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ENVIRONMENTAL ISSUES ASSOCIATED WITH CREMATORIA: A REVIEW

By

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A DISSERTATION

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Abstract

This study aims to educate both funeral industry practitioners and the general public about toxic emissions from crematoria as well as introduce sustainable practices to offset toxic emissions. Using publicly available data from four crematoria around the world, this study examines various factors associated with emissions including mercury, polychlorinated dibenzofurans, and Sulphur dioxide. The data was then converted to correlate the emissions results from the crematoriums to that of hazardous waste incineration. Due to the United States limited to non-existent regulations towards the industrial process of cremation, it was necessary to infer the data into a more relatable output. Although the modern cremation has been in practice for over a century, it can be said that measures to improve and mitigate impacts to the environment have moved quite slow. The conclusion of this research points towards continued studies; to engage leaders to consider the ramifications of the trends, especially when documented dangers of the by-product exist.

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Chapter One: Overview of the Dissertation in Practice Problem

Sustainability processes attempt to bridge social science with civic engineering and environmental science with future innovations. The word “sustainability” sways people to think of renewable fuel sources, to reduce carbon emissions to green business practices, to protect environments and a way of balancing the planet's ecosystem. In short, sustainability looks to protect our natural environment, human and ecological health, while driving innovation and not compromising our way of life (Edwards, 2009).

This study analyzes environmental issues associated with crematoria. Common health concerns surrounding the process of cremation exist. Opposition organizations such as “No Crematory” challenge the funeral industry and government alike to seek solutions towards the elimination of toxic emissions caused by cremation by the removal of crematoria whereas the Cremation Association of North America (CANA) differ as demonstrated in their collaboration with the EPA in 1998 (EPA, 1998). This research will examine a broad range of data to provide insights on both perspectives.

The Environmental Protection Agency that, in 2005, cremations produced about 3,000 kilograms of mercury (Green, n.d.), which was subsequently released (EPA) estimated into the air, the third largest source of mercury from any products in the country. Based on the National Funeral Directors Associations (NFDA) cremation and burial report in 2016, the United States cremation rate in 2005 was 32.3%. The current rate per CANA’s 2018 Annual Statistics Report, is 51.6%. Using this projection, in 2017 cremations will produce an estimated 4,792 kilograms of mercury. Therefore, we must ask, as the cremation rate increases, do toxic emissions too?

In a 2002 article examining the levels of 32 metals in the topsoil of Oslo, Norway, taking 300 samples at 1 km intervals (Tijhuis, et. al.), the researchers found mercury levels ranging up to 2.30 mg/kg, with a mean of 0.13 mg/kg and a median of 0.06 mg/kg. The highest median values were found in central Oslo, with levels eight times those of the average of the entire city. Using factor analysis, the authors conclude that mercury is in a group of metals that are "…not very usual in geologic materials and probably have an anthropogenic origin," of which industry, garbage incineration, and crematoria are listed as possible sources (Tijhuis, et al., 2002). Consequently, this study will use this case in point as well as others to determine what affects the amounts of emissions.

Although crematories for deceased human beings are also combustors, from a legal/regulatory perspective, these facilities are not considered as incinerators. For instance, in the United States (US), the EPA does not plan to regulate human crematoria. In the preamble to the final Other Solid Waste Incinerator (OSWI) rule (70 FR 74870), EPA concluded that the human body is not solid waste. Since the law requires EPA to establish regulations for solid waste incineration units, EPA found that human crematories were not solid waste incinerators, and, therefore, it was not appropriate to regulate them under Clean Air Action Section 129 (Kucinich, 2010).

A human crematory contains one or more combustion units known as cremators, used solely for the cremation of human bodies within appropriate containers. According to the Federal Trade Commission's Funeral Rule, an "alternative container" is an unfinished wood box or other non-metal receptacle or enclosure, without ornamentation or a fixed interior lining, which is designed for the encasement of human remains and which is made of fiberboard, pressed-wood, composition materials (with or without an outside covering), or like materials (n.d.). On the potential, polychlorinated dibenzo-p-dioxins and dibenzofurans (pcdd/f's), among other persistent organic pollutants, are byproducts of the cremation process. The body also contains a percentage of chlorine, and thus cremation produces pcdd/fs. Moreover, when waste wood is burnt, the level of pcdd/fs in the flue gas emissions has been reported to be significantly lower than that derived from other sources (Lavric et al., 2004). Even non-treated wood contains small amounts of chlorine. It means that pcdd/f emissions might be only minimized, but not eliminated (Salthammer et al., 1995). Pcdd/fs are created on particles of soot that enable the hazardous chemical to travel from the incineration site. These particles will eventually settle out onto land (Suzuki, 2007). Contaminated grass enables pcdd/fs to enter the food chain, and it will ultimately be consumed by humans and stored in body fat.

