquatic pollution based on their location and frequency of emission.

1. **Summarize your study design[[2]](#endnote-3). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?**

For this study I will be examining the variation of TRMP emissions sources and assess the particle sizes and concentration for each sample.

The independent variable will be road way **average daily vehicle counts**.

The dependent variables will be measured sample **TRMP mean particle size.**

If time allows, I will estimate the tire wear particle concentration; where average daily road counts is the independent variable and estimated TRMP emissions is the dependent variable.

1. **Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-4).**

Both existing and new data will be used in my analysis of tire rubber microplastics distribution. My thesis work will determine hotspots for tire rubber microplastic contamination which can help indicate streams at risk for urban runoff mortality syndrome. This will be attempted in a variety of ways.

Data sets:

* U.S. Census data from 2018-2021 for urban to rural areas and will highlight Thurston county’s populations size.
* I will also use the U.S. Census data on the impervious land coverage in Thurston County.
* Thurston County Roads and Zoning map layers from Thurston County Geo-Data Center.
* WSDOT open data source map layer of WA state highway and state road counts.
* Ersi living atlas map layer of Washington roads counts.
* SalmonScape will be used to identify Thurston County streams with Coho salmon and Steelhead trout because they are listed as the most susceptible species to stormwater and roadway runoff.
* I will also develop a separate dataset based on the data collected from roadway samples.

My project adapts GIS mapping to assess TRMP distribution and characteristics.

Table 1 breaks down the evidence collection type, the question addressed and analysis.

Methods:

Table 1 Methods for data collection for Thurston County TRMP emissions sources

|  |  |  |  |
| --- | --- | --- | --- |
| Evidence | Data Collection type | Question addressed | Analysis |
| Primary Source of TRMP: Road Dust samples | Dry dust samples will be collected from: Residential Road and sidewalk, High traffic road main connector, Median traffic road that connects to main connector road, Low traffic small road that connects other small roads. | Is there variation in particle size of TRMP based on the source of emission? | Dust samples will be assessed using Scanning Electron Microscopy and compound microscope to determine size of particles. |
| GIS map of Thurston County Road counts and secondary source locations | U.S. Census data on impervious land coverage, and population density.  WSDOT & Thurston County Roads average daily road counts | How can road frequency and impervious land coverage indicate TRMP density? | Data retrieval from US Census and WSDOT and Thurston Road counts. |

1. **Summarize your methods of data analysis. If applicable, discuss any specific techniques, tests, or approaches that you will use to answer your research question.**

* In this section I cover the methods for sample collection covering materials and method for collection. Surveys and road diagrams have been adapted for this project and are based on the EPA standard for road dust collection.
* I will also cover the laboratory analysis of field samples and procedures for sample prep for to be used on the SEM. I also list the chemicals need for lab work in table 2.
* Last but not least I will discuss the analysis of the data collected in table 3.

**Field Collection methods**:

Field materials:

* Portable hand vacuum with bags, or hand broom and dustpan
* 20 glass containers with lids
* Small measuring stick (mm)
* Meter stick or measuring tape
* String to help mark the location for sampling

I will be using road dust collection methods and procedures developed by the EPA. This will be the general information taken from Primary source locations.

**Road Dust SAMPLING DATA FOR PAVED and UNPAVED ROADS**

\*Obtain approximately 100 grams at each sample site

Date Collected \_\_\_\_\_\_\_\_\_\_ Recorded by \_\_\_\_\_\_\_\_\_\_

Sampling location\* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ No. of Lanes \_\_\_\_\_\_\_\_\_\_

Surface type (e.g., asphalt, concrete, etc.)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_

Surface condition (e.g., good, rutted, etc.)

\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Sample collection methods:

1. Sampling device: portable vacuum cleaner or whisk broom and dustpan if heavy loading present.

2. Sampling depth: measure any loose surface material (do not sample curb areas or other untraveled portions of the road)

3. Sample container: if using a portable vacuum tare and numbered each vacuum cleaner bags or if using dustpan and broom tared and numbered glass containers with lids. NOTE: Road dust collections should be limited to only portion of the road over which tires routinely travel (i. e., not from berms or any "mounds" along the road centerline).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID Sample No. | GPS location | Container type and Sample | Measure Surface Dimensions (1xw) | Time of day and weather conditions | Mass of ID Sample + Tare Wgt. Of container |
|  |  |  |  |  |  |

A transect at each site will vary depending on the length of the roadway. Below is an illustration adapted for this projects sampling procedure for paved and unpaved roads. As shown in figure 1 for paved road sweeping or vacuuming 1 to 10 ft every 0.5 mile and collecting this in one container per location.

