2018

PAHs in Coal Tar Sealants: Policy Analyses and Design

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A senior thesis
submitted in partial fulfillment of the
requirements for the degree of
Bachelor of Science

Environmental Program

University of Vermont

2018

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs), a class of organic compounds, form during the incomplete combustion of wood, fossil fuels, cooking, garbage, and tobacco (Abdel-Shafy and Mansour 2016). Empirical data has proven the toxicity of these compounds on human health and the environment due to their mutagenic, carcinogenic, persistent, bioaccumulative, and hydrophobic capabilities (Xue et al. 2015, White 2002, Abdel-Shafy and Mansour 2016). Coal tar-based emulsion is a sealant widely used throughout the United States (U.S.), particularly in the East, to protect and enhance the aesthetic appearance of pavement (Mahler et al. 2005). Coal tar sealants contain high concentrations of PAHs. Due to the toxicity of PAHs, jurisdictions across the U.S. have taken regulatory action prohibiting and/or restricting the use and/or sale of coal tar sealants. Analyses of three case studies from Washington, Minnesota and Austin, Texas, where successfully implemented regulations on the use and sale of coal tar sealants, informed a policy design for the State of Vermont. I recommend that the State of Vermont implement an incremental legislative ban against the use and sale of coal tar sealants, although two alternative regulations were considered: leaving coal tar sealants unregulated and implementing city-by-city ban.

Keywords: coal tar sealants, polycyclic aromatic hydrocarbons (PAHs), chemicals of concern (COCs), toxins, policy analysis, policy design.

EXECUTIVE SUMMARY

This report summarizes my main findings from my undergraduate thesis: *PAHs in Coal Tar Sealants: Policy Analyses and Design*. It outlines the impacts of coal tar sealants and polycyclic aromatic hydrocarbons (PAHs) on human health and the environment and details three policy analyses of existing bans on coal tar sealants in Washington, Minnesota and Austin, Texas. A recommendation of a phased-in statewide ban on the sale and use of coal tar sealants is suggested for Vermont, aiming to protect Vermont's citizens and natural resources and bridge the knowledge deficiency surrounding coal tar sealants.

Introduction

Policy analysis is a decision-making tool used to inform, evaluate, and meet specified goals. Policy design is used to develop efficient and effective policies to meet said goals. Coal tar sealant is sprayed or painted onto driveways, parking lots, and some playgrounds (The United States Geological Survey 2011). The sealant appears shiny and black, enhancing the aesthetic value while increasing lifespan of the pavement (The United States Geological Survey 2011). Polycyclic aromatic hydrocarbons (PAHs) are a class of more than 100 organic compounds formed during the incomplete combustion of organic materials such as the burning of wood or tobacco. PAHs can also be released through anthropogenic activities such as the idling of motorized vehicles. Coal tar and coal tar pitch contain high concentrations of PAH compounds.

Background

Coal tar sealants are derived from coal tar or coal tar pitch. Coal tar is comes from the coking of coal tar for the steel industry and coal tar pitch is a byproduct of coal tar distillation (Mahler et al. 2010). These two products contain many chemicals, including high concentrations of PAHs. The EPA lists sixteen PAHs as priority pollutants due to their persistent, bioaccumulative, hydrophilic, genotoxic, mutagenic, and carcinogenic capabilities (Xue et al. 2015, White 2002, Abdel-Shafy and Mansour 2016). Seven of these sixteen compounds are probable human carcinogens (Huang, Chernyak, and Batterman 2014; Morrison 2015). Benzo[a]pyrene is one of the most carcinogenic of PAH compounds due to its high molecular weight (Huang, Chernyak, and Batterman 2014; Morrison 2015). As a result, most PAH regulations are calculated based on this specific PAH compound.

Empirical evidence exists dating back to the late 1700s that suggests a correlation between coal tar and adverse health effects including: cancers, cataracts, skin abnormalities, tumors, kidney and liver damage, birth defects, and asthma (Karimi et al. 2015, Kim et al. 2013). No epidemiological studies to date have demonstrated a specific correlation between coal tar sealants and adverse health effects. There are, however, extensive studies that discuss the impact of coal tar and coal tar sealants on animal species, particularly marine life.

Source

Coal tar sealants bioaccumulate and persist in the environment over time. General wear and tear of the product, i.e., abrasion from tires or harsh weather conditions, break into tiny particles which get washed away by run-off and bioaccumulate in water and sediment. The product can also volatize into the air and can be tracked into homes and buildings and concentrate in dust particles.

Origin of Coal Tar Regulation

In 2003, the Austin, Texas Department of Watershed Protection collected water and sediment samples from drainage ponds and streams located in residential urban areas across the city (The United States Geological Survey 2014). The results indicated unusually high concentrations of PAHs ≈1,500 mg/kg within the sample locations (Mahler et al. 2005). A sampler from the Austin Watershed Department realized that a majority of the sample locations were below parking lots that appeared to be sealed with coal tar sealant (The United States Geological Survey 2014). He hypothesized that these high levels of PAH concentrations could be from the coal tar sealed lots. As a result, the USGS conducted the initial study to test this hypothesis (Mahler et al. 2005).

Following the work conducted by the Austin, Texas Department of Watershed Management, the USGS performed a broader study to reject or accept correlations between coal tar lots and high levels of PAH concentrations. Mahler et al. (2005, 5562) showed a PAH mean concentration of 3500 mg/kg in Austin parking lots sealed with coal tar, which was sixty-five times higher than unsealed lots. (Survey 2014, Metre, Mahler, and Wilson 2009).

The research that the USGS conducted influenced the City of Austin to implement the first coal tar sealant regulation in the U.S. Following, over sixty jurisdictions across the U.S. have implemented a breadth of institutional regulations on the use and sale of coal tar sealants including at the level of state, county, city, town, village, watershed, and university.

Research Question

This research was performed to answer the following question: what would a coal tar sealant regulation look like for the State of Vermont?

Methodology

I performed a comprehensive search of all coal tar regulations to determine the most appropriate case studies for analyses and to inform a policy design. Case studies of Washington, Minnesota, and Austin, Texas were chosen based on the availability of information.

Each policy analysis began with a historical literature review conducted in relation to PAHs and the appropriate case study (the historical literature reviews can be found in the footnotes of the thesis.) Once this background research was completed, I followed the eightfold path of policy analysis (Bardach and Patashnik's 2016), specifically focusing on:

1. Problem definition
2. Setting the agenda
3. Implementation
4. Evaluation

These policy analyses informed a policy design for the State of Vermont. To craft a comprehensive policy design, I performed an additional review of any literature that discussed coal tar or coal tar sealants in Vermont. Second, I analyzed the Vermont Department of Environmental Conservation's report: *An Evaluation of PAHs, Arsenic, Lead: Background Soil Concentrations in Vermont* (2017). This was the most comprehensive work that acknowledged the presence of PAHs in Vermont and attempted to analyze their impact on the State. I then constructed a policy design including the following elements:

1. Recommendations
a. Problem
b. Goal
c. Solution
d. Alternatives
2. Policy Design
a. Regulatory Oversight
b. Stakeholders
3. Costs and Benefits
4. Feasibility
5. Policy Limitations

Analyses: Case Studies

Listed are the following case studies and a general description of their regulations:

1. Washington (2011): Prohibited the sale of coal tar sealants effective January 1, 2011 and prohibited the application of the product, effective July 1, 2012, statewide.
2. Minnesota (2014): Prohibited the use and sale of coal tar sealants effective January 1, 2014, statewide and allocates funding to conduct further research into coal tar sealants and their impact in Minnesota.
3. Austin, Texas (2005): Citywide ban on the use of coal tar sealant and regulations of coal tar sealant, effective December 12, 2005 by unanimous vote from the City of Austin City Council.

Results: Policy Recommendations

Goals

The goal of this policy should be twofold. First, it should be to promote Vermont's overall public health and protect its natural resources, both of which are vulnerable to increased PAH bioaccumulation from coal tar sealants. Second, it should be to decrease our knowledge deficiency of the amount and location of coal tar sealant application and potential resultant PAH bioaccumulation.

*Solution*s

Implement a phased-in statewide ban on the sale and use of coal tar sealants

Alternative #1: continue with the status quo and leave coal tar sealants unregulated
Alternative #2: municipal bans on the sale and use of coal tar sealants, contingent upon statutory authority

Discussion and Further Questions

Feasibility

A ban would be dependent on the political climate and the actors involved throughout the policy process, including the political ideologies of the sitting Legislators and important stakeholders.

Further Questions

There were two main questions that were identified towards the end of this process that would have been useful in developing this policy design had I had the time and the resources:

1. How much coal tar sealant exists in Vermont?
   a. Where is it used?
   b. How much is used per year on average?
2. How many Vermont sealcoat companies offer coal tar sealants to customers?

Answers to these questions would be helpful in aiding stakeholders and policymakers who may be interested in advocating for a coal tar sealant regulation in Vermont.

It would have been useful to interview sealcoat companies that offered their services in Vermont in order to gain a better understanding of the products they offer and the popularity of each one. This information would better inform an economic impact analysis on a ban on the sale and use of coal tar sealants in the State of Vermont.

Recommendations

I recommend that a forensic analysis be performed on the data presented in the Vermont Department of Environmental Conservation report, *An Evaluation of PAHs, Arsenic, Lead: Background Soil Concentrations in Vermont* (2017). A forensic analysis would allow the State to look at the types of PAH compounds found at a particular site and make an informed hypothesis as to whether they match the makeup of coal tar sealants.

Conclusions

The USGS's study published in 2005 confirmed the City of Austin Watershed Department's hypothesis that abnormally high concentration levels of PAHs were a causation of stormwater runoff from coal tar sealed lots (Mahler et al. 2005). The State of Washington, Minnesota, and City of Austin, Texas were all successful in implementing policies that prohibit the use of coal tar sealants and ban or restrict the sale of coal tar sealants. The USGS confirmed the success of Austin, Texas's ban in decreasing the concentration levels of PAHs in lake sediment (Metre and Mahler 2013). Given the availability of a comparably similar alternative, asphalt-based sealant, and projections that despite an increase in coal tar sealant regulations the sealant market share will continue to increase, a coal tar sealant ban seems to be an obviously desirable solution. Employing a precautionary principle of regulating toxins can minimize future economic payouts that could be astronomical. The phased-in approach also intends to minimize potential economic impacts and disruption.

In order to address the public health and environmental concerns associated with coal tar sealant pollution, a phased-in statewide ban on the sale and use of coal tar sealants would be the most effective policy choice for the State of Vermont. The feasibility of this ban is dependent on current political climate. This thesis' policy recommendations will be presented to identified stakeholders that have voiced an interest in wanting to learn more about the implications of coal tar sealant and what a regulation could look like for the State of Vermont.

ACKNOWLEDGMENTS

I would like to thank Shaina Kasper from the Vermont Toxics Action Center for both cultivating my interest in this topic and for her advocacy promoting the health of Vermonters and the environment. Professor Bartlett, thank you kindly not only for agreeing to advise this project, but also, for your constructive feedback and holding me accountable! Many thanks to Professor Bindu for your guidance and expertise in public health; your passion for bringing public health services to all communities has inspired me to pursue a similar career path.

Warm thanks to the many friends and family who have showed their love and support throughout my entire academic career here at the University of Vermont. A particularly special thank you to my dear friend, Madeline Murray-Clasen for sticking it out with me throughout our entire thesis process!

Last but not least, a huge thank you to the Environmental Program, which graciously granted me the ENVS Summer Undergraduate Research Reward. This award allotted me the extra library time necessary to delve into the science behind the toxicity of PAH compounds; this was complex research instrumental to understanding the impact of coal tar sealants on the health and well-being of humans and our environment. This thesis was both humbling and challenging, allowing me to grow and develop skills that will aid me in far beyond my undergraduate career at The University of Vermont.

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INTRODUCTION

Policy design is used to address an identified problem and meet specified goals. Coal tar sealant pollution has been identified as a widespread problem, particularly in urban environments throughout the U.S. The State of Vermont does not have any existing legislation that protects against the impacts of coal tar sealants, giving rise to a need for a policy design that meets the goal of protecting the overall health of Vermont and decrease knowledge deficiency.

I conducted policy analyses of two statewide bans in Washington and Minnesota and a citywide ban in Austin, Texas. The "eightfold path" developed by Bardach and Patashnik (2016), the method for which clearly analyzes the main criteria of effective policy, was employed in each of my analyses sections. The data that supports these analyses was used to design policy recommendations surrounding the sale and use of coal tar sealants in the State of Vermont. The purpose of this paper is to offer a comprehensive overview of PAHs, coal tar sealants, their human and environmental health impacts, alternatives to coal tar sealants, and best practices for the State of Vermont. Additionally, this paper aims to both inform stakeholders and policymakers and to influence the regulation of the sale and use of coal tar sealants in the Green Mountain State.

Polycyclic aromatic hydrocarbons (PAHs) are a class of over one-hundred organic compounds that form during the incomplete combustion of coal, gas, oil, garbage, and tobacco (Abdel-Shafy and Mansour 2016). PAHs are highly toxic to human health and the environment due to their mutagenic, carcinogenic, persistent, bioaccumulative, and hydrophobic properties (Xue et al. 2015, White 2002, Abdel-Shafy and Mansour 2016).

Coal tar sealant, a popular product that is sprayed or painted onto pavement, protects the underlying surface, enhances its aesthetic appearance, and promotes its longevity, especially under harsh weather conditions (Needleman 2015). Coal tar sealants typically contain between twenty to thirty-five percent coal tar or coal tar pitch; both of which contain high levels of PAHs. Exposure to high concentrations of PAH compounds can lead to adverse health effects including: cancers, cataracts, skin abnormalities, tumors, kidney and liver damage, birth defects, and asthma (Karimi et al. 2015, Kim et al. 2013).

The State of Vermont Department of Environmental Conservation (VTDEC), is recently involved in setting exposure limits for PAHs. There is a general lack of awareness surrounding PAH pollution from coal tar sealants in Vermont. With an incremental ban, Vermont could see significant decreases in PAH concentrations, further protecting the health and well-being of its constituents and natural resources.

Following the presentation of my policy design, I suggest further questions and recommendations for research surrounding the issue of coal tar sealant usage and pollution in the State of Vermont.

REVIEW OF LITERATURE

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are classified according to the structure and size of their organic molecules and typically consist of two or more benzene rings (Choi et al. 2010). Figure 1 identifies selected PAH compounds according to molecular weight (Huang, Chernyak, and Batterman 2014).