Therefore, without a doubt, it is imperative that this study reflects the differentiating factors surrounding crematoria based on the region of location, specific emissions and governmental regulatory policies. This includes but is not limited to Mercury. For example, neither the European Union nor the US EPA has established specific recommendations for crematories (Mari & Domingo, 2010). With that said, this study will examine four specific toxic emission studies from crematoria around the world. The research will be enhanced by including remediation techniques used by the selected crematoria that can be implemented to minimize the toxic emissions.

Interdisciplinary research is often difficult to carry out, given the inherent challenges of bringing together multiple disciplines and therefore multiple ways of knowing and conducting research (Paradigmatic differences, power, and status: a qualitative (n.d.). This study will utilize an interpretive research philosophy alongside a speculative analyis; the next selection process revolves around the research approach by combining the results of the data using a biological discipline, the environment, social factors, and engineering. The goal of this interdisciplinary study is not to examine the same research from a new perspective, but to examine new research that have previously not been considered noteworthy or sufficiently related to the discipline, and to do so in new ways. For example, although mercury will be the primary source of data, concerns surrounding pcdd/fs are regularly ignored. Using this interdisciplinary approach will allow industry leaders to understand the environmental factors surrounding crematoria including best sustainable practices by incorporating all elements of the study.

Statement of the Problem

In recent years, cremation rates have significantly increased. Although this is not in itself an issue, whether toxic emissions are following suit is the question. CANA's Annual Growth Rate table is a great template to follow when establishing predictors of toxic emissions.

Table 1. 1

Historical Cremation Data – United States vs. Canada

Annual Growth Rate – Five-Year Average USA		Annual Growth Rate – Five-Year Average Canada	
Year	% Cremated	Year	% Cremated
2005	32.4%	2005	53.8%
2010	40.8%	2010	62.1%
2015	48.6%	2015	68.8%
%Change 2000-2005	6.2%	%Change 2000-2005	7.0%
%Change 2005-2010	8.4%	%Change 2005-2010	8.3%
%Change 2010-2015	7.8%	%Change 2010-2015	6.7%
Annual Growth Rate per year over 2010-2015	1.57%	Annual Growth Rate per year over 2005-2010	1.35%

Note. Projection Methodology**.** In 2015, the US cremation rate was 48.6%. By 2020, the US cremation rate is projected to reach 54.3%. Given the significant political and recessional changes, a regression analysis was implemented to aid the interpretation of the data. This regression analysis was applied over a ten-year period in states and provinces where such a data set was available. Adapted from “Annual Growth Rate,” Cremation Association of North America. Copyright 2015 by the Cremation Association of North America.

The National Funeral Directors Association (NFDA), the world’s leading and largest funeral association and a trusted leader in the funeral service profession, regularly conducts a survey tracking the average cost of a funeral. In 2017, the survey determined the average cost of a funeral in 2017. Two types of funerals were surveyed (both about adults): 1) a funeral with viewing and burial, and 2) a funeral with viewing and cremation. Although a family chooses what method of final disposition for a variety of reasons, price could be one variant.

The funeral industry utilizes this data to analyze trends in the marketplace, pricing constructs, community needs, wants and more. Henrik Vejlgaard describes a trend as a social process in which style and tastes change (2008). He further states that it is critical in trend sociology to observe the trendsetters in the places where they occur. In the mortuary community, these areas tend to be those of higher populations and historically, the first crematoriums were located in those geographical regions. However, as the trend of cremation has become anything but a trend, we have witnessed most communities across the country adopt and imitate practices made more popular and earlier in those more populated areas. However, as this study's primary focus is toxic emissions from crematorium, the demand for cremation directly affects this issue.

Table 1.2

National Median Cost of an Adult Funeral with Viewing and Burial

Item	2017
Non-declinable basic service fee	$ 2,100.00
Removal/transfer of remains to funeral home	$ 325.00
Embalming	$ 725.00
Other Preparation of the body	$ 250.00
Use of facilities/staff for viewing	$ 425.00
Use of facilities/staff for funeral ceremony	$ 500.00
Hearse	$ 325.00
Service car/van	$ 150.00
Basic memorial printed package	$ 160.00
Metal casket	$ 2,400.00
Median Cost of a Funeral with Viewing and Burial	$ 7,360.00
Vault	$ 1,395.00
Total with Vault	$ 8,755.00

Note. NFDA 2017 General Price List Survey. National Funeral Directors Association. Brookfield, WI.