Diagram

Description automatically generated

Figure 1 Adapted from EPA road dust sample procedure for paved roads (EPA n.d)

In figure 2, I wanted to have a method in case the road chosen in not paved as you can see from the picture collection occurs in 1-foot fragments. This is to reduce the amount of natural dust particles in sample.

Diagram

Description automatically generated

Figure 2 Adapted from EPA road dust sample procedure for unpaved roads (EPA n.d).

After samples are collected, they will be examined in lab using a Scanning Electron microscope to measure the length of tire rubber microplastics found in road dust.

**Methods for isolating tire rubber particles from road dust samples**:

Materials: for matrix solution and density separation of TRMP from road dust (Tajwar 2022; Jung 2022).

* Sieve shaker
* Graduated cylinders (not sure on sizes yet)
* Micropipettes
* Micron filters 0.45μm
* Vacuum filtration system
* Heat bath
* Fume hood

Table 2. Lists the Chemicals needed, safety hazards, method for use and waste removal

Safety and hazard information obtains from chemical safety data sheets links provided in the chemical column.

|  |  |  |  |
| --- | --- | --- | --- |
| Chemical | Safety/Hazards | Method/  Analysis | Waste removal |
| [Sodium bromide (purity 99.0 %)](https://www.fishersci.com/content/dam/fishersci/en_US/documents/programs/education/regulatory-documents/sds/chemicals/chemicals-s/S25538A.pdf) | Causes serious eye irritation, May damage fertility or the unborn child. | Density separation | Follow hazardous waste removal procedure |
| [Sodium iodide (purity 99.0%)](https://www.fishersci.com/store/msds?partNumber=S324100&productDescription=SODIUM+IODIDE+CERTIFIED+100G&vendorId=VN00033897&countryCode=US&language=en)  [CAS No. 7681-82-5](https://www.fishersci.com/store/msds?partNumber=S324100&productDescription=SODIUM+IODIDE+CERTIFIED+100G&vendorId=VN00033897&countryCode=US&language=en) | Skin Corrosion/Irritation,  Serious Eye Damage/Eye Irritation,  Specific target organ toxicity (repeated exposure)  Target Organs - Thyroid | Density separation | Follow hazardous waste removal procedures |
| [Chloroform (purity 99.5%)](https://www.sigmaaldrich.com/US/en/sds/SIAL/288306)  [CAS No. 67-66-3](https://www.sigmaaldrich.com/US/en/sds/SIAL/288306) | Harmful if swallowed. Causes skin irritation, serious eye irritation. Toxic if inhaled. May cause drowsiness or dizziness. Suspected of causing cancer. Suspected of damaging fertility or the unborn child. Causes damage to organs (Liver, Kidney) through prolonged or repeated exposure. Harmful to aquatic life with long lasting effects | Density separation | Follow hazardous waste removal procedure for disposal |
| [Hydrogen Peroxide H2O2 (30%)](https://www.fishersci.com/store/msds?partNumber=BP2633500&productDescription=HYDROGEN+PEROXIDE+30%25%2C+500ML&vendorId=VN00033897&countryCode=US&language=en) | Hazard statements: May cause fire or explosion; strong oxidizer Harmful if swallowed Causes severe skin burns and eye damage Harmful if inhaled | Sample Digestion | Follow lab procedure for hazardous waste disposal |
| Deionized Water | No safety hazards | Required for all lab work | No hazards as long as it’s not combined with any of the other chemicals. |

**Methods outline for sample collection and lab work.**

**Step 1:** **Sample location selection and collection.**

Sample collections will be performed in each town/city in Thurston County (i.e., Lacey, Olympia, Tumwater, Tenino, and Yelm). There are four road types to sample in Thurston County:

* Major roads that connect to highways and interstate roads
* Secondary roads that connect to major roads
* Rural roads
* Residential roads

During collection I will note stormwater drains and if they go straight to stream or not. I will also fill out the appropriate site survey noted above for sample collection. In total I will take twenty road dust samples in Thurston County.

**Step 2: Lab work**

Digestion and Density separation road dust samples (Tajwar 2022; Jung 2022).

Digestion: A process that removes organic materials from road dust sample (Rabik 2021).

Density fractionation: Figure 3 shows the separation procedure of tire rubber wear particles (TRWPs) from road dust by the density difference. According to this method TRWP’s were not found below 1.20 g/cm3 or above 1.70 g/cm3 (Jung 2022).