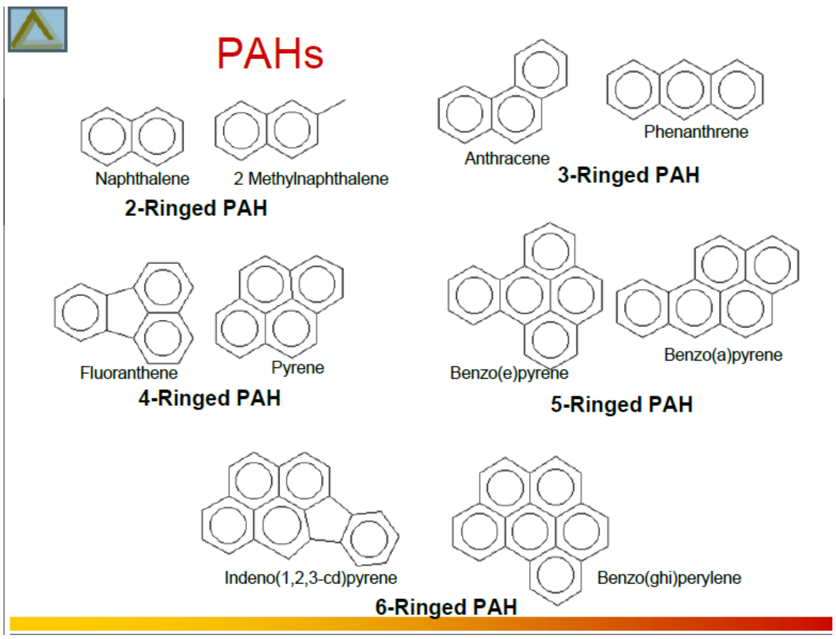

Figure 1. 2,3,4,5, and 6-Ringed PAH Compounds
Source: Sullivan, Gwen and Martin, "Environmental Forensic Principals for Sources Allocation of Polycyclic Aromatic Hydrocarbons," 2008.

PAHs are classified as high-weight molecular PAHs (HPAHs) or low-weight molecular PAHs (LPAHs) (Choi et al. 2010). Some HPAHs include fluoranthene, pyrene and benzo[a]pyrene (C.Martins et al. 2010). HPAHs are generally more toxic because they "are more resistant to oxidation, biodegradation, vaporization, and solubility, therefore making them more likely to bioaccumulate and persist in the environment. HPAHs are more susceptible to photo transformation, which can produce compounds that are more toxic" (Morrison 2015, 10). LPAHs consist of two or three benzene rings (Morrison 2015, C.Martins et al. 2010). LPAHs are more water soluble, meaning aquatic biodiversity is at greater risk of exposure (Morrison 2015).

PAHs can also be identified as pyrogenic, petrogenic, and biogenic (Sullivan, Martin, and Sandau 2008). Pyrogenic PAHs are produced through the process of coking coal and the burning of wood, gas, oil, garbage, and other organic matter (Abdel-Shafy and Mansour 2016). Petrogenic PAHs form during geological processes and are found in crude oil products, asphalt, and coal tar pitch, while biogenic PAHs derive from natural processes (Sullivan, Martin, and Sandau 2008).

Routes of Exposure

PAHs are typically colorless, white, or "pale yellow-green solids," often giving off a "faint, pleasant odor" (Abdel-Shafy and Mansour 2016, Agency for Toxic Substances and Disease Registry 1995). There are three main routes of exposure for human health hazards including: ingestion (eating or drinking), inhalation (breathing), and dermal contact (skin absorption) (Maxwell 2014). Dose exposure is indicative of the amount a chemical from the environment has been absorbed into the body (Maxwell 2014). Once in the body, the chemicals find their way into the bloodstream or lymph nodes, where enzymes attempt to break down or metabolize the toxin, a process that primarily occurs in the liver (Maxwell 2014). The ability of a chemical to have an effect on the body is dependent on exposure time. Maxwell (2014, 18) describes exposure as either acute (shorter period of time) or chronic (longer period of time). There are other demographic factors that influence the effect of exposure on humans, including sex and age (Maxwell 2014, Registry 1995).

PAHs: Human Health Effects

PAHs have occurred naturally in the environment for millions of years, but scientists have seen an increase in human exposure as a result of anthropocentric activities, primarily through the use of motorized vehicles (Mautz 2017). The first known study that confirmed a causal link between PAHs and cancer was conducted in 1775 by Percival Pott (Pott 1775). Pott conducted an examination of London chimney sweeps many of whom had cancer of the scrotum. Further studies were conducted, one in 1914 by Yamagiwa and Itchikawa, which examined the effects of high temperature coal tar on lab rabbits (Trosset et al. 1978). The study concluded rabbits exposed to high temperature coal tar saw an increase in tumors (Trosset et al. 1978) . In 1918, Tsutsui performed an analogous experiment in mice, reaching similar conclusions (Tsutsui 1918, Trosset et al. 1978). In 1929, a scientist Dr. J. W. Cook from the Scientific Staff of the Chemical Research Laboratory of the Department of Scientific and Industrial Research began experimenting with compounds, many of which had yet to be identified (Trosset et al. 1978, Cook 1933). With the help of his colleagues Hieger, Kennaway, and Mayneword, many of the compounds were classified as PAHs. Specifically through isolation, the scientists were able to identify benzo[a]pyrene, one of the carcinogenic compounds in coal tar (Kennawat 1955, Trosset et al. 1978).

Additional studies examined the effects of PAHs on coal tar sealant workers. Each of the studies indicated different adverse health impacts among workers [(Darby et al. (1986); Jongeneelen et al. (1988a); (Jongeneelen et al. 1988b); Knecht and Woitowitz (1989); Partanen and Boffetta (1994) and Partanen and Boffetta’s (1994)]. Overall, workers were subject to a heightened risk of the following adverse health effects: lung cancer, non-melanoma skin cancer, bladder cancer, stomach cancer, and leukemia (Trosset et al. 1978, Partanen and Boffetta 1994).

Armstrong et al. (2002, 2004) confirmed Partanen and Boffetta's (1994) findings; an increase in lung and bladder cancer among coal tar workers was linked to an increase in the presence of the carcinogenic PAH: benzo[a]pyrene (Partanen and Boffetta 1994). Workers were also found to be at risk of developing pancreatic cancer (Ojajärvia et al. 2000).

Padula et al. (2014) found an association between premature births and PAH exposure. Second, Mathiesen et al. (2009) suggested that traces of a specific PAH, benzo[a]pyrene was identified in the placenta, which led Perera et al. (2002) to determine that babies' exposure to these toxins correlated to poor fetal development (Mathiesen et al. 2009, Perera et al. 2002). More specifically, among the infants studied, researchers found a decrease in infant weight and an increase in premature birth, intrauterine growth retardation (IUGR) (inside the uterus) and disease and mortality (Dejmek et al. 2000, Perera et al. 2002, Choi et al. 2006, Wilhem et al. 2011, Padula et al. 2014).

Cuadras et al. (2016) researched a potential linkage between the inhalation of PAHs in humans and lung cancer. The scientists were able to detect eighteen different PAH compounds in particulate and gaseous form. The results indicated that "the average lifetime lung cancer risk did not show a high potential risk ($<10^{-4}$), but it was higher than the WHO's recommended value of 10^{-5} even for exposures lower than total lifetime hours" (Cuadras et al. 2016, 23225).

An analysis performed by the World Health Organizations (WHO) International Agency for Research on Cancer summarized a survey conducted in Europe on pavement companies that ended the use of coal tar sealants after evidence showed increased cancer rates among asphalt workers found in Table 2 (Trosset et al. 1978).

Table 2. “Cessation of Use of Coal Tar in Asphalt Paving (Surface Dressing)”

Country	Last Year of Use
Finland	1965
Denmark	1974
Sweden	1974
Norway	1984
Netherlands	1990
France	1992
Germany	1995

Source: “Investigation of Selected Potential Environmental Contaminants: Asphalt and Coal Tar Pitch” Trosset et al. and the Environmental Protection Agency, 1978, accessed March 1, 2018, https://nepis.epa.gov/Exe/ZyPDF.cgi/9100RXZK.PDF?Dockey=9100RXZK.PDF.

Coal Tar Sealants

Coal tar application has been a common practice for home and business owners, construction companies, and government agencies. Coal tar sealant is sprayed or painted onto driveways, parking lots, and some playgrounds (The United States Geological Survey 2011). The sealant appears shiny and black, enhancing the aesthetic value while increasing lifespan of the pavement (The United States Geological Survey 2011). The two most popular sealants offered on the market, are coal tar-based emulsion and asphalt-based emulsion sealers (Morrison 2015). Both emulsions are similar in appearance, purpose, and price; however, coal tar comes from the coking of coal for the steel industry, whereas asphalt comes from the purification of petroleum (Mahler et al. 2005). Coal tar sealant contains one-thousand times more PAHs compared to asphalt-based sealant (The United States Geological Survey 2011).

Coal tar and coal tar pitch contain high levels of PAH concentrations because coal tar sealants contain roughly twenty to thirty-five percent coal tar/coal tar pitch (The United States Geological Survey 2011).[1] Humans are most at risk of exposure to PAHs during the coal tar application process and drying period, as these processes volatize the compound (Abdel-Shafy and Mansour 2016). Sealant reapplication varies depending on climatic regions and traffic; however, the average recommendation is every two to three years (Mahler et al. 2005). General wear and tear from weather conditions and motorized vehicles abrade the sealcoat product overtime, allowing PAH compounds to wash off and bioaccumulate in stormwater, sediment, and homes (Metre, Mahler, and Wilson 2009, Mahler et al. 2005, Metre, Mahler, and Furlong 2000).

Although no studies have quantified how much sealant has been used throughout the U.S., Mahler et al. (2005) explained that their study used the *Blue Book of Building and Construction*, a reference for construction companies, which lists 3,300 coal tar companies that sell coal tar sealants across twenty-eight states. For example, New England Sealcoating offers services in Massachusetts, Rhode Island, New Hampshire, and Southern Maine. The company advertised to customers that they have sealed over 428 million square feet of pavement since 1945 (New England Sealcoating 2016).[2] There are companies in Vermont that offer coal tar-based sealant to customers, such as JDK Pavement Maintenance, LLC. The exact number is unknown.

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[1] In addition to asphalt and coal tar sealants, coal tar can be found in some medicines, foods, dyes, and pesticides (Abdel-Shafy and Mansour 2016).

[2] New England Sealcoating does not specify the type(s) of sealant(s) used to pave 428 million square feet. However, the website does advertise that their company offers "diluted coal tar sealer;" "Sealcoating Parking Lots, New England Sealcoating, accessed April 1, 2018, http://www.newenglandsealcoating.com/sealcoating.htm.

Linking PAH Pollution to Coal Tar Sealants

From 1970 to 2001 the United States Geological Survey (USGS) monitored trends of Dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyl (PCBs). Although concentrations from these two compounds had been decreasing, the USGS noticed that there was a steady increase in PAH concentrations across sample locations throughout the U.S (Mahler et al. 2005). In 2003, the Austin, Texas Department of Watershed Protection collected water and sediment samples from drainage ponds and streams located in residential urban areas across the City (The United States Geological Survey 2014). The results indicated unusually high concentrations of PAHs ≈1,500 mg/kg within the sample locations (Mahler et al. 2005). During this time, Tom Bashara, a sampler from the Austin Watershed Department, realized that a majority of the sample locations were below parking lots that appeared to be sealed with coal tar sealant (The United States Geological Survey 2014). He hypothesized that these high levels of PAH concentrations could be from the coal tar sealed lots. These high levels are typically attributed to Superfund sites and concentrations of around 23 mg/kg have the ability to adversely affect biota (The United States Geological Survey 2014). As a result, the USGS conducted the initial study testing this hypothesis (Mahler et al. 2005).

Following the work conducted by the Austin, Texas Department of Watershed Management, the USGS performed a broader study to reject or accept correlations between coal tar lots and high levels of PAH concentrations. Mahler et al. (2005, 5562) showed a PAH mean concentration of 3500 mg/kg in Austin parking lots sealed with coal tar, which was sixty-five times higher than unsealed lots. (Survey 2014, Metre, Mahler, and Wilson 2009). To date, the USGS is one of the leading actors in monitoring coal tar sealant pollution in the U.S.

The USGS intended to inform political actors and decision makers with its scientific evidence to provide knowledge, while remaining objective (Survey 2014). The research that it conducted influenced the City of Austin to implement the first coal tar sealant regulation in the U.S. Following, over sixty jurisdictions across the U.S. have implemented a breadth of institutional regulations on the use and sale of coal tar including: state, county, city, town, village, watershed, and university.

Sealcoat: Definition and Alternatives

Sealcoats are used to protect asphalt by providing a layer that repels oxygen and moisture molecules, which are responsible for depleting the condition of the underlying pavement. The process used to apply sealcoat includes brushing or spraying; however, spraying is the most common method of application. Some of the leading sealcoat companies in the U.S. include: "Neyra Industries, Inc., Bonsal American, Fahrner Asphalt Sealers LLC, Asphalt Coatings Engineering, Inc., RaynGuard, The Brewer Company, SealMaster, Vance Brothers, GemSeal Pavement Pro" (Transparency Market Research 2016).

As identified by the Minnesota Pollution Control Agency (MPCA), there are a few types of seal coats including: slurry seal, chip seal and fog seal (Minnesota Pollution Control Agency 2013). Slurry seal is "an asphalt emulsion with aggregates, mineral fillers and additives which bonds to existing pavement and cures to form a new wearing surface;" chip seal "combines a layer of asphalt emulsion (about 60% asphalt and 40% water) and a layer of fine aggregate on top of the existing pavement layer," and fog seal is "the sealcoat option used most by homeowners or others with a tighter budget is typically a form of fog seal emulsion of about 30% binder and 50% or more water, which may have polymers added to enhance product performance [these include]: asphalt (petroleum based) emulsion, coal tar pitch emulsion, Gilsonite© emulsion and acrylic emulsion" (Minnesota Pollution Control Agency 2013, n.d.-b, University of Wisconsin Extension: Solid and Hazardous Waste Education Center 2013).

Gilsonite© products may contain low levels of PAH and an additional hydrocarbon called naphtha, which is a by-product of crude oil. Naphtha is often regulated at the state level and does have some oversight by federal agencies such as the Occupational Safety and Health Administration (OSHA) (Services April 2007). Agricultural, oil-based sealcoating, acrylic-based sealcoats, and "cement-based micro-layers" are options to seal pavement with a product that does not contain PAHs (Agency n.d.-a, Center 2013). However, less information is available detailing the longevity of these products over time (Agency n.d.-a, Center 2013). Products typically come with an ingredient list that breaks down specific percentages of components; it is important to request this list (Agency n.d.-a) to better understand the suitability of the product. To explain, if a sealcoat is sought for harsher weather conditions, choose a product that contains polymers of 2.5 to 5 percent (Center 2013, Agency n.d.-a). Products that do not require a sealer include: permeable asphalt, pervious concrete, and paver products (Prince George's County 2015).