It should be noted that in Table 1.2, no cemetery expenses are included. This would include the plot, the opening and closing, monument or marker, and any other costs associated with the burial. This, as a result, could also contribute to ever-increasing cremation rate as well.

Furthermore, by comparing both pricing tables, the data can also give the industry a better understanding of how groups affect each other when choosing their method of disposition.

Table 1.3

National Median Cost of an Adult Funeral with Viewing and Cremation

Item	2017
Non-declinable basic service fee	$ 2,100.00
Removal/transfer of remains to funeral home	$ 325.00
Embalming	$ 725.00
Other Preparation of the body	$ 250.00
Use of facilities/staff for viewing	$ 425.00
Use of facilities/staff for funeral ceremony	$ 500.00
Service car/van	$ 150.00
Basic memorial printed package	$ 160.00
Cremation fee (if firm uses a third-party crematory)**	$ 350.00
Cremation casket	$ 1,000.00
Urn	$ 275.00
Median Cost of a Funeral with Viewing and Cremation	$ 6,260.00

Note. NFDA 2017 General Price List Survey. National Funeral Directors Association. Brookfield, WI.

*Median Price – The amount at which half of the figures fall below and half are above.
**69% of respondents use a third-party crematory (i.e., the funeral home does not own a crematory)

In Table 1.3, similar to Table 1.2, no cemetery expenses are included. In the case of cremation, this could include a plot, niche, or a use of a scattering garden if present, open and closing, monument or marker, and any other costs associated with the cremation. Also, this may or may not contribute to the increasing cremation rates.

Lastly, crematories are sources of several environmental pollutants. This study will investigate fire-based crematoria as they produce the most toxic emissions, what influences the level emissions, and then, may offer potential solutions.

Purpose of the Study

The purpose of this quantitative, explorational study is to examine the influence of various industrial practices on toxic emissions using statistical methods. This research will examine technological solutions to the dangers of air contamination. Lastly, this study may educate the consumer and funeral industry practitioners about the risks surrounding the process of cremation.

Research Question(s)

What factors influence rates of toxic emissions by crematoria?

Aim of the Study

The aim of this study is to present potentially useful information on environmentally sustainability practices to industry leaders. It may also serve to educate the public regarding the issue of toxic emissions from crematoria.

Proposed Methodology

The evaluation of the significance of environmental issues surrounding crematoria is an essential part of this review. The level of significance determines the resources deployed in avoiding or mitigating an adverse impact or identifying the actual value of a positive effect.

The interaction of two factors determines the importance of an effect: the value, importance or sensitivity of the environmental resource or those being affected (receptors), and the magnitude, scale or severity of the impact affecting it (O'Rourke, 2011). Therefore, this study will rely on a population of four different crematoria located in various parts of the world: United Kingdom, Canada, Japan, and Hong Kong. All statistical, descriptive data will reflect each crematory's specific study.

In this study, a speculative, descriptive analysis will be utilized to examine influences on toxic emissions from crematoria. The unit of analysis will be individual crematoria. Four crematoria from around the world were selected, consisting of 24 cremators and 15 stacks, and these vary not only in their locations but in the methods they use to cremate. Per the data, results from 24 hours cremation time, including 77 observed cases will be the focus. Potential influences will be identified by whether or not the modeling techniques generate a statistically significant result.

Definition of Relevant Terms

Alternative Container: An unfinished wood box or another non-metal receptacle often made of fiberboard, pressed wood or composition materials and much lower in cost than caskets. (Planning a Funeral, 2016.)

Burial: the act or process of burying (Merriam-Webster, n.d.)