Diagram

Description automatically generated

Figure 3 Road dust density fractionization of tire rubber wear particles (TRWP) (Jung 2022).

**Step 3:** **Identification of TRMP**

Microscopy will be used to identify tire rubber pieces from each float of the density fractionation stages. Key observations to look for are elongated non-transparent pieces via compound microscope. Then using the Scanning Electron Microscope (SEM) JEOL JSM-6480LV I will look at tire particles surface area and measurements.

Microscopy has two stages: First identify pieces to use in SEM with compound microscope. Second step to microscopy is SEM analysis. (If available, I will use EDX mapping with SEM to determine size variation in sample).

\*If time allows the use of FTIR can be used to identify tire rubber concentrations in road dust samples looking for styrene butadiene a tire rubber polymer.

This will all be followed by statistical and geospatial analysis. Table 3 details the methods, tests and analysis that will be used and indicate the approach to answering the research question.

Table 3 Methods, Test, and Analysis

|  |  |
| --- | --- |
| Methods, tests, and Analysis | Approach to answering Research Questions |
| **GIS Mapping:** (sources for each dataset listed in question 7)  Map layers   * Thurston County’s urban gradient (Thurston County zoning, roads, and population counts) * Tire rubber microplastics distribution (sample data) * Streams and rivers of Thurston County | This method is useful in showing the distribution of TRMP in Thurston County.  By looking at urbanization and tire rubber microplastic particle size distribution one could infer streams most at risk for frequent tire rubber microplastics exposures. This is because with increase impervious land and high populations should result in high traffic areas which in turns increases TRMP emissions and stream exposures. |
| **Calculating Tire wear emissions:**  The equation used to estimate TWPs production goes as follows: (**E) is E = Emissions Factor × Vehicle Km Travelled × Number of vehicles.** (Lou 2021; Järlskog 2021; Kole 2017)  Predictive modelling of TRMP emissions assumes EF is equal to 100 mg/vehicle-km and 2000 kilometers of travel. (Lou 2021; Järlskog 2021; Kole 2017). | This method of analysis helps to answer where the tire wear particle density is based on road use.  The equation is designed to predict roadway tire tread wear in milligrams per vehicle per distance travelled on roadway.  To calculate TRMP emissions I will need road frequency and kilometer travelled. As well as the number of registered vehicle owners in Thurston County which I have accessed through the WA state department of licensing open data source. |
| **Correlation tests:**  I will run a couple of tests on my particle’s sizes and road frequency data sets.  Calculate the correlation between TRMP emission source particles sizes and roadway frequency.   * Pearson’s r * Regression-to see if there is a linear relationship between particle size and road counts * t-test   In the case of non-normal distribution of data, I will run Kruskal–Wallis test followed by pairwise Dunn’s test | This analysis will help me answer the question if size variation and road frequency share a statistical relationship.  The Kruskal-Wallis and pairwise Dunn’s test will measure for differences in sample size variation amongst sample sites. |

1. **Address the ethical issues[[4]](#endnote-5) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).**

My thesis work does not pose any ethical issues for others. My husband Vincent Riggs does have the potential to incur harm because he will help me as I collect samples by looking out for traffic. I also have the potential to incur harm as the researcher when collecting samples, as well as from chemical use during sample prep and analysis.

1. **List specific research permits[[5]](#endnote-6) or permissions you need to obtain before you begin collecting data (e.g., landowner permissions, agency permits).**

No permits are required to collect road dust samples in Thurston County. All regions that I will collect samples have public access and do not require permission for access.

1. **Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-7).**

My position as a researcher for this study is from an environmental toxicologist’s point of view whose focus is on mitigating chemical pollution in the environment. I chose this topic because it has been the natural flow of my MES studies on salmon habitat and environmental pollution. Part of my study works to understand the cycle of tire rubber pollution within the environment by understanding how, what, and where chemical pollution originates via human development and waste. I want to document the distribution of tire rubber microplastic emissions in Thurston County because tire production is not regulated yet acts as a significant source of heavy metals and chemical pollution to the environment. My undergraduate is in Environmental Chemistry and Biology from the Evergreen State College and gives me the technical background to perform the lab work for this project. I also have experience using of Evergreens’ lab spaces and SEM for previous class project work and am confident in my ability to analysis data.

Salmon have been a research interest of mine since I applied to the MES program, it was the first time I connected chemical action policy with salmon populations in the Puget Sound. Since then, my research has largely related to the restoration of salmon habitats, and landscape connectivity of aquatic ecosystems for salmon. My candidacy paper was on sourcing toxins for coho mortality syndrome which is where I learned that tires are the source of 6PPD-quinone the casual toxicant to induce urban runoff mortality syndrome.