Economic Projections

With U.S. coal tar sealant legislation and publications identifying the consequences of applying coal tar sealers, there has been a decreased demand for coal tar sealants and an increased demand for asphalt-based and bitumen sealers (Transparency Market Research 2016). "By product, bitumen and asphalt-based sealers were the leading revenue generators in the North America sealers market in 2015" (Transparency Market Research 2016). Despite an increase in regulatory action on coal tar sealants, the sealant market value is projected to rise 4.7 percent by 2024 (Transparency Market Research 2016).

Many variables may influence the cost of sealing a driveway: the product, climatic region, contractor's, and most importantly, the condition of pre-existing pavement. (Minnesota Pollution Control Agency n.d.-a).

According to the University of Wisconsin Extension and the MPCA, "a comparison of 2012 retail prices shows asphalt-based sealcoating averaging about $3.60 per gallon; acrylic-based at an average of $8.00 per gallon; and, Gilsonite®-based at an average of $8.40 per gallon" (Agency n.d.-a, Center 2013). Below is a specific list of costs modeled to a large surface area in good condition:

- "Asphalt fog seal/sealcoat jobs can be in the $1.00 to $1.50/square yard range;
- Chip seal (asphalt emulsion with fine aggregate embedded into it), in the $1.50 to $2.25/square yard range;
- Gilsonite® and acrylic sealcoat, in the $3.00 to $7.00/square yard range (smaller jobs will cost more, towards the high end of the range);
- Agricultural oil seals, in the $1.70 to $2.00/square yard range" (Agency n.d.-a, Center 2013).

The price of coal tar varies; one estimate for coal tar sealant ranges from $0.14-$1.26 per square yard (Brahney 2014).

Federal Monitoring of PAHs

Although ineffective, the Toxic Substances Control Act (TSCA) of 1976 is the primary legislation responsible for monitoring and regulating existing and new chemicals, amended in recent years. In 2012, U.S. Congressman Lloyd Doggett (Democrat-Texas) introduced H.R. 4166, "To amend the Toxic Substances Control Act to prohibit the manufacture, processing, distribution in commerce, and use of coal tar sealants, and for other purposes" (U.S. Congress H.R. 4166 2012). The bill was referred to the Committee on Energy and Commerce and has since be stagnant.

Had the bill passed, it would have regulated the following: "(1) manufacturing any coal tar sealant beginning one year after this Act's enactment, (2) processing or distributing in commerce any such sealant beginning one and one-half years after such enactment, or (3) using any such sealant beginning two and one-half years after such enactment" (U.S. Congress H.R. 4166 2012). This is the one of few, if not the only piece of congressional legislation considered to regulate coal tar.

In implementing the Clean Air Act (1970) rules and regulations, the Environmental Protection Agency (EPA) is responsible for continued testing of chemicals of concern (COCs). In 1983, the EPA commissioned the National Academy of Sciences to conduct an analysis of PAH's and their contribution to air pollution (Committee on Pyrene and Selected Analogues 1983). The PAH compounds were selected according to their "pharmacological activity" and their present concentration levels in "emission or combustion products" (Committee on Pyrene and Selected Analogues 1983). When calculating detection and regulatory limits, the scientists mainly referred to PAHs most toxic compound, benzo[a]pyrene (BaP) (Committee on Pyrene and Selected Analogues 1983). The report calculated risk assessment associated using 1974 air data that suggested a commuter could inhale 21 ng of BaP in 24 hours (Committee on Pyrene and Selected Analogues 1983, D-11). This calculation was used to further suggest that there is a 0.02-0.06 percent increase in becoming diagnosed with lung cancer by the age seventy when exposed to 1 ng/m^3 of BaP over the course of a lifetime; the chance of premature death was 0.00009 percent (Committee on Pyrene and Selected Analogues 1983, D-12). Lastly, the report suggested that PAH contamination could be combated through "controlling forest fires, structural fires, and coal-refuse fires (largely in abandoned coal mines)" (Committee on Pyrene and Selected Analogues 1983, D-13).

A summary of findings from a report published by the World Health Organization (WHO) concluded that in some areas of the U.S., PAH concentrations from coal tar pitch were up to 600,000 micrograms per kilogram of soil (Choi et al. 2010). The study confirmed previous research, indicating that coal tar workers did have a greater chance of developing cancers, particularly lung cancer. Increased PAH concentrations were also found in drinking water and marine life; although, the study indicated that humans have a much greater chance of exposure to PAHs through food sources. This is due to an increase in PAH concentrations tested in soils in which food is grown. The conclusion of this analysis illustrated steps in "public decision-making," in efforts to guide the public and regulatory bodies in determining appropriate PAH concentrations limits through "risk-valuation analyses" (Committee on Pyrene and Selected Analogues 1983).

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, the ATSDR and the EPA are required to regulate the Substance Priority List (SPL) of pollutants that pose the greatest risk to human and environmental health (Agency for Toxic Substances and Disease Registry 2017). PAHs as a class of compounds ranked seventh out of two hundred seventy-five compounds. The specific PAH compound benzo[a]pyrene is ranked eighth (Agency for Toxic Substances and Disease Registry 2017).

The EPA listed sixteen PAHs as priority pollutants, seven of which are considered probable human carcinogens (refer to Appendix A, Table 3 for a list of compounds.) On the other hand, the ATSDR list seventeen PAHs as priority pollutants (refer to Appendix A, Table 4 for a list of compounds.) Specifically, scientific evidence classifies benzo[a]pyrene, an HPAH, as the most threatening of PAH compounds to human health, due to its high molecular weight (Huang, Chernyak, and Batterman 2014 , Morrison 2015).

Under the Safe Drinking Water Act (1974), PAH regulation limits are set for benzo[a]pyrene, at 0.2 parts per billion (42 U.S.C. §300f et seq. 1971). The Integrated Atmospheric Deposition Network (IADN), commissioned by the EPA is in charge of monitoring PAHs in the Great Lakes regions (Agency n.d.). The Occupational Safety and Health Organization (OSHA) has no set occupational exposure limits for PAHs. However, regulations have been set for "coal tar pitch volatiles." The limits are calculated according to an eight-hour work day at 0.2 mg/m3, "which is measured as the benzene-soluble fraction of coal tar pitch volatiles" (Morrison 2015).

In summary, federal legislation does little to regulate PAH compounds and as a result, it is left to the states to implement smart environmental policies. The 2005 discovery of coal tar sealant as a major contributor to increases in PAH concentrations in sediment and water samples became the catalyst for coal tar regulation across the U.S.

State Action

A blog Coal Tar Free America claimed that roughly twenty-two million Americans are living in a jurisdiction that has implemented a regulation to protect them against PAH exposure from coal tar sealants (Ennis 2016). In 2005, Austin, Texas was the first location in the U.S. to successfully pass legislation that banned the use and regulated the sale of coal tar sealants (Ennis 2010). Washington and Minnesota are the only two states successful in implementing statewide bans on the use and sale of coal tar sealants (refer to Appendix B, Table 5, Table 6, Table 7, and Table 8 for a list of state and district bans, government restriction bans, institutional bans and proposed bans, respectively.)

Opposition

The most vocal stakeholder in opposition to coal tar sealant regulations in the U.S. is the Pavement Coatings Technology Council (PCTC). When the City of Austin decided to ban coal tar sealants, the PCTC shifted its priorities as it assumed more jurisdictions across the U.S. would follow suit (For Construction Pros 2009). As a result, the PCTC started to conduct research and advertise a pro-coal tar sealant stance (For Construction Pros 2009). In an interview, the PCTC's executive director stated, "the regulatory challenge we face is a sealing issue, not just a coal tar issue. We want to encourage makers of both products to understand we're all in this together. Coal tar sealer has PAHs but so does asphalt sealer so any concerns applied to coal tar can eventually be applied to asphalt regulations," she says. "The goal of the restructured PCTC is to strengthen the sealcoating industry; it's as simple as that. That's the big picture of the new PCTC" (For Construction Pros 2009). Despite opposition, many jurisdictions across the U.S. have been successful in protecting their constituents and natural resources against increased PAH exposure from coal tar sealant.

METHODOLOGY

Objectives

Policy makers use policy analyses to make informed decisions. With all policies come alternatives; analyses are conducted to determine a policy solution that meets the established goal(s) and addresses the defined problem(s). According to Bardach and Patashnik (2016, xv) policy analyses "help in program evaluation, program design, program management, public relations, planning, budgeting and other functions." I performed three policy analyses on successful coal tar sealant regulations in Washington, Minnesota and Austin, Texas. The objective was to use these analyses to inform policy recommendations for the State of Vermont.

Data Collection and Case Study Collections

I first gained a greater understanding of the scientific literature associated with PAHs and coal tar sealants. I consulted websites and peer reviewed articles to begin to understand the general chemistry of PAHs.

Three case studies were chosen based on the availability of online information. I began research by performing a comprehensive online search, compiling a list of all identifiable U.S. regulations on coal tar sealants. In an attempt to finalize a complete regulatory list, I modified the MPCA's "Actions to restrict or discontinue the use of Coal Tar Based Sealants in the United States" (2016) with input the blog Coal Tar Free America. I then performed a deep dive into each case study to determine the availability of information through a comprehensive review of available resources including: stakeholder websites, legislation, newspaper articles, and peer reviewed literature. With more than sixty jurisdictions across the U.S. that have taken action against coal tar sealants, for most of which the regulations provide minimal online information, I chose three case studies supported by the greatest amount of resources for the purposes of analysis: Washington, Minnesota and Austin, Texas.[3] First, I researched the ecological and social demographics of each case through a comprehensive online search. Second, I compiled a historical timeline of peer reviewed scientific articles that acknowledge PAHs in each case study. This provided the background for determining the relevance of PAHs in each case.

Conducting a Policy Analysis

Policy making can be defined as "the manner in which problems get conceptualized and brought to government for solution: governmental institutions formulate alternatives and select

[3] Washington D.C. implemented a districtwide ban on the use and sale of coal tar sealants in 2009. This district was not considered for purpose for analysis because of its classification as a district and also, a lack of information as compared to the three chosen case studies for this paper.

policy solutions' and those solutions get implemented, evaluated and revised" (Sabatier and Jenkins-Smith 1993).

The three analyses allowed me to propose a phased-in statewide ban on the sale and use of coal tar sealants in Vermont, with two alternative policies: a government restriction on the use of coal tar sealant and a ban on the use and sale of coal tar sealant in the City of Burlington.

Bardach and Patashnik (2016, xvii) developed a mode of policy analysis called "the eightfold path." The eight steps are as follows:

- Define the problem
- Assemble Some Evidence
- Construct Alternatives
- Select Criteria
- Project the Outcomes
- Confront the Trade-offs
- Stop, Focus, Narrow, Deepen, Decide!
- Tell Your Story

Bardach and Patashnik (2016, xvii) explain that when using the eightfold path, the product should resemble the following:

- In a coherent narrative style, you describe some problem that needs to be mitigated or solved.
- You lay out a few alternative courses of action that might be taken.
- To each course of action, you attach a set of projected outcomes that you think your client or audience would care about, suggesting the evidentiary grounds for your projections.
- If no alternative dominates all other alternatives with respect to all evaluative criteria of interest, you indicate the nature and magnitude of the trade-offs implicit in different policy choices
- Depending on the client's expectations, you may state your own recommendation as to which alternative should be chosen

To conduct the policy analyses; I looked for evidence of the steps outlined in the eight-fold path in each case.

Constructing a Policy Design

I compiled historical background literature specific to PAHs in Vermont through comprehensive internet searches and a review of peer reviewed literature. I also analyzed the DEC's (2017), *An Evaluation of PAHs, Arsenic, Lead: Background Soil Concentrations in Vermont* report. This was the most comprehensive piece of literature that acknowledged the presence of PAHs in Vermont and attempted to analyze their impact on the State. I requested the generation of Geographic Information System Mapping Technology maps to layout the Commercial/Industrial and Residential TEQ PAH outliers for further examination in future research (refer to Appendix D Figure 10 and Figure 12 to view the maps.)

To craft a comprehensive policy design, I included the following elements:

1. Recommendations
    a. Problem
    b. Goal
    c. Solution
    d. Alternatives
2. Policy Description
    a. Regulatory Oversight and Enforcement
    b. Stakeholders
3. Costs and Benefits
4. Feasibility
5. Policy Limitations

POLICY ANALYSES

Statewide Analysis: Washington

In February 2011, Washington became the first state to adopt a statewide ban on coal tar sealants. The legislation prohibited the sale of coal tar, effective January 1, 2011, and prohibited the application of the product, effective July 1, 2012. House Bill 1721, passed the House 64-32 and the Senate 36-12 (Washington House Democrats 2011).

Problem Definition

Using data from the Agency for Toxic Substances and Disease Registry (ATSDR) and California EPA Office of Environmental Hazard Health Assessment, the Washington State Department of Ecology (WSDOE) calculated cancer risks of PAHs. The WSDOE ranked the COCs according to their likelihood of cancer risk. A rating of three was the most threatening, two was moderate, and one was mild. After examining additional ways PAHs persist in the environment, the study concluded that, “the results indicate that these five PBTs [persistent, bioaccumulative and toxic chemicals] in particular are widely present in Washington’s environment, and routinely exceed water quality, the Model Toxics Control Act cleanup level, and sediment quality standards” (Washington State Department of Ecology 2007). The study also stated, “PAHs are not only formed unintentionally through combustion but are made intentionally to produce asphalt and tars, so treating them simply as a combustion product would not be appropriate” (Washington State Department of Ecology 2007). When this study was published in 2007, agencies, like the WSDOE, were aware of the correlation between coal tar and the impacts of PAHs.[4]

[4] One of the first studies examining hydrocarbons and their impact on Washington State was conducted in 1984 (Bates, Hamilton, and Cline 1984). This study examined the potential impact of PAH compounds within the Pugent Sound Basin located in Washington. Sediment samples were taken for purpose of analysis at depths of 50, 100, 160 and 200 meters within the water basin (Bates, Hamilton, and Cline 1984). One of the study’s main findings suggested that sediment samples taken from deeper depths showed an increase in PAHs that correlated with increased urbanization of surrounding communities. In addition, the study suggested that the higher concentrations of PAHs were found in sediment samples from the year 1950, which correlated to an influx in coal tar emissions from heating homes. Moreover, they observed a decrease in PAH concentrations with the installment of a wastewater treatment facility in Seattle (Bates, Hamilton, and Cline 1984).