Casket/Coffin: A box or chest large enough for burying remains (Planning a Funeral, 2016)

Cemetery Services: Opening and closing graves, set up for services, crypts or niches, setting grave liners and vaults, setting markers, and long-term maintenance of cemetery facilities and grounds (Planning a Funeral, 2016)

Cemetery: Land specifically used as a burial ground for the dead (Planning a Funeral, 2016)

Columbarium: A structure with niches or small spaces which allow for placement of cremated remains in urns or other small containers. It may be outdoors or part of a mausoleum (Planning a Funeral, 2016)

Committal Service: A brief service of prayers or readings at the graveside during or before the burial of the casket (Planning a Funeral, 2016)

Cremation: Exposing remains to extreme heat, flame, and processing to reduce the body to ashes and small bone (Planning a Funeral, 2016)

Cremated Remains/Cremains: The result of the reduction of a dead body to inorganic bone fragments by intense heat (CANA, 2018)

Crypt: A space in a mausoleum or other building underground in a vault that can hold cremated or non-cremated remains (Planning a Funeral, 2016)

Disposition: The placement of cremated or whole remains in their final resting place (Planning a Funeral, 2016)

Endowment Care Fund: Money collected by the cemetery from the purchasers which is put in trust for the maintenance and upkeep of the cemetery in the future (Planning a Funeral, 2016)

Entombment: Burial in a mausoleum or grave (Planning a Funeral, 2016)

Environment: the conditions that surround someone or something: the conditions and influences that affect the growth, health, progress, etc., of someone or something (Merriam-Webster, n.d.)

Funeral Ceremony: A service commemorating the deceased, with the body present (Planning a Funeral, 2016)

Funeral Services: Basic Service Fee services provided by a funeral director and staff, which may include consulting with the family on funeral planning; transportation, shelter, refrigeration of remains; preparing and filing notices; obtaining authorizations and permits; and coordinating with the cemetery, crematory or other third parties. (This fee typically cannot be declined) (Planning a Funeral, 2016)

Grave Liner: A concrete cover that fits over a casket in a grave. Some liners cover tops and sides of the casket. Others referred to as vaults, completely enclose the casket. Grave liners minimize ground settling (Planning a Funeral, 2016)

Grave: A space in the ground in a cemetery for the burial of remains (Planning a Funeral, 2016)

Graveside Service: A service to commemorate the deceased held at the cemetery before burial (Planning a Funeral, 2016)

Green Burial: Natural burial in a designated park-like area designed for burial in simple wood caskets or none at all. (No embalming permitted, all natural products, grave marker rules vary according to provider) (Planning a Funeral, 2016)

Interment: Burial in the ground, inurnment or entombment (Planning a Funeral, 2016)

Inurnment: The placing of cremated remains in an urn followed by placement in a niche or some other resting location (Planning a Funeral, 2016)

Leadership: A position as a leader of a group, organization, etc. (Merriam-Webster, n.d.)

Mausoleum: A building in which remains are buried or entombed (Planning a Funeral, 2016)

Memorial Service: A ceremony commemorating the deceased, without the body present (Planning a Funeral, 2016)

Niche: A space in a columbarium, mausoleum or niche wall to hold an urn (Planning a Funeral, 2016)

Scattering of Ashes: The scattering of someone's cremated remains (Planning a Funeral, 2016)

Urn: A container to hold cremated remains. It can be placed in a columbarium or mausoleum, buried in the ground, or some other significant spot (Planning a Funeral, 2016)

Vault: A grave liner that completely encloses a casket (Planning a Funeral, 2016)

Visitation/Viewing: Pre-determined place and time for the family to receive friends and extended family. The casket may be opened or closed (Planning a Funeral, 2016)

Summary

Throughout this chapter, a brief overview into environmental issues associated with crematoria, primarily mercury and pcdd/f's, current regulations, statistics, and the factors influencing the consumer in choosing cremation as their final disposition were broached. In doing so, the purpose of this study examines the influence of various industrial practices, potential technological solutions, and most importantly, to educate both the consumer and funeral practitioner. Lastly, a definition of relevant terms was outlined for the reader who may or may not be familiar with funeral industry terminology. Collectively, chapter one summarizes the aim and purpose of the study. Next, associated scholarly literature will be reviewed in Chapter 2.

Chapter Two: Literature Review

In the 1970's, the geochemist James Lovelock wrote that the chemistry of the biosphere is charged up like a battery. We human beings are machines running off that battery, one pole connected to the oxygen in the atmosphere and other pole connected to food, the organic carbon produced by photosynthesis (Lovelock, 1974). Using this analogy, cremation could be examined the same way. The crematory furnace is charged up like a battery, a machine running off of natural gas, electricity, light diesel, kerosene or propane in some cases, and via the stack, one pole is connected to the atmosphere and the other pole connected to the earth, including water, land, and humans. As a result, emissions such as mercury, sulfur dioxide, dioxins, furans, and more find its way into our environment. In this research, an environmental assessment will be conducted.