I will account for my position in my research by ensuring multiple perspectives in the use of 6PPD as a tire additive, this will include tire company’s and stakeholders’ perspective; as well as note policy makers and environmental researchers concerns in regard to tire rubber pollution. This will help bring a holistic perspective of tire rubber pollution and concerns to my study.

1. **Provide at least a rough estimate of the costs associated with conducting your research, if any. Provide details about each budget item so that the breakdown of the final cost is clear**.

Since I am already a GIS user and all the data sets, I am using are free and available to the public. As well as no permit fee for road dust collection. Table 4 breaks down any costs from travel to chemicals needed.

I will need access to Evergreen lab spaces and instruments:

Scanning Electron microscope to measure tire rubber microplastics.

* I will need a variety of chemicals that might already be available in the lab space, not sure but it has been mentioned.

Table 4 Cost associated with project work

|  |  |
| --- | --- |
| Items | Costs |
| Handheld vacuum | $ 60 +/- |
| Approx 20 Sample containers (glass) with lids | $ 20-50 +/- or free if MES lab has some to use |
| Sodium bromide (purity 99.0 %) | $ 52.50 for 100 grams |
| Sodium iodide (purity 99.0%)  CAS No. 7681-82-5 | $ 43.50 for 100 grams |
| Chloroform (purity 99.5%)  CAS No. 67-66-3 | $ 99.00 per gallon |
| Hydrogen Peroxide H2O2 (30%) | $ 12.95 per 100mL |
| Deionized Water | Available in lab |
| Travel expenses to sample location and to campus | $0.625 per mile predicted per day of sampling Est. 44-80+ miles (1 to2 days of sampling planned) |
| Final Costs rough est. high end and low end | $ 470 with travel included (high estimate) |

1. **Provide a detailed working outline of your thesis.**

Thesis Outline general overview of what the thesis is planned to cover.

1.0 Introduction

1.1 Tire Rubber prominent source of Pollution in Washingtons Aquatic ecosystems

Roadmap Connecting Tire rubber microplastics (TRMP) emissions to Urban Runoff Mortality Syndrome (URMS).

2.0 Literature Review

2.1 Tires History, Production and Characteristics

2.1.1 History: This section gives a quick history of the research surrounding tire rubber and the environment.

2.1.2 Global Tire Production: This section provides the reader with the understanding that tire rubber microplastic emissions is a global issue and has become an emerging area of concern when it comes to microplastics and their effects on the environment.

2.1.2 Tire Rubber Physical and Physicochemical Characteristics

2.1.2.1 Physical Characteristics: this section is a physical description of the tire and how it is made.

2.1.2.2 Physicochemical Characteristics

This section describes the chemical attributes of tire rubber, this is to help the reader understand why and what chemicals are added to the tire rubber

2.1.3 Defining Primary Sources Tire Rubber Microplastics

2.1.3.1 Primary sources of Tire Rubber microplastics: this section defines tire wear particles as the primary source of tire rubber microplastics to environment. This distribution of which can indicate the health of streams impacted by runoff and stormwater effluent.

2.1.3.2 Identifying Tire rubber microplastics from Road Dust

This section covers methods on how to characterize tire rubber microplastics from road dust by density and visual identification. (These will be the main studies featured in this section: Gehrke 2020; Rabik 2021; Kovochich 2021; Jung 2022; Järlskog 2021 and 2022).

2.1.4 Urbanization of Streams

This is an important section on how urbanization impacts streams and those impacts vary based on land practices. In this study the relevant land practices include all roads with tire wear occurring. This is why the section focuses on URMS in order to connect that tire rubber microplastic chemical leachate 6PPD-quinone with frequency of emissions.

2.1.4.1 Geospatial mapping Coho Mortality Syndrome (CMS) aka. Urban mortality Syndrome: this section highlights the work of Fiest et al 2017 who mapped coho mortality syndrome and was the first to show the occurrence of CMS was strongest in regions of high rates of motor vehicle use.

2.1.4.2 Environmental prevalence and abundance of casual toxicant 6PPD-quinone: this section works to show the reader how 6PDD-quinone is highly prevalent in the environment and is transported via stormwater and roadway runoff to surface waters, and sediments. Also highlights that 6PPD-quinone has been found in tire crumb used for playgrounds and synthetic turf.