Another study conducted within the Pugent Sound Basin examined concentrations of PAHs in three fish populations: English sole (*Parophrys vetulus),* starry flounder (*Platichthys stellatus*) and the rock sole (*Lepidopsetta bilinear*) (Stein et al. 1993). The study confirmed findings of PAHs in each of the three fish species at different concentrations depending on the specific waterway the samples were taken from within the Pugent Sound Basin. The findings established that “chemical and biochemical processes” were an effective method of determining environmental contamination of COCs, PAHs and polychlorinated biphenyls (PCBs) within benthic fish.

The WSDOE is responsible for publishing Chemical Action Plans (CAP), which examines priority pollutants to inform an appropriate action plan determined to best protect the State. In its 2007 report, the WSDOE suggested that along with perfluorooctane (PFOS) and lead, PAHs should also be included in chemical action plan reports published over the next three years. The report examined the impact of PAHs in Washington and identified an increase in PAH concentration in Puget sound, particularly among benthic fish. A toxics release inventory was performed for PAHs, benzo(g,h,i)perylene, and mercury compounds on "releases" and determined that PAHs were most prevalent, accounting for 87.62 percent of compounds detected (Washington State Department of Ecology 2007).

The Environmental Conservation Division along with the Northwest Fisheries Science Center, conducted a study to analyze the impact of PAHs in aquatic life for the National Marine Fisheries Service (NMFS). The analysis was performed to determine if the water and sediment concentrations that are set for PAHs (detection limits vary by state and not all states regulate PAHs) were adequately protecting fish species (Johnson, Collier, and Stein 2002). The researchers indicated that Washington State does have set limits for PAHs in sediment samples but that the number is calculated for larger, benthic marine species (Johnson, Collier, and Stein 2002). Because these species are benthic, it allows for more bioaccumulation of the compound than it may in other marine animals (Johnson, Collier, and Stein 2002). The study claimed that this formula that establishes a detection limit "may not be suitable for assessing the direct impacts of sediment PAHs on fish because fish metabolize PAHs, and fish may differ from invertebrates and sensitivity to PAHs" (Johnson, Collier, and Stein 2002). Specifically, it analyzed the English sole (*Pleuronectes vetulus)* and used existing data pertaining to the English sole and the impact of PAHs on this specific fish species (some of the studies are already mentioned above). After analyzing effects of PAHs including: DNA damage, growth reduction, liver disease and reproductive dysfunction, the researchers suggested a concentration level of 1,000 ppb should be set as standard for sediment quality (Center 2013). Anything that tested above 1,000 ppb lead to an increase in adverse effects such as liver disease and infertility in English sole (Johnson, Collier, and Stein 2002).

An additional study conducted in the Anacostia Watershed further examined stormwater runoff and toxicity persisting within this watershed. The Watershed continued to be listed on the EPA's "highest priority region" at the time this second study was conducted (Hwang and Foster 2006). Between the months of April and August 2002, samples were taken at six "free-flowing branches" within the Anacostia River (Huang, Chernyak, and Batterman 2014). Of these six sites, "baseflow" and "stormflow" samples were collected at three of the sites and "stormwater samples" were collected at the remaining three sites (Hwang and Foster 2006). Samples collected in areas categorized as storm flow, exhibited PAH distribution coefficients 340 times higher than hypothesized (Hwang and Foster 2006). An entire section of this study was dedicated to discussing potential sources of PAH runoff into the Anacostia River. The study stated that there were "many spills of petroleum related materials," but, suggested that cars were the largest emitters of PAHs, which contributed to an increase in PAH concentrations in the Anacostia Watershed. The research further suggested that in order to improve the health of the lake, impervious surface should be reduced to minimize the amount of stormwater runoff into the body of water. This could take shape as the study suggests as a "hybrid" lot, incorporating both impervious and pervious membranes in conjunction with one another.

Asphalt sealants were believed to be more widely used compared to coal tar sealants at the time of the ban. It was estimated that roughly 400,000-600,000 gallons of coal tar sealants were applied in 2004 (Washington State Department of Ecology 2007), contributing an accumulation of an estimated 113.5 metric tons of PAHs per year (Ecology 2007).

Setting the Agenda

The bill was introduced in the Washington State House by David Frockt, Representative, who later became a Senator. Representative Frockt became concerned with PAH contamination after reading the article: *Study Sees Parking Lot Dust as a Cancer Risk: Sealant Doesn't Stay Put on Pavements, Raising Health Concerns* (McClure 2010). The article outlined the scientific evidence that suggested coal tar sealants are a major contributor to increase in PAH concentrations and the harmful effects associated with increased exposure (McClure 2010). Stakeholders that advocated in support of Washington's statewide regulation included: the Association of Washington Cities, the Department of Ecology, the Department of Natural Resources and the People for Puget Sound and the Washington Environmental Council (Morrison 2015).

The MSDOE and stakeholders involved, including Representative Frockt and the Washington Environmental Council, acknowledged that coal tar sealer was not the most pressing environmental issue that Washington may be facing. The stakeholders recognized that the effects of PAHs were alarming; however, the benefits outweighed the costs of banning coal tar statewide. According to Representative Frockt and supporters, the strongest argument for passing the legislation was the availability of asphalt-based sealants, a viable alternative to coal tar sealants, which had been determined to already be the main product in use. Further, the Washington State Department of Transportation had already ceased the use of coal tar sealants, which was disclosed in an article published by the Washington House Democrats in 2011 (Washington House Democrats 2011).

The bill saw opposition when first introduced in the House Committee on Environment and later in the Senate Committee on Environment. According to Morrison (2015), the Pavement Coatings and Technology Council (PCTC) and a private consultant the PCTC hired testified before both the House and the Senate voicing their opposition to a ban on coal tar sealant. The two actors disputed the evidence presented by the USGS and claimed that there had not been enough research performed specifically in Washington that looked at the correlation between PAHs and coal tar sealant pollution (Morrison 2015). Despite testimony from the PCTC and its consultant, the bill was signed into law by Governor Gregoire on May 5, 2011. Passing a statewide ban on coal tar sealants sent a powerful message to other states across the U.S. about the severity of the issue and the feasibility to prevent increased PAH contamination.

Implementation

The State of Washington's Department of Ecology, who advocated for the coal tar sealant ban, is the main party responsible for overseeing this regulation. The bill also states: "a city or county may adopt an ordinance providing for enforcement of the requirements of subsection (1) or (2) of this section. A city or county adopting an ordinance has jurisdiction concurrent with the department to enforce this section" (Chapter 70.295 2011). Sections (1) and (2) referring to the application of coal tar and the sale of coal tar sealants.

The Agency's website has limited guidance for constituents and minimal information regarding the Agency's regulatory role. The website does establish a relationship in monitoring PAHs with the Washington Department of Public Health and links to its 2012 CAP report (Washington n.d.) The Department's webpage has a published fact sheet titled "Law Affects

Coal Tar Sealants" (2016) that states: "[Department of] Ecology may issue a notice of corrective action to a person in violation of Washington's law" (Washington State Department of Ecology 2007).

Nine amendments to HB 1721 had been proposed and all failed (WashingtonVotes.org n.d.). Two related to enforcement stating "to require the Department of Ecology to provide cities and counties with training to identify and test coal tar and coal tar pavement products if the city or county has adopted an ordinance to enforce the requirements of the bill; to require the Department of Ecology, prior to issuing a notice of Corrective Action, to verify that a product is a coal tar pavement product using credible testing data that incorporates peer reviewed science" (WashingtonVotes.org n.d.). Both of these amendments failed February 28, 2011 and April 6, 2011, respectively (WashingtonVotes.org n.d.).

Evaluation

There is no evidence to suggest so far that the coal tar sealant ban had been successful in reducing PAH concentrations in Washington. According to the USGS, it takes roughly fifteen years to see a decrease in PAH concentration due to their persistence in the environment (Morrison 2015, 55). According to Tina Schaefer, a Research & Policy Analyst in the Hazardous Waste & Toxics Reduction Program with the Washington State Department of Ecology, there have been no reported violations since the ban went into effect (Tina Schaefer Correspondent, email message to author, April 18, 2018). Although good, this could be perceived as a flawed policy as it is unlikely that there have not been any violations at all in the seven years the ban has been in place.

Statewide Analysis: Minnesota

The State of Minnesota became the second state to adopt a statewide ban on the use and sale of coal tar sealants on May 20, 2013. The legislation prohibited the use and sale of coal tar sealants effective January 1, 2014. The bill also granted funding to conduct further research into coal tar sealants and their impact in Minnesota.

Problem Definition

In 2001, the Minnesota Department of Health (MDH) published an informational sheet "to identify a consistent approach for agencies and programs to assess the health risks from exposures to carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in air, water, soil, and other media" (Health 2016). This information was updated in 2013 in response to a "request" from the Minnesota Pollution Control Agency (MPCA).[5] This guideline continues to recognize

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[5] Collecting snow core samples, researchers analyzed atmospheric depositions of PAH concentrations from years 1989 through 1992 in central and northern Minnesota (Franz and Eisenreich 2000). As a result, PAH concentrations were measured at levels of 35 to 3280 ng/L (Franz and Eisenreich 2000). The lowest concentrations were detected in more rural areas, ranging on average of 35 to 120 ng/L, whereas the higher concentrations were detected in urban settings measuring 230 to 3, 280 ng/L (Franz and Eisenreich 2000). Although this study went into detail on estimating "the riverine inputs of these chemicals furing snowmelt," there was no discussion on potential sources of contamination (Franz and Eisenreich 2000).

Between 1997 and 2000, researchers collected water samples from three types of wells: "non-sewered residential" homes, "commercial and industrial" spaces, and "sewered residential" homes (Trojan et al. 2003). Of the 23 wells tested in total, only one tested above detection limit of 0.010 ug/L: benzo(g,h,i)pyrelene was detected at 0.013 ug/L and indeno(1,2,3,c,d)pyrene at 0.012 ug/L (Trojan et al. 2003). Overall, this study intended to suggest best practices to mitigate "land use change" as a result of poor ground water quality and management (Trojan et al. 2003). The study concluded by stating "the results also indicate the potential importance of new chemicals that have not been extensively studied…," at the time PAHs could be considered one of these under-studied chemicals (Trojan et al. 2003).

The Minnesota Children's Pesticide Exposure Study (2003) examined the effects of PAHs on children ages three to fourteen. The researchers examined the effects that PAHs may have on one of the most vulnerable populations: children. After sending out a screening survey, researchers selected 102 children for purpose of analysis. Specifically, they looked at 13 types of PAH compounds: (benzo(a)pyrene, benzo(a)anthracene, acenaphthylene, anthracene, chrysene, benzo(e)pyrene, benzo(ghi)perlene, benzo(k)fluoranthene, fluoranthene, phenanthrene, pyrene, indeno{1.2.3.-cd]pyrene and benzo(b)fluoranthene (Sefton 2003). They then collected food, indoor air (personal and professional) outdoor air, soil, drinking water and dust samples. The results indicated that most of the PAH concentrations were found in personal air sampling; over fifty percent (Sefton 2003). In addition, PAH concentrations were found in three to forty-seven percent of all dust samples and seventeen to ninety-nine percent of professional indoor and outdoor samples (Sefton 2003). It should be noted that pyrene, phenanthrene and

and suggest benzo[a]pyrene as a cPAH and a baseline for assessment for additional PAH compounds (Health 2016). Since then, Minnesota has set toxicity levels at the following:

- "B[a]P contaminated water: 0.06 µg/L
- B[a]p adult dermal and oral exposure: 1.7 mg/kg per day
- B[a]p inhalation: 0.001 µg/m" (Health 2016).

Minnesota became aware of the direct impact coal tar sealants may be having, when a study was conducted in the Twin Cities that indicated increase in PAH contaminants in stormwater ponds (Crane 2012). As Minnesota was conducting further samples, the State was also being required by legislation to determine the costs associated with the clean-up. The

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fluoranthene concentrations, were present in between 97 and 99 food samples of the total 102 samplings, respectively (Sefton 2003).

Within Minnesota's rural and urban communities, researchers analyzed three outdoor air sources of PAH's including: wood combustion from residential homes, combustion boilers and motorized vehicles (Lobscheid and McKone 2004). Using "the CalTOX regional multimedia mass-balance model," researchers compared outdoor air samples to the results from the Minnesota Children's Pesticide Exposure Study (MNCPES) (2003). Specifically, researchers predicted airborne concentrations of PAHs based on "… (1) regional-scale estimates of PAH airborne emissions, (2) predict the resulting ambient outdoor air concentrations [Caltox] with multimedia mass-balance model, and (3) assess the degree comparability between predicted concentrations and regional-scale ambient measurement" (Agnes B. Lobscheid and McKone 2004, 5502). After examing sixteen compounds of PAHs, the evidence suggested that of these sixteen, the compounds most present were two and three ringed compounds. The most significant emitter of PAHs were from motorized vehicles and residential wood combustion (Agnes B. Lobscheid and McKone 2004). Further within the results section, the study recognized that there was a potential for PAH compounds including pyrene and fluoranthene pollution sources such as asphalt (Agnes B. Lobscheid and McKone 2004). The study recognized that more research needed to be conducted to increase the certainty of PAH concentrations and route of exposure (Agnes B. Lobscheid and McKone 2004).

A study conducted by Billiard et al. (2007) recognized that the majority of past research had identified PAHs are carcinogens; specifically, benzo(a)pyrene; yet, evidence lacked the impact of these compounds on vertebrate species. This study identified the complexity of understanding the way in which the many PAH compounds interact not only with one another, but also, other toxins and environmental conditions (Billiard et al. 2007). Hence, this study analyzed a mixture of PAH compounds as opposed to singular compounds. Dioxin showed the potential for adversely affecting the heart organ in rodent species during gestational periods (Thackaberry et al. 2005). Fish species seem to be the greatest of vertebrates at risk to exposure of PAHs. Specifically, research has suggested that exposure to dioxin increased the chances of salmon species acquiring "an overt toxicity syndrome called blue sac disease (BSD), characterized by increased rates of mortality, pericardial and yolk sac edemas, regional ischemia, subcutaneous hemorrhages, craniofacial deformities, and arrested growth" (Billiard et al. 2007, Spitsbergen et al. 1991, 7). In addition, several other species including zebra fish (*Danio rerio*), rainbow trout (*Oncorhynchus mykiss*), killfish (*Fundulus herteroclitus*) and Japanese medaka (*Oryzias latipes*) showed similar symptoms attributed to BSD (Billiard et al. 2007, Chen and Cooper 1999, Elonen et al. 1998, Helder 1980, Toomey et al. 2001, Walker and Peterson 1991, Wannemacher et al. 1992).

League of Minnesota Cities and the Minnesota Pollution Control Agency were responsible for drafting a bill that restricted state agencies from purchasing "undiluted" coal tar as noted above. (An example of the bill's template can be found in Appendix C.) Notably, the legislation encouraged the MPCA to analyze environmental impacts of PAHs in Minnesota communities, consider banning coal tar sealants within their municipality and, in addition, perform more background research to gain a better understanding of the effects of PAHs on the environment to inform later policy recommendations (Minneapolis 2012, Agency n.d.-c).