The literature review components are equally important. A brief historical review of cremation's beginnings as it transitions into modern processes will be discussed. This will lead to examining emissions from modern crematoria, primarily mercury and pcdd/fs. In light of the emissions, both North American regulations and fuels used by crematoriums will add to the overall understanding of how modern cremation works. From here, social disciplines will be highlighted. What are the community's concerns with cremation and what issues surrounding disposition of the deceased determines what a family chooses? Reviewing global cases as it affects emissions and community will tie together the overall aim of this study.

The History and Modern Practice of Cremation

It was 1884 that, on the top of a hill in a South Wales field, Dr. William Price of Llantrisant set light to modern Britain's first funeral pyre (Kerrigan, 2007). On it burned his baby son. Price narrowly escaped lynching by an angry crowd; he was arrested by the police, but to universal astonishment acquitted at his trial. The judges could not find that he had committed any crime: cremation, it turned out was legal under British law (Kerrigan, 2007).

Modern cremation began only a little over a century ago, after years of experimentation into the development of a dependable chamber. When Professor Brunetti of Italy finally perfected his model and displayed it at the 1873 Vienna Exposition, the cremation movement started almost simultaneously on both sides of the Atlantic (History of Cremation - Cremation Association of North America, 2002).

Crematories soon sprang up in Buffalo, New York, Pittsburgh, Cincinnati, Detroit and Los Angeles. By 1900, there were already 20 crematories in operation, and by the time that Dr. Hugo Erichsen founded the Cremation Association of America in 1913, there were 52 crematories in North America, and over 10,000 cremations took place in that year (Cremation Association of North America, 2002). When reviewing Table 2.1, the findings demonstrate that although cremation began to grow in both the United States and Canada, it remained very consistent for many years. Even though this is not the rate of cremation today, modern cremation is now the selected method of final disposition. The Cremation Association of North America predicts that in the year 2020, the cremation rate will be 54.3% in the United States and 74.2% in Canada (2015). Using the 2020 prediction, the United States cremation rate is 29.26% and Canada's 28.05% higher than when in 1998, the EPA performed their emissions testing at the Bronx Crematorium. Based on population and the rate of increase in cremation, modern cremation is officially growing at a clip previously unrealized by the industry.

Table 2.1.

Summary of Historical Cremation Data – United States vs. Canada 1980-2002

	United States			Canada		
Years	Deaths	Cremations	%	Deaths	Cremations	%
1980	1989841	193343	9.72	172000	32423	18.85
1981	1977981	217770	11.01	173000	34884	20.16
1982	1974797	232789	11.79	183700	37222	20.26
1983	2019201	249182	12.34	184000	41887	22.76
1984	2039369	266441	13.06	185500	44630	24.06
1985	2086440	289091	13.86	190500	49216	25.84
1986	2105361	300587	14.28	195000	54482	27.94
1987	2123323	323371	15.23	197000	53867	27.34
1988	2167999	332183	15.32	186600	57568	30.85
1989	2150466	352370	16.39	195500	60087	30.74
1990	2148463	367975	17.13	193000	62797	32.54
1991	2169518	400465	18.46	195000	66087	33.89
1992	2175613	415966	19.12	185211	64557	34.86
1993	2268553	448532	19.77	193557	70017	36.17
1994	2278994	470915	20.66	195331	75489	38.65
1995	2312132	488224	21.11	210545	79206	37.26
1996	2314690	492434	21.27	207772	81960	39.45
1997	2314245	533773	23.06	209395	85196	40.69
1998	2337256	563384	24.10	213004	90200	42.35
1999	2391399	596721	25.04	219836**	101545	46.15
2000	2404000	630800	26.24	223789*	106747***	47.70***
2001	2416425*	650776	26.93	223580	N/A	N/A
2002	2436467*	676890***	27.78***	N/A	N/A	N/A

Note. Table adapted from Historical Cremation Data – United States vs. Canada – Copyright 2003 Cremation Association of North America.

*Figure from the National Vital Statics System
**Figure form the Canadian Statistical Reference Centre
***Preliminary Figure
N/A = Not Available

Although cremations began to rise, the general public was still apprehensive. Like choosing dinner, some people will prefer a traditional meal made at home. Some do not. Therefore, some people do not need to visit graves whereas some do. In some cases, those who do care about visiting graves can be hurt when cremation is chosen. The hurt may reflect one’s religious beliefs, it may surround not seeing the person one last time, or it may even be for environmental reasons. Regardless the intention, since cremations have become a modern option, the science surrounding the process has evolved, including continuous research.