2.1.4.3 Trophic interactions and accumulation of 6PPD and 6PPD-q in aquatic food webs: 6PPD-quinone has been found in fish tissues and have been assessed for the multiple human exposure pathways via inhalation, dermal, and ingestion.

2.1.5 Prioritizing Fish Passage Projects and other Restorations project at risk for Tire Rubber Microplastic contamination

This section is meant to highlight how necessary it is to identify and quantify the amount of TRMP emissions that may affects greater salmon habitat restoration efforts. Tire rubber microplastics represent social injustices because there are specific groups that are more effected than others.

2.1.6 Green Infrastructure (GI)

The assessment and mitigation of TRMP in the environment begins with understanding the distribution of tire rubber microplastics once emitted into the environment.

2.1.7 Geospatial distribution of Road dust utilizing GIS-based assessment methods

Using GIS modelling for showing the distribution of tire rubber microplastic sources and the calculated predictions of tire wear particles.

2.1.8 Empirical and Statistical models used to determine Environmental flows of TRMP’s

This section will help the reader understand how tire rubber microplastics are transported through the environment. This section models how tire rubber microplastics.

2.1.9 Multiple perspectives of TRMP pollution and 6PPD use in Tire production

This section details the tire companies’ justification for using 6PPD and the opposing view point that is should be stopped in use for tire production.

2.1.10 Literature Review Conclusions

This section ties together the main ideas and concepts of the lit. review.

3 Methods

3.1 Determining the Urban gradient of Thurston County.

This section will use the collected existing data sets to develop a map of Thurston counties urban gradient to choose which roads to collect road dust samples from.

A description of each dataset and the parameters set for the analysis of the urban gradient.

* WSDOT and Thurston County Road count parameters
* Impervious Land coverage and population: Using census data
* Analysis of Deschutes tributaries Coho and steel head streams

3.1.2 Tire tread wear observations and secondary sources surveys

I will identify five types of location to sample road and sidewalk dust for tire rubber microplastics. These samples will be taken on a dry day from a variety of location types: Analysis will be done with visual measurement of tire rubber microplastics found in samples. Will there be a relationship with size of particles and frequency of roadway?

|  |  |
| --- | --- |
| Location type (road and sidewalk dust) | Sample date and time |
| Residential road and sidewalk | TBD |
| High traffic road main connector | TBD |
| Median traffic road that connects to main connector road | TBD |
| Low traffic small road that connects other small roads | TBD |

The sample will be analyzed for tire rubber microplastics size and abundance.

3.2 GIS Join feature and description of data layers

3.3 GIS maps and statistical methods for TRMP

3.4 Methods and materials for primary and secondary source data collection:

This section will detail the methodology use in my data collection of road dust.

3.4.1 SEM Analysis

This section details how do I use the scanning electron microscope to measure and identify tire rubber microplastic particle sizes.

4 Results and analysis

4.1 Analysis the relationship between tire rubber microplastics emission sources, impervious surface, and salmon populations in urban streams.

4.1.1 Indicators of streams vulnerabilities.

These indicators would include high frequency roads, increased number of secondary sources and increased impervious land coverage percentage in ratio stream size.

4.1.2 Determining the distribution of TRMP in Thurston County

4.2 Acknowledging the uncertainty

4.3 Environmental Significance

4.4 GIS map that displays TRMP distribution in Olympia

5 Discussion

5.1 Particle size distribution of TRMP distribution in Thurston County.

5.2 Environmental Significance

5.3 Tire Rubber Microplastics distribution

6 Conclusion (tie it all together)

1. **Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic and specific as you can at this point, including the deadlines for Spring quarter.**