The MPCA also performed an economic analysis of costs associated with clean-up. Overall, the analysis suggested that it could cost around $50 per cubic yard to transport and properly dispose of sediment containing PAHs. Further, in "2010, the MPCA estimated that if ten percent of sediment in 20,000 Minnesota ponds exceeded the most stringent PAH standard, the total cost of clean-up to Minnesota cities could exceed $1 billion" (Innes 2017, 29). The MPCA suggested that a ban would most likely decrease costs associated with clean-ups to taxpayers (Agency n.d.-c). Given this, 29 Minnesotan municipalities implemented coal tar sealant regulations before the statewide ban was enacted in 2014 (Innes 2017).

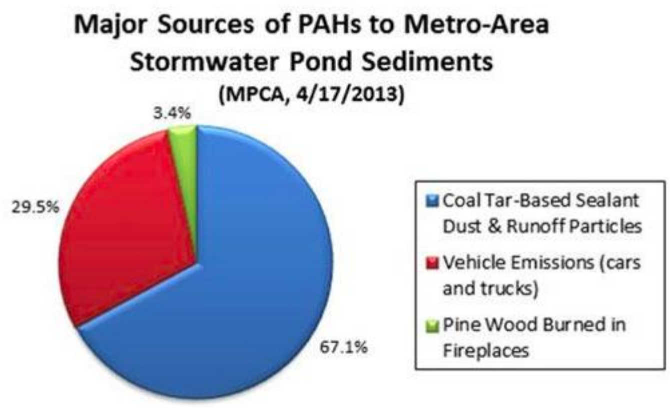
Setting the Agenda

Two bills were introduced in the Minnesota legislature in 2009: HF 1991 and SF 2045. Representative Bev Sclaze introduced HF 1991 on March 19, 2009 in response to a request from the MPCA which sought grant money to perform an in-depth background study of the implied impact of coal tar sealants on stormwater ponds throughout the State (Morrison 2015). SF 2045 was adopted into HF 1231 Omnibus Cultural Resources Finance Bill on March 19, 2009. The Bill prohibited the purchasing of coal tar sealants by all Minnesota State Agencies effective July 1, 2010 and allocated $155,000 for the MPCA to perform a background study to be used to inform jurisdictions and policymakers of potential coal tar sealant pollution, and establish a protocol for remediation of soils and stormwater monitoring schedules (Minnesota Pollution Control Agency 2010).

In addition to the first grant, $345,000 was to be stipulated, “to develop model ordinance for the restricted use of undiluted coal tar sealants and to provide grants to local units of government for up to fifty percent of the costs to implement best management practices to treat or clean up contaminated sediments in storm water ponds and other waters as defined under this article” (Minnesota Pollution Control Agency 2010). Municipal governments were only eligible for grant money if they adopted a “local ordinance” restricting the use of undiluted coal tar sealants (Minnesota Pollution Control Agency 2010).

As a result of HF 1231, the MPCA collected and analyzed fifteen samples from stormwater ponds in St. Paul, Minnesota. The results showed that coal tar run-off contributed to 67.1 percent of PAHs, where vehicles contributed 29.5 percent and wood combustion contributed 3.4 percent (Crane 2013). (Please refer to Figure 9. to review the results of these findings.)

Figure 9. Contribution of Coal Tar in Metro-Area Stormwater Ponds



Source: "Coal Tar Based Sealcoat FAQs," The Minnesota Pollution Control Agency, n.d., accessed April 24, 2018, https://www.pca.state.mn.us/water/coal-tar-based-sealcoat-faqs.

In response to the evidence that was being published, twenty-nine Minnesota jurisdictions implemented localized regulations on coal tar sealant. White Bear Lake was the first municipality in Minnesota to ban the use of coal tar sealant (Blake 2011). Before this ban was passed, researchers were collecting annual sediment samples from two stormwater ponds in White Bear Lake (Bratrud 2007). Researchers found that two sediment samples contained concentrations for benzo[a]pyrene that were detected over regulation standards (Schnick 2014). Remediation methods for cleaning and maintaining these stormwater ponds required a method called dredging (Schnick 2014). Unfortunately, the dredging method would have cost White Bear Lake upwards of $500,000 (Brent Thompson, personal communication to Amy Garcia, April 17, 2009). The City of White Bear Lake determined that the external costs were too great to continue allowing the use of coal tar sealant.

The Minnesota Legislature's web page states, "they [PAHs] pollute water, cause birth defects in fish and other aquatic life, and can cause cancer in humans, so the accumulations must be treated like hazardous waste, which is expensive" (Minneapolis 2012).

Implementation

The two main stakeholders responsible for overseeing this regulation were: the MPCA and the University of Minnesota, who worked in conjunction with one another to perform analyses and conduct scientific studies. These two stakeholders developed informational guidelines published for homeowners who used coal tar sealants. They developed a list of alternative methods that included options comparable to coal tar sealants in price, aesthetic and durability, deeming asphalt as the most feasible option. Additionally, they provided citizens with a list of reputable pavement companies who they could use for future business (Innes 2017). Overall, the Minnesota Pollution Control Agency is the primary stakeholder responsible for ensuring this policy is implemented and overseen. The MPCA is the main contact for local municipalities who have questions or concerns about coal tar, also, they are responsible for "managing" and overseeing the "contaminated sediments" (Minnesota Pollution Control Agency n.d.-b)The Minnesota Department of Health is also required to monitor regulation and provide aid to the MCPA in setting regulatory values of PAHs (Health 2016). In addition, the MPCA in particular, acted as educators and consultants for their constituents and other states, which allowed them to keep the public informed. A violation results in a $1,000 fine for the first offense and up to a $5,000 for any recurring offenses (MN HB2401 2013).

Evaluation

The 2009 legislation was successful in educating municipalities on the potential impacts of PAHs, which encouraged 29 locations to ban the application of coal tar sealants at the local level. The grants that the State offered with the first piece of legislation allowed the MPCA to perform scientific testing the gain a better sense of how impactful PAHs were on the environment. The Minnesota Legislature also set aside a budget to invest in further testing and evaluate the feasibility of a ban.

Overall, this protective legislation could be viewed as both successful and unsuccessful. No violations have been recorded to date. This could be indicative of a lack of transparency between the MPCA and constituents, poor communication, and/or inadequate of regulatory oversight. On the other hand, these results could be ominous of a successfully planned and implemented policy.

Citywide Regulation: Austin, Texas

On November 17, 2005, the City of Austin City Council unanimously voted to place a citywide ban on the use and sale of coal tar sealant, effective December 12, 2005 (Texas n.d.).[6] Austin was the first municipality in the U.S. to implement a coal tar sealant legislation. (Refer to note 5 for a history of the study of PAHs in Texas.)[7]

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[6] The sale is prohibited unless the application is not intended in the City of Austin.

[7] Over the course of one year, from August 1998 to 1999, researchers collected water and air samples from Corpus Christi Bay, Texas and tested for PAH and PCB compounds. Researchers explained that the samples indicated that "total atmospheric input of PAHs to Corpus Christi Bay is not as large as inputs from land runoff and periodic oil spills (Park, Wade, and Sweet 2002). The study did mention that they believed PCBs and PAHs to come from similar sources, noting "large industrial and urban areas, similar controls on inputs, and/or transportation pathways" (Park, Wade, and Sweet 2002). They also made the claim that "they [PAHs] are composed of a mixture of petroleum and combustion sources… The majority of PAHs found on particulates in air and rain samples are attributed to combustion activities" (Park, Wade, and Sweet 2002). In all, the evidence suggested that PCBs were a "net source" whereas PAHs were a "net sink" (Park, Wade, and Sweet 2002).

Using Asiatic clams (*Corbicula fluminea*) and semipermeable membrane devices (SPMD), researchers detected PAH concentrations in different streams within the Dallas-Fort Metropolitan Area (Moring and Rose 1997). After analyzing the Asiatic clams, the researchers found that three PAH compounds were present (Moring and Rose 1997). However, using the SPMDs, the devices detected 20 different PAH compounds in the selected areas (Moring and Rose 1997). Nine of the sixteen persistent organic pollutants as identified by the EPA were detected using these samples. Specifically, the SPMDs detected: benz[a]anthracene, chrysene, benzo[a]pyrene, all of which exceeded the EPAs set detection limits (Moring and Rose 1997).

Problem Definition

Geographically, the City currently monitors forty-five creeks and three reservoirs with over twenty-five years of accumulated water quality data (Scoggins 2015). Evidence has been collected over the years, specifically looking at PAH concentrations by the USGS and the City of Austin Department of Watershed Management (Mahler et al. 2010, Mahler et al. 2012, The United States Geological Survey 2014, Metre and Mahler 2003, 2013, 2014, Metre, Mahler, and Wilson 2009, Mahler et al. 2005, Metre, Mahler, and Furlong 2000). In 2003, the City of Austin was the first jurisdiction to suggest the correlation between coal tar sealant and elevated PAH concentrations (Survey 2014). After making this revelation, the City of Austin informed the USGS who decided to perform extensive research into these preliminary findings (Mahler et al. 2005). The City of Austin stated: “in 2003, City of Austin scientists identified coal tar-based pavement sealants as a significant source of polycyclic aromatic hydrocarbon (PAH) contamination in Austin area stream sediments” (Texas n.d.).

Specifically, Mahler et al. (2005) studied thirteen urban parking lots located in Austin, Texas and three test plots at the Robert Mueller Airport, which had been out of commission since 1999. This comparative study evaluated urban lots sealed with coal tar sealant, asphalt-based sealant, and unsealed cement to determine PAH concentrations. More importantly the researchers yearned to understand whether or not there was a relationship between the compound and sealed parking lots. The results were statistically significant, concluding that PAHs contribute 65 times higher levels than asphalt sealant and cement pavement (Mahler et al. 2005). This was the first comprehensive study that supported the hypothesis that coal tar sealant was the largest contributor to PAHs persisting in the environment.

In 2004 the EPA estimated that over 600,000 gallons of coal tar sealants were applied every year in Austin, Texas (Scoggins 2015). Given all of this information, lobbyists, citizens and policymakers sought to implement a policy that would cease the use of coal tar-based sealants.

Setting the Agenda

In 2000, the USGS collected core sediment from three lakes and seven rivers within different urban areas around the U.S. (Metre, Mahler, and Furlong 2000). For two of these sample locations, researchers chose to sample Town Lake in Austin and White Rock Lane in Dallas, Texas (Metre, Mahler, and Furlong 2000). Both lakes are estuaries for collecting drainage and stormwater. The researchers were able to analyze trends over time through the method of sediment core sampling and found that there were slight increases in PAH concentrations from years 1970 to 2000 that correlated with increased traffic from motorized vehicles in the area (Metre, Mahler, and Furlong 2000). The research concluded that “PAHs are proportional to increases in vehicle traffic” (Metre, Mahler, and Furlong 2000). No acknowledgment of the potential contribution of coal tar pitch or any other routes of exposure were discussed.

Another study from USGS’ Peter Van Metre and Barbara Mahler examined the potential for “particle-associated contamination in rooftop runoff,” comparing concentrations of shingles made of asphalt and shingles made of galvanized metal (Metre and Mahler 2003). The study suggested that despite their working hypothesis, there were no differences in PAH concentrations with the two roofing materials (Metre and Mahler 2003). The researchers hypothesized that the asphalt roofing material contributed to the PAH runoff in sampled watersheds (Metre and Mahler 2003). Additionally, they found that the higher detected concentrations were located in samples taken further from the expressway; the researchers originally hypothesized that higher concentrations would correlate to proximity to the expressway (Mahler et al. 2005). The researchers did find that more types of PAH compounds were present in samples taken at or near the expressway (Mahler et al. 2005). All in all, the researchers suggested that atmospheric deposition was the greatest contributor to PAHs in the environment (Metre and Mahler 2003).

The Mahler et al. (2005) study was the first study that published sound and credible scientific information linking increased PAH concentrations to coal tar sealed lots. Due to the fact that these researchers performed their study in Austin, Texas, the issue of coal tar contamination was brought to light and put on the political agenda. It could also be assumed that Austin would “look bad” had it concluded that coal tar was leaching PAHs into the environment at alarming rates and not done something about it. The evidence was there that proved not only the toxicity of the compounds but linked coal tar and PAH detection limits, encouraging the City of Austin to ban the use of coal tar sealants.

In January 2004 during a press conference, the City of Austin announced its “pavement sealant hypothesis,” referring to the 2003 discovery made by Tom Bashara. Stakeholder meetings with sealant industries were held in January 2004 and July 2005 and a community meeting was held. After an informational sheet was mailed out to “local retailer[s], producer[s] and applicator industry [professionals],” the City requested that voluntary bans be implemented in April of 2004 (Scoggins 2015). After additional research was conducted by the Watershed Department and the USGS, the City unanimously voted to ban coal tar sealants on November 17, 2005.

Implementation

The City of Austin held stakeholder meetings to discuss the feasibility of a ban on coal tar sealants and what that might look like (Scoggins 2015). The City of Austin informed and kept in contact with the USGS, the EPA and the Department of the Interior. One could infer that their constant communication encouraged and facilitated public discussions and the increase in PAH analysis, especially those performed by the USGS. Last, the City of Austin included their constituents by means of "local public process" (Scoggins 2015).

The City of Austin Watershed Protection Division is the Agency responsible for oversight of the ban on coal tar sealants. Its website clearly details its role in enforcement of this policy, claiming that its field staff is responsible for keeping an eye out for potential violations "as they drive throughout the city to their other job duties" (City of Austin Texas n.d.-a). If an alleged violation is observed, the field staff conducts an analysis to determine whether it is coal tar sealant. The violator then has to comply with a remediation of all surfaces with applied coal tar sealant. If this request is not complied with, the violators are fined and the website even suggests jail time (City of Austin Texas n.d.-a)

The City of Austin Watershed Protection Division been instrumental in ensuring the proper implementation of this policy. It was the first stakeholder to hypothesize that coal tar sealants could be the reason for increase PAH concentrations. Also, The City of Austin government website is also a useful tool as it is abundant with thorough information on coal tar sealants. The website has a list of tabs with information for constituents from "alternative products" to "education and outreach efforts for the coal tar ban" (City of Austin Texas n.d.-b).