Cremation takes place at a crematory or crematorium. The deceased person's body is placed in a casket or durable cremation container. The container is then put in the cremation chamber, where the temperature is raised to approximately 1,600 to 1,800 degrees Fahrenheit. After approximately two and one-half hours, all organic matter is consumed by heat or evaporation (Goetting & DelGuerra, 2003). What remains are bone fragments, or “cremated remains/cremains.” Outside the industry, these are referred to as “ashes.” After the chamber is cooled, the cremains are removed. Most crematories process the bone fragments into fine particles that resemble fine gray or white sand and then place them in a container or an urn provided by the family (Goetting & DelGuerra, 2003).

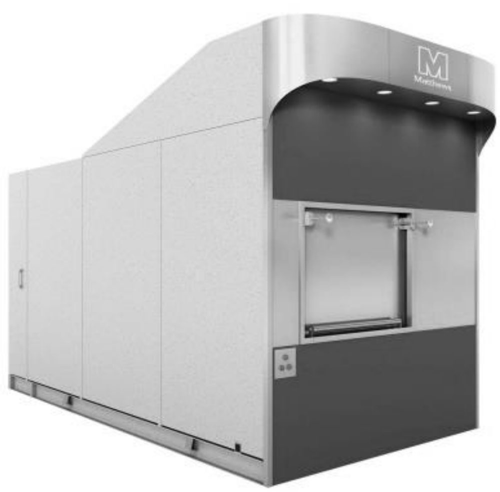

Figure 2.1. *EnerTek IV Plus* – Matthews Environmental Solutions. Photo of EnerTek IV Plus cremation furnace retrieved from Matthews Environmental Solutions. Copyright 2017 Matthews Environmental Solutions.

Emissions from Modern Crematoria

In this section, the focus is on the emissions created by the process of cremation or instead everything that occurs between the receipt of the deceased and the processed cremated remains. Cremation is an increasingly popular method for the disposal of human remains due to its relatively low cost and presumed low environmental impact compared to traditional burial. Both the fumes expelled during cremation and the mineralized remains of the skeleton (called "cremains") are possible sources of toxic waste (Huffman, 2007).

The gaseous emissions are by far the most significant source of cremation pollution and thus far the only crematoria waste regulated, usually by the State of residence and also by the Environmental Protection Agency (Mari & Domingo, 2010). In addition to harmless compounds such as water vapor (H_20), emissions include the greenhouse gas carbon dioxide (CO_2); pollutants and carcinogens carbon monoxide (CO), nitrogen oxide (NO_2), and sulfur oxide (SO_2); volatile acids such as hydrogen chloride (HCl) and hydrogen fluoride (HF), both of which form during vaporization of plastics or insulation; and mercury (often from dental fillings). Organic compounds such as benzenes, furans, and acetones are also emitted and react with HCl and HF under combustion conditions to form polychlorinated dibenzodioxins (pcdd's) and polychlorinated dibenzofurans (pcdf's), both which are carcinogens. Hg, pcdd's, and pcdf's are of particular concern because they are susceptible to bioaccumulation (Huffman, 2007).

In many parts of the world, crematoria have dealt with public opposition (Sanburn, 2016). For example, in late 19th-century America, cremation was a progressive idea. LeMoyne and other cremation advocates believed that burying the dead in the ground allowed germs to seep into the soil, thus contributing to the spread of diseases like cholera, typhus, and yellow fever (Bragg, 2016). Cremation promised to sterilize human remains and bypass the altogether slow process of decomposition. When performed in a state-of-the-art indoor furnace, it was a sanitary and high-tech alternative to burial (Bragg, 2016).

The practice of cremation at this time was considered blasphemous and less dignified than traditional burial. In 1900, the New York Times ran a satirical news item about the cremation of Willard's cat: "Each of Toots's human friends will sprinkle a little myrrh or frankincense over the body, and while it is being consumed the incense will counteract any odor which might be emitted through the furnace chimney." That aside, the satirical nature alongside the dangerous contrasting ideologies at the time brought forth investigation. Thus, when LeMoyne painted a picture of diseases present at that point as infiltrators of the soil and ultimately the water table, a select few individuals began to approach the differentiating aspects of cremation versus traditional burial with a new set of eyes. This pragmatic type of thinking was not only a profound step forward in the funeral industry but also a new way of old thinking.

Throughout researching crematoria, two particular emissions concern those investigators the most, mercury and pcdd/fs. As stated earlier, other emissions are present, however, none as toxic as these. Although further chapters will focus more on what these are and how they are delivered to both the environment and humans, it is paramount to understand more before discussing methodology details.