I use an excel spreadsheet to keep track, here is a table of my working calendar for my thesis work. I have broken it down by the task and the timeframe I will complete each task. This is done all the way through to end of spring quarter, but I am sure I will add a few things along the way.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TASK** | **ASSIGNED TO** | **PROGRESS** | **START** | **END** |
|  |  |  |  |  |
| **Tire Rubber Microplastic emission sources effects on Urban streams with URMS** |  |  |  |  |
| Drafting Lit Review | Marlene | 70% | 12/3/22 | 11/20/22 |
| Prospectus Questions | Marlene | 100% | 11/15/22 | 11/30/22 |
| Poster Project | Marlene | 100% | 11/30/22 | 12/4/22 |
| Prospectus Approval by reader | Erin |  | 12/4/22 | 12/16/22 |
| Data layer collection WSDOT, SALMONSCAPE, U.S. CENSUS --TIGER DATABASE | Marlene | 70% | 11/20/22 | 1/5/23 |
| Project Design | Marlene |  | 11/16/22 | 11/20/22 |
| **Collecting Existing Data and setting up Lab Space** |  |  |  |  |
| Contact Jena about lab time with SEM and Lecia stereomicroscope | Marlene | 70% | 11/30/22 | 12/1/22 |
| Winter Break --still working though | Marlene |  | 12/22/22 | 1/1/22 |
| Create Request for MES research fund | Marlene |  | 12/1/22 | 1/5/23 |
| Fill out: Student Project Form (PDF) This outlines your research project & helps determine what lab space, specialized equipment, and trainings you need. Attach any supporting literature and drafts of your methodology you might have.  the Equipment/Chemical Request Form (PDF) (you can submit additional requests as needed) and Chemical Fact Sheets for any chemicals you will need. | Marlene | started |  |  |
| Revising and completing Lit. Review | Marlene |  | 11/22/22 | 1/15/22 |
| DOT roadway frequency data, salmon stream data, impervious/urban data analysis prep for GIS layers | Marlene | 75% | 11/22/22 | 11/25/22 |
| **Data Development and Analysis** |  |  |  |  |
| Develop survey for tire sources | Marlene |  | 12/25/22 | 12/30/22 |
| Data Collection--sample and surveys on tire locations | Marlene |  | 2/4/23 | 2/15/23 |
| Sample prep and analysis with SEM | Marlene |  | 2/15/23 | 2/25/23 |
| Analysis lab sample data | Marlene |  | 2/25/23 | 3/2/23 |
| Create GIS map layer with sample info | Marlene |  | 3/2/23 | 3/6/23 |
| Write Method and Discussion | Marlene |  | 1/20/23 | 3/25/23 |
| Interpret Data write analysis and results | Marlene |  | 2/15/23 | 3/25/23 |
| Finish Map in GIS with all featured layers and begin story map for Thesis presentation | Marlene |  | 2/15/23 | 3/25/23 |
| **Complete Thesis** |  |  |  |  |
| Complete Draft of Thesis for Reader by Week 2 Spring Quarter |  |  | 3/5/23 | 4/8/23 |
| Submit one of two forms, signed by Thesis Reader, to MES Director during Spring quarter by  Friday of Week 5: “Request to Present Thesis Research” to complete your thesis during Spring 2023, OR “Request to Extend Thesis Research” if you plan on/need to extend your work into  another quarter1 |  |  | 4/2/23 | 5/1/23 |
| Prep for your presentation, create a story map of your project. |  |  | 4/8/23 |  |
| Sign Up for Thesis Presentation |  |  | 4/2/23 | 5/1/23 |
| Look into graduation to-do list |  |  | 4/2/23 |  |
| Submit signed, final version of thesis—electronic copy required—to MES Office by Friday, June  9, 2023. |  |  | 4/1/23 | 6/9/23 |
| Breathe Easy for graduation :) |  |  | 6/9/23 | 6/15/23 |

1. Who (if anyone), beyond your MES thesis reader, will support your thesis (in or outside of Evergreen)? Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.

My husband Vincent Riggs will be supporting me in the collection of road dust samples.

1. Provide the 5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis, and/or provide a basis for interpretation. Annotate these references with notes on how they relate to/will be helpful for your thesis. For any other sources cited in your prospectus in other answers, provide a complete bibliographic citation here as well.

**Kovochich, M., Parker, J. A., Oh, S. C., Lee, J. P., Wagner, S., Reemtsma, T., & Unice, K. M. (2021). Characterization of individual tire and road wear particles in environmental road dust, tunnel dust, and sediment. *Environmental Science & Technology Letters*, *8*(12), 1057-1064.**

In this article researcher characterized and quantified tire rubber particles from road dust samples. This article is very helpful in my project because I am looking for lab methods to replicate in order to identify and quantify tire rubber microplastics from road dust samples, in this study researchers use SEM, FTIR spectrometry, and GC-MS to analysis road dust samples. Details on their supplement data page are very useful in detail procedure for road dust analysis for TRMP emission factor. This paper is in a series of research that identifies TRMP from environmental samples and estimate of tire wear emission rates made though GC-MS assay for styrene butadiene rubber degradation product 3-phenylcyclohexene.

**Gehrke, I., Dresen, B., & Blömer, J. (2020) Modelling of The Distribution of Tyre Wear Particles in Germany.**

This article is pretty integral to my research in the distribution of tire rubber particles within the environment. The study focuses districts on Germany where they found the highest volumes of tire rubber particles came from dense urban areas and high us roads. The study also uses GIS to map the spatial distribution of tire rubber microplastics. The article is helpful in understanding how to use emission factors in predicting regions of high tire microplastic exposure.