Evaluation

DeMott et al. 2010 collected 44 sediment samples in total: 17 in 2005 from watersheds within Ladybird Johnson Lake or Town Lake, and again in 2008, 20 sediment samples from previous sample locations (DeMott et al. 2010). This study performed an analysis on the samples collected; specifically, the study ran a principal component analysis on the data (DeMott et al. 2010). The analyses showed that there was no decrease in PAH concentrations after the ban had been in place two years. The study recognized that two years "may be an insufficient amount of time" given the results and variability of the data (DeMott et al. 2010). This statement was also confirmed by a USGS representative when a representative from the PCTA argued for the validity of this study during the Washington testimony (Morrison 2015).

From 2012-2014, the USGS conducted an analysis of PAH concentrations from Lady Bird Lake in Austin, Texas collecting core sediment samples from 1998, 2000, 2001, 2012 and 2014 (Van Metre and Mahler 2013, Van Metre and Mahler 2014). This location was chosen for analysis as it receives most of the run-off from the "greater Austin area" (Van Metre and Mahler 2013). Calculating the mean of detection limits for the EPA's sixteen priority pollutants, the USGS saw a 75 percent decrease in mean concentrations of PAHs as compared to samples dating before 2006 (Van Metre and Mahler 2013). PAH concentrations were by no means non-detectable (Van Metre and Mahler 2013). For example, the mean of four samples taken before 2006 was 8,090 ug/kg, whereas the mean of two samples from 2012 resulted in 2,030 ug/kg-1 (Van Metre and Mahler 2013). As a result, the USGS assumed that the majority of PAH detections continue to leach from pre-existing coal tar sealant application (Van Metre and Mahler 2013). At the American Geophysical Meeting Conference in Fall of 2013, The USGS claimed that "the results presented here are the first direct evidence that removing this source can lead to a substantial reduction in PAH concentrations in receiving water bodies" (Van Metre and Mahler 2013).

In a ten-year update to the public, the Watershed Protection Division stated that it had completed 1477 inspections, along with 606 screenings. In addition to its work in the field, it continued to update and improve educational resources to the public and other jurisdictions seeking information. The Division states that most "ongoing education and outreach" is through means of "mail-outs, advertisements and website [content]" in relation to the coal tar sealant ban. The Division also stated that "enforcement is complaint and staff driven" (Protection 2015).

Per the scientific study conducted by Van Metre and Mahler (2013), the evidence suggests that the ban is causing a decrease in PAH concentrations. As mentioned above, the study did recognize that it may take a long period of time before PAH levels are non-detectable as these compounds persist in the environment for long periods of time (Metre and Mahler 2013).

Given the expanse of scientific evidence that was first conducted in Texas and the continued monitoring of PAHs, a statewide ban seems to be the most obvious policy choice. However, Austin is the most liberal progressive city, no other city in Texas is. It is not politically surprising that a statewide ban has yet to be implemented.

POLICY DESIGN: THE STATE OF VERMONT

The goal of this thesis is a crafted policy design for the State of Vermont, informed by policy analyses performed on Washington, Minnesota and Austin, Texas.

History of PAHs in Vermont

In the 1800s the Gas Company of Vermont (GCV) provided coal gas to customers throughout the state until it was abandoned in 1954. The DEC opened an investigation into the site in 1983, after constituents observed small droplets of coal tar in waterways, and also complained of coal tar odor in the air. The DEC and the general public were concerned that the exposure of PAHs could have consequences on health (Moore and Revell 1989).

The abandoned site was in close proximity to homes and the Stevens Branch of the Winooski River (Moore and Revell 1989). Moore and Revell (1989) conducted a policy analysis and proposed bioremediation to clean the toxic areas, submitting a report to the State of Vermont. The study looked primarily at "saturated and unsaturated zones" of the site, as the effects of coal tar contaminants impacted both air quality and the Stevens Branch of the Winooski River (Moore and Revell 1989). Soil and water tests confirmed that "over the past fifty years, coal tar and soluble coal tar components have moved toward the Stevens Branch, the discharge zone for the shallow aquifer, seeping directly into the river" (Moore and Revell 1989, 494).

Scientific Monitoring in Vermont

In the 1990s the Green Mountain National Forest (GMNF), Vermont Monitoring Cooperative (VMC), and the Green Mountain National Forest (GMNF) were responsible for surveying bodies of water within the Lye Brook Wilderness Area. One study monitored aquatic species, sediment, and water quality between 1993 and 1995. Specifically, in 1994, scientists analyzed fish tissues for POPs including chlorinated pesticides, PAHs, and PCBs (Kellogg, Fiske, and Langdon 1996). Based on the sediment samples, the scientists determined that the PAH concentration levels did not pose a risk to human or environmental health (Kellogg, Fiske, and Langdon 1996). In the final report, the scientists recommended monitoring for persistent organic pollutants, which includes PAHs, every five years (Kellogg, Fiske, and Langdon 1996). It appears that under the Forest Ecosystem Monitoring Cooperative (FEMC), formally known as the VMC, the recommended monitoring was not performed five years later (Cooperative 1993).

The U.S. Department of Interior and the USGS, with funding from the U.S. Congress, initiated the National Water-Quality Assessment (NAWQA) Program to survey water quality throughout the U.S., particularly, drinking water sources. Samples were taken across the east coast of Vermont. Through sediment samples and samples taken from marine life, scientists found toxic contaminants including but not limited to lead, copper, dichlorodiphenyltrichloroethane (DDT) and PAHs (Garabedian 1998).

In 1997, the State of Vermont Agency of Transportation in conjunction with the U.S. Department of Transportation Federal Highway Administration conducted an Environmental Impact Statement (EIS) on a Vermont Brownfields site, the Pine Street Barge Canal. The EIS intended to evaluate the feasibility of building a highway that would run through the Superfund site. When conducting the EIS, soil samples contained trace levels of multiple PAH compounds. As a result, the EIS recommended that any materials during or after the construction period be deemed Superfund waste and addressed accordingly (The Johnson Company 2016).

A Corrective Action Feasibility Investigation for Site Remediation of the former Richmond Creamery in Richmond, Vermont, found trace levels of "asbestos, lead paint, mold, ammonia, possible polychlorinated biphenyl (PCB)-containing building materials, polycyclic aromatic hydrocarbons (PAHs), and metals," listing it as a hazardous area. The PAHs found within soil samples from the site were suggested to be from the "presence of a railroad along the property border" and a former "railroad tie" that existed in the area until the 1970s. The plan also suggested that the release of PAHs could be explained by the "idling [of] rail cars" (The Johnson

Company 2016, 5). It recommends that further PAH soil sampling should be conducted to gain a better understanding of their impact on the environment and residential communities.

In October 2014, leftover soil from the creation of the Burlington Waterfront bike path was moved to a parking lot at Leddy Park. Vermont Digger reported that the site had been monitored by the VTDEC since 1992, as sediment testing indicated high concentrations of PAHs. The article stated, “Burlington officials knew soil was likely contaminated prior to ‘stockpiling’ Leddy Park” (Olsen 2015).

Vermont House Bill 269, “An Act relating to the transportation and disposal of excavated development soils legally categorized as solid waste” passed both the House and the Senate and was signed into law on June 5, 2015. This bill allows for any excess soil as a result of excavation from construction at “downtown or village centers” that “contain low levels” of PAHs, arsenic, lead, and other heavy metals be transferred to a site with soils testing positive for the same contaminated particles of equal or greater concentration value instead of disposing them at “certified waste management facility[ties]” (Vermont HB 269 2015). The bill recognized that many of the downtown areas may test over the regulatory limits for these compounds, often times “as a result of deposition of exhaust products, from incomplete combustion of hydrocarbons, including oil, gasoline, coal, wood, and solid waste (Vermont HB 269 2015). This bill intended to promote the development of downtowns without creating large economic burdens, as it is often costly to dispose of these contaminated materials at a designated waste facility.

The jurisdiction in-charge of managing a project with contaminated soils is required to submit a work plan to the “Secretary” for approval pre-construction of the site (Vermont HB 269 2015). This work plan includes an analysis of the contaminants that are present within the materials and other specific criteria such as the effect these materials have on groundwater when and if moved to a new location. When suggesting the desired location for the contaminated materials, the work plan must include an analysis of the desired site as well; the contaminated materials being transferred to the site must have lower concentrations than the site they are being transferred to (Vermont HB 269 2015). “Development soils concentration level” means those levels of PAHs, arsenic, or lead, expressed in units of mass per volume, contained in the soils (Vermont HB 269 2015, 40).

In 2015, the VTDEC, Waste Management and Prevention Division, conducted a statewide background study on arsenic, lead and PAHs (Vermont Agency of Natural Resources 2017). This study was performed to evaluate and establish regulatory detection limits for arsenic, lead, and PAHs through collection of soil samples taken over a one-hundred square mile radius in the state.

Specifically, for PAHs, the DEC evaluated concentrations using the WHO’s Total Equivalency Quotient (TEQ), making calculations based on benzo[a]pyrene and categorized the data into two categories: commercial/industrial TEQ PAHs and residential TEQ PAHs based on sampling location (Vermont Agency of Natural Resources 2017). The highest PAH concentration detected within commercial/industrial boundaries, not considered an outlier, was 425.7 parts per billion (ppb), the median was 93.83 ppb (Vermont Department of Environmental Conservation 2017). The highest detected TEQ PAH concentration for commercial/industrial locations was 4759.35, in Main Street Park in Rutland, Vermont. The DEC set commercial/industrial soil TEQ PAHs “threshold values” at 580 ppb or 0.580 mg/kg (Vermont Agency of Natural Resources 2017). For residential TEQ PAHs, the highest concentration detected not considered an outlier was 26.18 ppb, the median was 8.81 ppb. As a result, the DEC established a threshold value for residential soil TEQ PAHs of 26 ppb or 0.026 mg/kg. (Refer to Appendix D Figure 9 and Figure 11 for a list of values over the threshold limit set by the DEC and two maps, Figure 10 and Figure 12 a Commercial/Industrial map and Residential map that plots samples that surpassed their threshold values, 580 µg/kg and 26 µg/kg, respectively.) With further analysis, these maps could be used to gain a better understanding as to why higher concentrations persist in those specific locations (i.e., one sample could have been taken in close proximity to an oil deposit for example).[8]

Effective July 2017, the DEC published an Investigation and Remediation of Contaminated Properties Rule. This Rule would be used as a tool to determine requirements for corrective action plans and investigative measures in response to hazardous spills (State of Vermont 2017). PAHs are directly addressed in the report in conjunction with arsenic and lead. The Rule outlines the following: "(3) The receiving site shall have concentrations of arsenic, lead, and PAHs that are equal to or greater than the concentrations from the site undergoing redevelopment. (4) Receiving sites that have concentrations of arsenic, lead and PAH's in excess of industrial risk-based standards will be required to conduct a site investigation in accordance with Subchapter 3" (State of Vermont 2017, 38).

The Chittenden County Regional Planning Commission Board of Directors submitted a memorandum in response to the Draft Investigation and Remediation of Contaminated Properties

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[8] Some could argue that the removal of outliers discredits statistical data analysis; however, the class of PAH compounds is so great, and the history of Vermont's land use quite different from today, that it is often difficult to determine the cause of these outlying concentrations, many variables could have an impact. When choosing sample locations, it is important to keep in mind the previous and current use of the land; however, it would take an immense amount of time and energy to conduct the in-depth historical analysis necessary to ensure that all sample locations would not result in statistical outliers. For example, the sample taken at the Main Street Park in Rutland, Vermont, sample ID K2, there was a devastating fire that destroyed most of the town in 1902, this sample location would have been within the boundaries of the fire. Although this is just a hypothesis that has not been confirmed by running more concise statistical models, it could be inferred that this is the reason for a TEQ PAH concentration level of 4759.35 (ug/kg) as PAHs do not breakdown and persist for great amounts of time.

Rule. The Commission Board of Directors did not agree with the TEQ PAH regulatory levels set by the DEC stating "…the rules would regulate PAHs for residential projects at amounts 1/200th the regulatory limit of Massachusetts, but do not claim that Massachusetts regulations are creating public health or environmental concerns that justify such an approach" (Directors 2017, 2). The memorandum attached a table detailing soil cleanup standards by state, as observed in Figure 9. The proposed residential and commercial/industrial contamination levels for Vermont are not indicative of the levels that are currently in place for the State as a result of the 2017 statewide background study (Vermont Agency of Natural Resources 2017). The current levels are less stringent than the ones indicated below in Table 13.

Table 13. Residential and Commercial/Industrial Soil Regulations by State

Residential Use Soil Cleanup Standards (ppm)

Contaminant	CT	ME	MA	NH	NJ	NY	RI	VT
Lead	500	375	300	400	400	400	150	400
Arsenic	10	5.375	20	11	19	16	7	0.68
PAHs (expressed as Benzo-a-pyrene)	1	1.1	2	0.7	0.2	1	0.4	0.01

Commercial/Industrial Use Soil Cleanup Standards (ppm)

Contaminant	CT	ME	MA	NH	NJ	NY	RI	VT
Lead	1000	SS	300	400	800	1000	500	800
Arsenic	10	SS	20	11	19	16	7	3
PAHs (expressed as Benzo-a-pyrene)	1	SS	4	5	0.2	1	0.8	0.29

Source: "Memorandum: Draft Investigation and Remediation of Contaminated Properties Rule (I-Rule)," Chittenden County Regional Planning Commission Board of Directors, April 19, 2017, accessed May 1, 2018, https://www.ccrpcvt.org/wp-content/uploads/2016/01/Comments-on-Soils-Rule.pdf.

The first acknowledgement of the potential effects of coal tar sealants in Vermont was from the DEC in a report published in 2017. The report stated, "little is known about PAH contamination from coal tar sealant in water bodies in Vermont" (Vermont Agency of Natural Resources 2017, 14). The report does not mention any regulatory actions taken by other states, as it does for a flame retardant poly-brominated diphenyl-ethers (PBDEs), nor does it suggest regulatory measures to combat the issue in Vermont.

Recommendation: Statewide Ban

Problem

There are no jurisdictions in the State of Vermont that regulate the sale and use of coal tar sealants to manage the potential impacts of PAHs. Regulatory bodies need to implement sensible policy to address this issue, thus promoting the health and wellbeing of constituents and natural resources.

The quantity of coal tar sealant applied in Vermont is unknown. But it can be assumed that the majority of citizens have been exposed to coal tar sealants to some degree, whether it be from their driveways, parking lots, or playgrounds. Vermont lacks specific measures of the frequency and amount of coal tar sealant used; this lack of knowledge presents an issue because it is unclear whether coal tar is or is not a widespread issue throughout the State.

Goals

The goal of this policy should be twofold. First, it should be to promote Vermont's overall public health and protect its natural resources, both of which are vulnerable to increased PAH bioaccumulation from coal tar sealants. Second, should be to decrease our knowledge deficiency of the amount and location of coal tar sealant application and potential resultant PAH bioaccumulation.