What is mercury (Hg)?

There are three kinds of mercury (DEFRA, 2003). Depending on what the exposure is, you could have different symptoms and disease states. Elemental, or metal mercury, is found in thermometers. The problem with that is the inhalation of fumes that come off that mercury. Playing with it and ingesting it is not as toxic. That kind of mercury causes significant amounts of neurological damage. As the exposure gets longer, there may be additional changes in the bone marrow that affect the ability to produce blood cells, infertility, and problems with heart rhythms (DEFRA, 2003).

Mercury salts, which are industrial, if you breathe in or ingest them, gravitate more toward the kidney and not so much the nervous system. Organic mercury, a by-product of the cremation process, bio accumulates in the food chain. It is put into the water by chemical plants that are manufacturing things, and it will get into shellfish and fish, or elemental mercury that gets into the water is changed into organic mercury by sea life; we eat fish or shellfish, and we get mercury exposure. That organic mercury acts very similarly to the elemental form. It can enter the nervous system causing damage. If a woman is pregnant, this can also cause congenital disabilities and loss of the fetus if the levels get high enough (DEFRA, 2003).

In crematories, mercury enters the process because it is present in humans. Although mercury is only the thirty-sixth most abundant element in the body (at 6 mg for the average body), there is a source of mercury that means grave concern. Fillings made with dental amalgam contain more than 0.5 mg of mercury. This metal will leak from these fillings because of mercury's low vapor pressure and add to the mercury levels already present in the body. The extreme temperatures of cremation cause the mercury found in the fillings to volatilize, and added to the mercury found in the body may give place to a release of a relatively large amount of this toxic metal. Studies have found as much as 200 μm^3 (Cubic Micrometer) during the cremation process of a body with dental amalgam fillings (DEFRA, 2003).

What is PCDD/F?

Polychlorinated dibenzo-p-dioxins and dibenzofurans (pcdd/f's), among other persistent organic pollutants, are byproducts of the cremation process. Pcdd/f's like mercury stand out because of their toxicity and capacity for bioaccumulation, which means potential risks for human health (Mari and Domingo, 2009). In contrast to incinerators, only a few studies have been published on pcdd/f emissions from crematories (Wang et al., 2003). Although crematories of human beings are also combustors, from a legal/regulatory point of view, these facilities are not considered as incinerators. When discussing pcdd/f emissions from crematoria, it must be noted that these compounds are formed during combustion processes when chlorinated products such as plastic are burned. These plastics can be found in prosthetics, parts of alternative containers, body bags, caskets, and so forth. Even non-treated wood contains small amounts of chlorine. It means that pcdd/f emissions might be only minimized, but not eliminated (Salthammer et al., 1995).

The byproducts of the cremation process raise concerns about issues of toxicity and bio-accumulation. Although human exposure to pcdd/fs mainly occurs via food consumption, and more specifically through the ingestion of fatty foodstuffs (Doming and Bocio, 2007; Libet et al., 2008), environmental exposure to pcdd/fs must not be

neglected. Among the different pathways of direct exposure to these pollutants, inhalation seems to be the most critical route
(Nadal et al., 2004).

In Chen and Chang-Chien's 2010 study, "Point source identification using a simple permutation test: a case study of elevated pcdd/f levels in ambient air and soil and their relation to the distance to a local municipal solid waste incinerator (MSWI)," they explored the spatial correlations between the ambient air and soil pcdd/f congener profile concentrations and their distances to a municipal solid waste incinerator (MSWI) in northern Taiwan. The results showed that the correlation was highly negatively associated for soil and was marginal for airborne pcdd/fs, conditional on the seasonal wind attributions. The analytical results show that dioxin emissions from the investigated MSWI had a definite environmental impact on the surrounding area. Current research suggests that the toxic emissions from crematoria exceed that of just mercury, including pcdd/fs. Based on Chen and Chang-Chien's results, it could be said that crematorium should engage in future pcdd/f testing alongside mercury as it may prove to be significant.

Regulation in North America

Cremators are usually made of a high-grade steel plate and lined inside with heavy refractory tile or brick. Most cremators have a variety of automatic controls and use gas to heat the cremator. As a result of the Clean Air Act of 1990, the US EPA first classified crematories as medical waste incinerators, and later as OSW ("Other Solid Waste") incinerators. After an intensive, costly and aggressive testing project in 1999 on working crematories that covered most types of emissions, including particulate matter, carbon monoxide, and mercury, done jointly with the Cremation Association of North America and reviewing information presented, the US EPA decided not to regulate human or animal crematories (Mari and Domingo, 2003). Based on the collected 1999 data, proposed regulatory measures in 1991 were proven unsubstantial (CANA, 1999).