**French, B. F., Baldwin, D. H., Cameron, J., Prat, J., King, K., Davis, J. W., ... & Scholz, N. L. (2022). Urban Roadway Runoff Is Lethal to Juvenile Coho, Steelhead, and Chinook Salmonids, But Not Congeneric Sockeye. *Environmental Science & Technology Letters*, *9*(9), 733-738.**

The finding of this article further the evidence that 6PPD-quinone in stormwater and roadway runoff have a stark contrast in salmon species affected. Researchers evaluated for species-specific reactions for mortality when exposed to stormwater runoff. The four species were Chinook, Sockeye, Coho, and steelhead trout. The evidence conclude that the effects of stormwater and roadway runoff is highly toxic to susceptible species. For example, when salmon species were exposure to collected stormwater, they found that Coho are highly susceptible to mortality even when the stormwater was diluted up to 95%. Steelhead trout have also exhibited the unique sensitivity and experience mortality when exposure to stormwater. Chinook and Sockeye had little susceptibility to toxins in arterial roadway/ stormwater runoff. This article is useful in determining regions that urban runoff mortality syndrome occurs at most risk are streams and rivers near arterial roadways.

**Klöckner, P., Seiwert, B., Weyrauch, S., Escher, B. I., Reemtsma, T., & Wagner, S. (2021). Comprehensive characterization of tire and road wear particles in highway tunnel road dust by use of size and density fractionation. *Chemosphere*, *279*, 130530.** [**https://doi.org/10.1016/j.chemosphere.2021.130530**](https://doi.org/10.1016/j.chemosphere.2021.130530)

In this article details the biological effects of tire wear and road dust biological impacts. This article is important to my study of characterizing tire rubber chemicals and byproducts. I am particularly interested in their scientific methods used.

Through a fractionation process and using an advanced liquid chromatography mass spectrometer researchers separated out 7 analytes found in road dust (OHBT, ABT, 6PPD, OBS, BT, aniline, and DPG). Two compounds identified by exact masses and fragmentation products of 6PPDQ (exact mass= 297.1964 positive ionization mode; retention time of 10.7 minutes) compound showed it was highly resistant to aging and low leaching potential occurred in different tire treads. Researchers established the content or density fraction calculated by the mass of each respective analyte: C(F)= manalyte/ mfraction M=mass percentage---M(F)= manalyte/ manalyte,total \*100 This calculates the sum of all m analyte of all fraction.

This study also used the SEM to do a shape assay of the collect road dust something to think about for providing visuals of degradation. Findings showed that tire rubber particle size organic constituents increased with the surface area of the particle, so it increases from coarse to fine. For 6PPD it increased by a factor of 50- 80. This means that by increasing the tire rubbers surface area for oxidation you get an increase of 6PPDq being formed. Both the size and density of the particle are crucial factors to consider how the particle is transported into and through the environment e.g., distance, velocity of travel, and settling in water. As for Zn concentration increase as density decreased.

The study found in the in vitro assay that an oxidative stress response to the road dust where they had expected a neurotoxicity response. I think they we are looking for responses that ZnO would give as a biological response, however 6PPD-Q was one of the highest reported concentrations and we know that 6PPD-Q is attacks the respiratory oxygen transport in Coho and breaches the blood brain barrier. I found the finding interesting for this article because it showed amount of these toxicants are in ratio to road tire rubber particles. the study also gives the exact retention time and ion mass needed for analysis of 6 PPD-Q in the GCMS which I will need if I am able to test tire rubber for 6PPD-Q contents.

**Redondo-Hasselerharm, P. E., de Ruijter, V. N., Mintenig, S. M., Verschoor, A., & Koelmans, A. A. (2018). Ingestion and Chronic Effects of Car Tire Tread Particles on Freshwater Benthic Macroinvertebrates. *Environmental science & technology*, *52*(23), 13986–13994.** [**https://doi.org/10.1021/acs.est.8b05035**](https://doi.org/10.1021/acs.est.8b05035)

In this article researchers conducted in laboratory experiments on four species of fresh water benthic macroinvertebrates (Tubifex spp. , *Gammarus* pulex, *Lumbriculus* variegatus, and *Asellus* aquaticus) by exposing them for 28 days to a varying levels of tread particles from used cars. The concentrations tested of TP was 0 , 0.1 , 0.3, 1, 3, and 10 % of sediments dry weight.