Solution

Analyses of the effectiveness of no or low costs of policies in Washington, Minnesota and Austin, Texas, supports the adoption of Vermont legislation that phase in the prohibition of the sale and use of coal tar sealants. A phased-in ban is suggested because there is so far, no evidence to indicate that PAH concentrations in Vermont are linked to coal tar sealants, although previously introduced literature shows causal links in Washington, Minnesota, and Austin, Texas. Second, an incremental ban is suggested with manufacturers, retailers, and users in mind to alleviate potential economic impacts. Third, phasing out the sale and use of coal tar sealants overtime would eliminate costs that may be associated with this transition. For example, it is not evident whether the DEC, the main regulatory authority of this policy, would be overwhelmed by the increase in responsibility; funding may be required to address this concern. This policy would reduce PAH pollution from coal tar sealants that persist and bioaccumulate in humans, animal species, water, sediment, dust, and indoor, and outdoor air statewide.

Alternatives

There are two alternative policy solutions. First, the State of Vermont could continue to permit the application and sale of coal tar sealants. This policy is undesirable given the known adverse impacts of PAHs on human health and the environment. The DEC identified accumulation of PAHs in Vermont and although not all concentrations can be directly linked to the application of coal tar sealants, evidence suggests PAHs are present, putting the State at risk for costs associated with environmental clean-up.

The second alternative, contingent upon statutory authority, is municipal bans on the sale and use of coal tar sealants. The expectation being that a citywide policy would encourage additional regulations at other institutional levels with an end goal of a statewide ban. For example, Burlington is the largest city in Vermont and increased congestion of motorized vehicles encourages the development of roadways that could contain coal tar sealant. These roadways are also channels for run-off containing PAHs and other widespread contaminants into the Lake Champlain watershed. This citywide ban is an alternative policy, because it does not address the problem holistically, since its benefits would be localized. An ideal policy would include a broad enough scope to protect the entire state of Vermont. (Refer to Appendix C to view a sample ordinance on the use and sale of coal tar sealant courtesy of the League of Minnesota Cities.)

Policy Description

Regulatory Oversight and Enforcement

The primary regulatory body responsible for monitoring a statewide ban on coal tar sealants is the Vermont Agency of Natural Resources, Department of Environmental Conservation, Wastewater Treatment Division (WTD). It is the WTD's responsibility to monitor environmental toxins and set appropriate regulatory limits with input from the Vermont Department of Health (DOH) and the Vermont Agency of Transportation. The WTD is currently responsible for managing contaminated sites and hazardous facilities throughout the State, with the obligation to inform constituents and stakeholders involved.

With a legislative ban, the WTD, with input from the DOH should publish information on their websites detailing the extent of the ban, why it is important, and its potential implications for persons who currently purchase coal tar sealants and companies who offer this product. These two Agencies should be transparent about the strict monetary sanction that would be imposed if a violation is reported and identified. A primary contact person within the DEC should be established and announced on the website to communicate to Vermonters that inquiries and report violations should be sent their way.

A combination of enforcement mechanisms from the State of Minnesota and the City of Austin, Texas is recommended. This policy would impose a mix of a monetary fines and Corrective Action Plan (CAP) published and distributed by the DEC. When a violator is identified, the DEC would be responsible for issuing a CAP report that detailed the appropriate measures to remediate the violation within 45 days. If the violator does not comply with the CAP report, a fine of $500 for the first offense would be imposed and $2,000 per incident for any subsequent offenses. A fine should not exceed $2,000. These monetary sanctions were chosen specifically because Austin was the only analyzed case study in which eleven violations have been made to date.

Because in Vermont there is to date no evidence of a direct correlation between the application of coal tar sealants and the accumulation of PAHs in the environment, an incremental statewide ban on coal tar sealants would allow for a structured program evaluation to determine the impact and effectiveness of the policy; specifically, if there is a decrease or stabilization of PAHs in the environment.

Stakeholders

There are several publications available online from Vermont organizations that discuss the use of coal tar sealants and their implications for Vermont. Lake Champlain International, an advocacy group, has dedicated two sections of its webpage to discuss the uses for coal tar (they identify: driveways, tar roofing and parking lots) and their toxic properties (Lake Champlain International n.d.-a). It has an additional page that specifically addresses driveway sealant and suggests anyone interested in sealing their driveway should consider choosing a product containing no coal tar (Lake Champlain International n.d.-b).

The City of Burlington, Vermont also recognizes the potential threat of coal tar sealant in the State. Burlington Public Works has provided its constituents with a guide to "Stormwater Friendly Driveways" that recognizes the impact of coal tar sealants and list the following as alternatives:

- "ENVIROSEAL LAS-320™ asphalt sealer is not petroleum based, and is EPA approved
- AFM DynoSeal Driveway/ Asphalt Sealer
- INTEGRA-SEAL by UNIQUE Paving Materials, asphalt- based, zero VOCs, no PAHs
- Eco-Seal Brand Sealer

- Latex-ite®
- Blacktop Driveway Sealers Black Jack® Asphalt Sealers”

(Burlington Vermont Public Works n.d., 11).

The Vermont Toxics Action Center, a nonprofit advocacy group, has expressed interest in gaining insight into coal tar sealants and ways that other communities have combatted this issue. Other stakeholders who have not expressed explicit concern but may be interested in becoming involved in a coal tar sealant regulation include: the Vermont Public Interest Research Group, the Vermont Natural Resources Council, and Vermont Conservation Voters. These groups are vocal advocates for environmental legislation that protects the State of Vermont.

Several Vermont sealant companies were identified as potential opponents. It is assumed that a ban on coal tar sealant would have a direct impact on businesses; however, the extent of this economic impact is unknown. What is known from a comprehensive online search is that most Vermont businesses that offer sealcoating services are more likely to advertise that they use asphalt sealant as opposed to coal tar sealant.

The Pavement Coatings Technology Council (PCTC) is an additional potential opponent to a statewide ban on coal tar sealants. The PCTC has been vocal about its stance on coal tar sealants and has hired a third-party consultant whose findings sought to discredit the USGS’ conclusion that coal tar sealants are a major source of PAH concentration in urban waterways (Pietari, O'Reilly, and Boehm 2011). Additionally, representatives have been vocal during testimony, as described in the Washington case study earlier.

Costs and Benefits

Few costs are associated with implementation of a statewide ban. The Legislature would not be expected to budget for this proposed regulation. The WTD has the skilled staff and technical experience necessary for dealing with these regulatory measures. The phased-in legislative period of a statewide ban would likely be indicative of the workload increase that could be induced on the WTD. This period would give coal tar users an opportunity to vocalize their concerns, providing the DEC and Legislature with a better understanding of how widespread this issue may be in Vermont. Pending this testimonial period, the DEC would gain a better understanding on whether it would need to acquire additional help to oversee this new regulation or if its current staff would suffice. The DEC has internal databases that keep track of hazardous waste sites; the technology exists that would allow the DEC to manage track coal tar sealant application and violations if applicable.

Over 620,000 Vermont citizens would be protected by this proposed ban, along with the State's natural resources. Minnesota performed an analysis that indicated that costs for proper disposal of PAH contaminated soil was estimated at $40-$50 per cubic yard, about $125,000 per pond which had the potential to total close to $1 billion for their State (Innes 2017). These numbers are projected costs associated with stormwater runoff. There is no indication of the dollar amount that could correspond to the impacts on human health as a result of coal tar sealants. By regulating coal tar sealants Statewide, Vermont would eliminate future costs associated with PAH pollutants; the benefits therefore outweigh potential costs.

Feasibility

Implementing a phased-in statewide ban on the use and sale of coal tar sealants would require legislative action and support. There is a general lack of awareness surrounding the issue of coal tar pollution in Vermont, which in turn translates to a lack of public concern. An educational and political agenda setting period would be necessary to bring attention to and create momentum for a policy addressing the risks associated with the use of coal tar sealant. A ban would be dependent on the political climate and the actors involved throughout the policy process, including the political ideologies of the sitting Legislators and important stakeholders.

An online search of sealant companies in Vermont shows that most companies advertise that they offer asphalt-based sealants, while few companies transparently advertise that they offer coal tar sealants to customers. There seems to be a narrow market for coal tar sealant as compared to asphalt-based sealant. But taking away business is always of concern with implementing new policy because there is the potential for direct economic impact. Yet, in a law school thesis by Hannah Needlman (2016), which lays out an economic impact assessment of banning coal tar sealants, the following conclusions were drawn in favor of banning coal tar from an economic standpoint:

1. "The use of coal tar-based sealants hurts industries that rely on healthy populations of fish, crabs, and oyster.
2. The continued use of coal tar-based sealants will increase the already high cost of cleanup.
3. The cleanup and removal of coal tar-based sealants could create jobs in the region.
4. Major retailers have already stopped selling the product, so consumers are already encouraged to purchase alternatives" (Needlman 2016).

Policy Limitations

There are few limitations associated with the ability of this policy to address its stated goal, beyond just the feasibility assessment. A statewide ban on coal tar sealants would essentially eliminate any further introduction of coal tar sealant into the environment, thus halting the accumulations of PAHs from coal tar sealants in Vermont. One possible limitation could be that the regulatory bodies responsible for enforcing this policy, the DEC and the

Vermont Agency of Transportation, have not identified all applications of coal tar sealant in Vermont through forensic analyses.

A second limitation is there is essentially no true way of knowing that a ban would completely eliminate further application of coal tar sealants, as it is difficult to monitor the entire State of Vermont. The DEC would be responsible for enforcing this policy and providing contact information for constituents to report illegal applications or sales. However, it is naïve to think that they would be able to identify all violations in the largely rural state.

DISCUSSION

Vermont's Current Political Climate

Over the last two years, water quality and environmental legislation has been prominent on Vermont's political agenda. One case in particular, is the widespread Perfluorooctanoic acid (PFOA) contamination that was discovered in Bennington, Vermont in 2016. As a result of this toxic contamination of many of the residents' drinking water wells, S.103 "An act relating to the regulation of toxic substances and hazardous materials" was introduced and passed both the House and Senate on March 30, 2018, but Governor Scott vetoed the bill on April 20, 2018 (Vermont S.103 2016). A ban on the sale and use of coal tar sealants in Vermont is not necessarily high legislative priority; however, given the PFOA case in Bennington there is a lesson to be learned that exercising caution and employing a precautionary principle by banning a known toxin could ultimately save the State from future costly government interventions. A statewide ban on the sale and use of coal tar sealants would address the widespread public health and environmental concerns associated with PAHs.

The two alternative policy recommendations: continue with the status quo and keep coal tar sealants unregulated and municipal bans on the sale and use of coal tar sealants are inferior policies as they are not effective in protecting the entire State of Vermont.

Further Questions

There were two main questions that were identified towards the end of this process that would have been useful in developing this policy design had I had the time and the resources:

1. How much coal tar sealant exists in Vermont?
    a. Where is it used?
    b. How much is used per year?
2. How many Vermont sealant companies offer coal tar sealants to customers?

Addressing These Questions

1. How much coal tar sealant exists in Vermont?

An attempt was made to quantify the amount of coal tar sealant that has been applied in the State of Vermont. Unfortunately, The Vermont Agency of Transportation and the DEC does not quantify it.

2. How Many Vermont sealant companies offer coal tar sealants to customers?

I was able to identify seven sealant companies that offered their services in Vermont through an internet search. I assume that I did not produce a complete list. For the ones that I could find, I tried to determine whether the company offered coal tar sealant based on its online advertising, whether that be a personal website or Facebook page. Most of the companies advertised the use of asphalt-based sealers online, and were less transparent about the use of coal tar sealants. This leads me to the following conclusions: either the companies do not offer coal tar sealant or the companies do not want to transparently advertise that they offer coal tar sealants. Answers to these questions would be helpful in aiding stakeholders and policymakers who may be interested in advocating for a coal tar sealant regulation in Vermont.

RECOMMENDATIONS AND CONCLUSIONS

Recommendations

I recommend that a forensic analysis be performed on the data presented in the DEC report, *An Evaluation of PAHs, Arsenic, Lead: Background Soil Concentrations in Vermont (2017).* A forensic analysis would allow the State to look at the types of PAH compounds found at a particular site and make an informed hypothesis as to whether they match the makeup of coal tar sealants. This type of analysis, although intensive, would give the State a solid indication of the quantity of coal tar sealant, its general location and its impact.

GIS maps detail the TEQ PAH Commercial/Industrial and Residential outliers that were omitted from statistical analysis of this study. (Refer to Appendix D, Figure 10 and Figure 12 to view these maps.) Further research could use these maps to conduct a study that analyzed geographic distribution of these outliers and potential correlations that indicated a reasoning for the detected outliers. This in-depth analysis could have an impact on informing public health and environmental actors.

Lastly, it would have been useful to interview sealcoat companies that offered their services in Vermont in order to gain a better understanding of the products they offer and the popularity of each one. This information would better inform an economic impact analysis on a ban on the sale and use of coal tar sealants in the State of Vermont.

Conclusions

The USGS's study published in 2005 confirmed the City of Austin Watershed Tom Bashara's hypothesis that abnormally high concentration levels of PAHs were a causation of stormwater runoff from coal tar sealed lots. The State of Washington, Minnesota and City of Austin, Texas were all successful in implementing policies that prohibit the use of coal tar sealants and bans and/or restrict the sale of coal tar sealants. The USGS confirmed the success of

Austin Texas' ban in decreasing the concentration levels of PAHs in lake sediment (Metre and Mahler 2013). Given availability of a comparably similar alternative, asphalt-based sealant, and projections that despite an increase in coal tar sealant regulations the sealant market share will continue to increase- a coal tar sealant ban seems to be an obviously desirable solution. Employing a precautionary principle of regulating toxins can minimize future economic payouts that could be astronomical. In order to address the public health and environmental concerns associated with coal tar sealant pollution, a statewide ban on the sale and use of coal tar sealants would be the most effective policy choice for the State of Vermont. The feasibility of this ban is dependent on current political climate.

This thesis' policy recommendations will be presented to identified stakeholders that have voiced an interest in wanting to learn more about the implications of coal tar sealant and what a regulation could look like for the State of Vermont. With a completion date for the thesis in May 2018, these stakeholders would have roughly eight months before the Vermont Legislature convenes January 2019. If a stakeholder wanted to get a coal tar sealant regulation on the political agenda, eight months would be an adequate amount of time to formulate their positions and gather the necessary tools to successfully present a coal tar sealant policy and to get this issue onto the political agenda.

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APPENDICES

Appendix A

Table 3: EPA list of 16 priority pollutants, the 7 Probable Human Carcinogens Denoted *:

Anthracene	Pyrene*	Naphthalene	Benzo[ghi]perylene
Benzo[a]anthracene*	Chrysene*	Benzo[e]pyrene	Dibenzo[ah]anthracene*
Benzo[b]fluoranthe*	Fluoranthene	Acenaphthylene	Indeno[cd]pyrene*
Benzo[a]pyrene	Phenanthrene	Perylene	Coronene

Source: Choi et al., *WHO Guidelines for Indoor Air Quality*, 2010*;* Rubailo and Oberenko, *Polycyclic Aromatic Hydrocarbons as Priority Pollutants*, 2010.

Table 4: ATSDR Seventeen Priority Pollutants

Acenaphthene	Benzo[a]pyrene	Benzo[j]fluoranthene	Fluoranthene	Pyrene
Acenaphthylene	Benzo[e]pyrene	Benzo[k]fluoranthene	Fluorine	
Anthracene	Benzo[b]fluoranthene	Chrysene	Indeno[1,2,3-c,d]pyrene	
Benz[a]anthracen	Benzo[g,h,i]perylene	Dibenz[a,h]anthracene	Phenanthrene	

Source: "ATSDR's Substance Priority List," Agency of Toxic Substances and Disease Registry, 2017, accessed April 24, 2018, https://www.atsdr.cdc.gov/spl/.

Appendix B

These figures house coal tar sealant regulations and proposed legislation within jurisdictions across the U.S. through April 1, 2018. This list was modified from the MPCA publication: "Actions to Restrict or Discontinue the Use of Coal Tar Based Sealants in the United States" published July 12, 2016, and updated from the blog "Coal Tar Free America" and a comprehensive Google search.

Table 5. U.S. State or District Restrictions

State/District	**Jurisdiction**
Connecticut	Statewide
District of Columbia	Washington (District)
Illinois	Glenview Park District (Park District)
	Highland Park (City)
	Wilmette (Village)
	Winnekta (Village)
Kansas	Winfield (City)
Maryland	Annapolis/Anne Arundel County (County)
	Montgomery County (County)
	Prince George's County (County)
Massachusetts	Andover Wetlands (Wetland)
	Commonwealth Wetlands (Wetland)
	Sudbury (Town)
	Westwood (Town)
Michigan	Ann Arbor (City)
	Dexter (Township)
	Hamburg (Township)
	Scio (Township)
	Spring Lake Township (Township)
	Van Buren Township (Township)
	Ypsilanti (City)
Minnesota	Statewide
New York	Suffolk County (County)
North Carolina	Boone (Towne)
South Carolina	Greenville (City)
Texas	Austin (City)
Washington	Statewide
Wisconsin	Dane County (County)

Source: "Actions to restrict or discontinue the use of Coal Tar Based Sealants in the United States," Minnesota Pollution Control Agency, last updated July 12, 2016, accessed March 28, 2018, https://www.pca.state.mn.us/sites/default/files/tdr-g1-12.pdf.

Table 6. Government Restrictions

State/District	**Jurisdiction**
California	California Department of Transportation
Illinois	Village of Lake in the Hill
	Village of Spring Grove

	Barrington Area Council of Governments[9]
	DuPage County/Salt Creek Workgroup
	McHenry County
Michigan	Byron Township
	Charlevoix
	Clark Township
	Erie Township
	Fruitland Township
	Laketon Township
	Scio Township
	Village of Shepherd
	Powell Township
	Whitehall
	Whitehall Township
	White River Township
Missouri	City of Springfield
New York	State-owned non-road paved surfaces

Source: "Actions to restrict or discontinue the use of Coal Tar Based Sealants in the United States," Minnesota Pollution Control Agency, last updated July 12, 2016, accessed March 28, 2018, https://www.pca.state.mn.us/sites/default/files/tdr-g1-12.pdf.

Table 7. Institutional Ban Restrictions

School/University	**Jurisdiction**
Kalamazoo	Kalamazoo Michigan
Lake Forest College	Lake Forest Illinois[10]
Lake Superior State University	Sault Sainte Marie, Michigan
San Diego Unified School District	San Diego, California
University of Illinois	Springfield, Illinois
University of Michigan	Anne Arbor, Michigan

Source: This chart was taken from "Actions to restrict or discontinue the use of Coal Tar Based Sealants in the United States," Minnesota Pollution Control Agency, last updated July 12, 2016, accessed March 28, 2018, https://www.pca.state.mn.us/sites/default/files/tdr-g1-12.pdf.

Table 8. Proposed Coal Tar Sealant Legislation

State	**Jurisdiction**
Illinois	Libertyville (Village)
	Statewide
	Village of Deerfield
Indiana	Statewide
Michigan	Statewide

[9] Ban on all sealcoats that contain a weight of 0.1% PAH or 1,000 parts per million.
[10] Fifty percent use in reduction.

Appendix C

[Title]**, LMC Model Ordinance**

League models are thoughtfully developed by our staff for a city's consideration. Models should be customized as appropriate for an individual city's circumstances in consultation with the city's attorney. Helpful background information on this model may be found in the [Environmental Regulations](#) chapter of the Handbook for Minnesota Cities.

ORDINANCE NO. _____

AN ORDINANCE TO ENFORCE THE STATUTORY PROHIBITION ON THE USE AND SALE OF COAL TAR SEALANT PRODUCTS WITHIN THE CITY OF_____, MINNESOTA

The City Council of _____, Minnesota ordains:

SECTION 1. PURPOSE.

The City of _____understands that lakes, rivers, streams and other bodies of water are natural assets which enhance the environmental, recreational, cultural, and economic resources and contribute to the general health and welfare of the community.

The use of sealers on asphalt driveways is a common practice. However, scientific studies on the use of driveway sealers have demonstrated a relationship between stormwater runoff and certain health and environmental concerns.

The 2013 Minnesota Legislature enacted a statewide prohibition on the use and sale of coal tar sealant products. This new statewide prohibition has been codified under Minn. Stat. § 116.202 and is effective on Jan. 1, 2014.

The purpose of this ordinance is to prohibit violations of Minn. Stat. § 116.202 in the City of _____, Minnesota, in order to protect, restore, and preserve the quality of its waters.

SECTION 2. DEFINITIONS.

Except as may otherwise be provided or clearly implied by context, all terms shall be given their commonly accepted definitions. For the purpose of this ordinance, the following definitions shall apply unless the context clearly indicates or requires a different meaning:

ASPHALT-BASED SEALER. A petroleum-based sealer material that is commonly used on driveways, parking lots, and other surfaces and does contain polycyclic aromatic hydrocarbons (PAHs).

COAL TAR. A byproduct of the process used to refine coal.

COAL TAR SEALANT PRODUCT. A surface-applied sealing product containing coal tar, coal tar pitch, coal tar pitch volatiles, or any variation assigned the Chemical Abstracts Service (CAS) numbers 65996-93-2, 65996-89-6, or 8007-45-2.

CITY. The City of _____.
MPCA. The Minnesota Pollution Control Agency.

PAHs. Polycyclic aromatic hydrocarbons. A group of organic chemicals formed during the incomplete burning of coal, oil, gas, or other organic substances. Present in coal tar and believed harmful to humans, fish, and other aquatic life.

SECTION 3. PROHIBITIONS.
In accordance with Minn. Stat. § 116.202

A. No person shall apply a coal tar sealant product on asphalt paved surfaces within the City of _____.

B. No person shall sell a coal tar sealant product that is formulated or marketed for application on asphalt-paved surfaces within the City of _____.

C. No person shall allow a coal tar sealant product to be applied upon property that is under that person's ownership or control.

D. No person shall contract with any commercial sealer product applicator, residential or commercial developer, or any other person for the application of any coal tar sealant product to any driveway, parking lot, or other surface within the City.

E. No commercial sealer product applicator, residential or commercial developer, or other similar individual or organization shall direct any employee, independent contractor, volunteer, or other person to apply any coal tar sealant product to any driveway, parking lot, or other surface within the City.

SECTION 4. EXEMPTION.
Upon the express written approval from the MPCA and in accordance with Minn. Stat. § 116.202, a person who conducts research on the environmental effects of coal tar sealant product or where the use of coal tar sealant product is necessary in the development of an alternative technology shall be exempt from the prohibitions provided in Section 3. Any person that is granted approval by the MPCA must provide a copy of the written approval from the MPCA to the City of _____, Minnesota twenty (20) days before conducting the research.

SECTION 5. ASPHALT-BASED SEALCOAT PRODUCTS.
The provisions of this ordinance shall only apply to coal tar sealant products in the City and shall not affect the use of asphalt-based sealer products within the City.

SECTION 6. PENALTY.
Any person convicted of violating any provision of this ordinance is guilty of a misdemeanor and shall be punished by a fine not to exceed one thousand dollars ($1,000.00) or imprisonment for not more than ninety (90) days, or both, plus the costs of prosecution in either case.

SECTION 7. SEVERABILITY

If any provision of this ordinance is found to be invalid for any reason by a court of competent jurisdiction, the validity of the remaining provisions shall not be affected.

SECTION 8. EFFECTIVE DATE

This ordinance becomes effective on the date of its publication, or upon the publication of a summary of the ordinance as provided by Minn. Stat. § 412.191, subd. 4, as it may be amended from time to time, which meets the requirements of Minn. Stat. § 331A.01, subd. 10, as it may be amended from time to time.

Passed by the City Council of _______, Minnesota this _____ day of Month, Year.

____

Mayor

Attested:

____

City Clerk

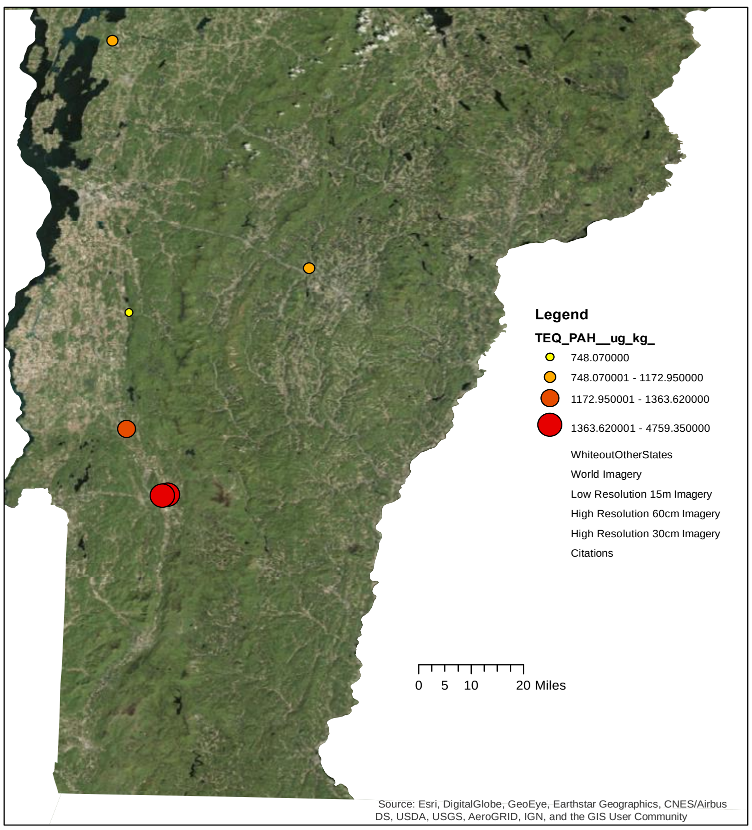
Source:

Appendix D

Table 9. Commercial/Industrial Samples ≥ 580 µg/kg

Sample ID Number	Longitude/Latitude	Property Name	TEQ PAH (ug/kg)
A1	44.91885, -73.125502	Swanton Village Green	1172.95
F4	44.26173, -72.5813	Montpelier-State Capital	1149.6
G2	44.13381, -73.079457	Bristol Town Green	748.07
J2	43.798028, -73.087183	Brandon Green	1363.62
K2	43.608056, -72.973056	Main Street Park-Rutland	4759.35
K2b	43.604722, -72.988056	Meadow Street Park	3846.6

Figure 10. Commercial/Industrial TEQ PAH Outlier Concentrations

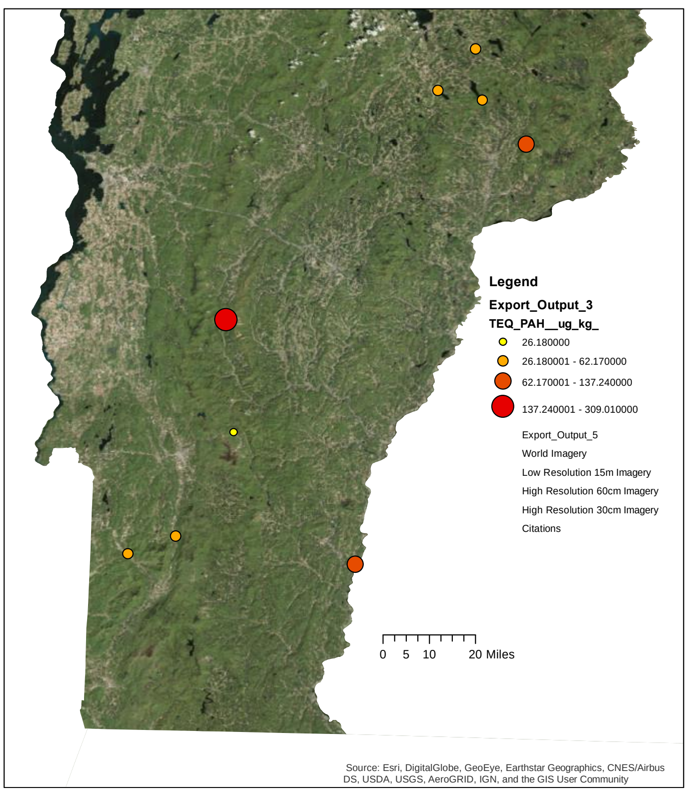


Source: James Finney of the UVM Spatial Analysis Lab, University of Vermont, April 23, 2018.

Table 11. Residential Samples ≥ 26 μg/kg

Sample ID Number	**Longitude/Latitude**	**Property Name**	**TEQ PAH (ug/kg)**
B7	44.8774, -72.05226	Pensioner Pond	55.15
C6	44.74703, -72.16972	Crystal Lake State Park	43.98
C7	44.71641, -72.03065	Willoughby State Forest	53.3
D8	44.578758, -71.892672	Darling State Forest	94.62
H3	44.0281, -72.8336	Granville Reservation State Forest	309.01
K3	43.674397, -72.810191	Gifford Woods State Park	26.18
M1	43.293056, -73.140556	Mettawee River Boat Launch	60.24
M2	43.348889, -72.991111	Green Mt National Forest	62.17
N5	43.26116, -72.42876	Hoyts Landing	137.24

Figure 12. Residential TEQ PAH Outlier Concentrations



Source: James Finney of the UVM Spatial Analysis Lab, University of Vermont, April 23, 2018.