Researchers indicated that the need for research comes from the knowledge that tire particles will settle into the sediments which holds potential adverse effects to the benthic communities in freshwater.

Methods and materials used in the analysis of TP effects on benthic macro-invertebrates:

Study used a standard setup that was used in a study on the effect of polystyrene micro plastics on the same species listed in this study. The study quantified the amount of TP inside the organisms and used imaging for analysis. This article in particular drew my interest by the way it characterized the tire particles used in the assay.

Prep for the Care tire particles: the brought five used tires of different brands; used a metal grader to millimeter sizes scraped from the first two inches of each tire. they froze the tire particles with liquid nitrogen to prevent them from burning, they were ground and sieved with a 500 μm sieved. All tire types added to a mixture in equal part and sieved till all large pieces were removed. They characterized the particle by size using a laser diffraction a Mastersizer 3000 that measures between .01 and 3500 micrometers. Shape was analysis using Olympus SZX10 stereomicroscope. The major components of the tire particles were quantified by thermogravimetric analysis. When heated the sample lost the volatile substances in the range of 30-300 degrees C, the actual polymer they said was between 300-600 degree C, Carbon black at 600-850 degrees C. While the samples were heated between the 300-600 C the gases were trapped to be used in the Gas Chromatography Mass spectrometer. Researchers went further and analyzed the Zinc contents by the inorganic residues that were exposed to microwave acid extraction using 13 % nitric acid, heated under pressure and kept at temp between 133 and 163 C for 30 minutes. Sample was then filtered, and Zinc amount assessed with the use of ICPMS. The assays of heavy metals in soil this studied performed is also helpful resource. The statistical assay was done in SPSS 23 were they used generalized Linear Models to study the effects of care tire TP on all the end points using log-transformed concentration as a covariate. A One-way ANOVA (p< 0.05) performed to see the effect of TP on the # of worms for *L*. *variegatus*, the growth of *G. pulex*, A. *aquaticus, Tubifex spp.* One-way ANOVA test was done to determine the difference in the amount of TP found in bodies and feces. Residuals tested for normality with Shapiro-Wilk test (p>0.05) and visualized with the Q-Q plot. They assessed the variance with the Tukey and Bonferroni tests. Also tested if the assumption of the homogeneity of variances was violated with one-way Welch ANOVA. Finally, the independent t-test was done to compare average dry weights and area of particles before and after the H2O2 and the H2O treatments.

Results of the study found in its heavy metals assay that Zn was the only real measurable metal and its total concentration in sediments was linearly correlated to R2 = 0.99 with nominal concentrations of the tire TP sediments.

This means that Zn was added per 1% of TP and translates to a Zn content of 6.54+-.037 g/Kg.

The results of these finding showed no significant impact on any of the four species after chronic exposure to tire particles. However, these species did ingest the tire particles which leads us to trophic transfers of tire particles for *G*. *pulex*. Researchers say that trophic transfer factor estimated in this study is 4.7 x 10-9. This finding is important when relaying the trophic implication tire rubber has with the food web and affects to human health. A discussion point in that Zn poses longer term risks due to it gradual environmental degraded a become bioavailable.

Work Cited not listed in the annotated bibs:

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3. Gaafar, M., Mahmoud, S. H., Gan, T. Y., & Davies, E. G. (2020). A practical GIS-based hazard assessment framework for water quality in stormwater systems. *Journal of Cleaner Production*, *245*, 118855.
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6. Järlskog, I., Jaramillo-Vogel, D., Rausch, J., Gustafsson, M., Strömvall, A. M., & Andersson-Sköld, Y. (2022). Concentrations of tire wear microplastics and other traffic-derived non-exhaust particles in the road environment. *Environment International*, 107618.
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11. Tian, Z., Zhao, H., Peter, K. T., Gonzalez, M., Wetzel, J., Wu, C., Hu, X., Prat, J., Mudrock, E., Hettinger, R., Cortina, A. E., Biswas, R. G., Kock, F., Soong, R., Jenne, A., Du, B., Hou, F., He, H., Lundeen, R., Gilbreath, A., … Kolodziej, E. P. (2021). A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. *Science (New York, N.Y.)*, *371*(6525), 185–189. <https://doi.org/10.1126/science.abd6951>
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1. You are not locked into this title; we want you to identify the main point or topic of your thesis. [↑](#endnote-ref-2)
2. You might discuss selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-3)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-4)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-5)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-6)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-7)