Fuels Used by Crematoria

Cremators, dependent upon design, can operate on different kinds of fuel (Stevens, 2009). Hal Stevens stated in a roundabout way that, on the surface, cremation seems to be a more-friendly option to burial. However, cremation should be considered a real industrial process where non-renewable fossil fuels are used (Stevens, 2009).

Even though the cremation process consumes fossil fuels, it is critical to have a deeper understanding of the current study. To begin, crematoria use electricity. This power may derive from hydropower, nuclear, coal, solar, wind, biomass, and much more. The voltage is necessary for controlling the computer controls, which assist in making the cremation process more automated. Also, oxygen sensors, temperature gauges, in addition to pre-programmed software based to counteract the weight of the deceased allows for less user intervention. The computer is essential towards streamlining records for tracking data linked to environmental and maintenance purposes. Therefore, without electricity, the cremator will not work (Stevens, 2009).

Fuel, also dependent the furnace and geographical location of the crematory, is afforded an array of options, typically, Liquid Propane/Butane (LPG) and Natural Gas (NG). In some places, wood, fuel oil, kerosene and Light Diesel are the primary fuels used, just far less common throughout the industry as a whole. Each one of these fuels has specific characteristics, some more detrimental to the environment than the other.

Liquid Propane/Butane (LPG)

LPG is a mixture of gaseous hydrocarbons produced from natural gas and oil extraction as well as oil refining (Atlantic Consulting, 2009). These three physical properties are relatively significant to its carbon footprint. However, in comparison to most hydrocarbons, LPG has a little carbon to hydrogen ratio. As a result, LPG will generate less carbon dioxide per amount of heat produced. While the proportion will be different whether it be propane or butane, the heating value is comparable, meaning that it contains more energy than most competing fuels (Atlantic Consulting, 2009). Overall, LPG, when used in conjunction with electricity, in particular, hydro power where available, is a fuel that when used, is a safe use of energy with a lowered impact on air quality.

Natural Gas (NG)

Natural gas is a highly combustible odorless and colorless hydrocarbon gas primarily composed of methane. Natural gas is created in roughly the same manner as oil, by processes that act upon an organic matter over millions of years (Energy Safety, n.d.). Unlike LPG, natural gas is lighter than air, made of methane, produces high and efficient heat, and is very safe (Energy Safety, n.d.). Also like LPG, when used in conjunction with electricity, in particular, hydro power where available, is a fuel that when used, is a safe use of energy with an even lower impact on air quality (Energy Safety, n.d.).

Light Diesel Oil (LDO)

Also known as Distillate fuel oil, diesel is a general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in onhighway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation. In the cremation process, distillate fuel oil No. 4 is used. This fuel oil is made by blending distillate fuel and residual fuel oil stocks (U.S. Energy Information Administration, 2018). Although not commonly used in crematoria, it is used extensively in India, Pakistan and other random sites in Asia. The concern surrounding light diesel oil is the significant SO_2 emissions. Due to this, natural gas and propane, both very similar in lowered emissions and costs, are widely utilized.

Kerosene

Kerosene is a flammable hydrocarbon oil usually obtained by distillation of petroleum and used as a fuel, solvent, and thinner (U.S. Energy Information Administration, 2018). Like light diesel oil, kerosene is seldom used in crematoria, more regionally based, primarily in Asia. Also, kerosene creates substantial SO_2 emissions.

Fuel Energy

Energy and the environment have been a global issue for years (Shah, 2011). For example, the funeral home needs to make the removal and then bring the deceased to the crematory. At this point, the crematory then processes the body. Upon conclusion, the funeral home or family picks up the cremated remains. From there, the family chooses a variety of options from the scattering of ashes, to inurnment. Regardless the stage of the process, energy will be used.

In practice, all materials contain some amount of thermal energy. Even frigid air or ice have a considerable amount of heat energy in them. Zero thermal energy — that is no random motion of atoms or molecules — is achieved only at a temperature known as absolute zero, which is equal to about -273 degrees Celsius (about -460 degrees F). An absolute zero temperature cannot be reached by any practical device (Watson, 2014). As a result, the 2nd Law of Thermodynamics requires us to accept that energy is always required where atoms and molecules exist. The measurable difference in energy is based on efficiency (Watson, 2014).

In the cremation process, the amount of fuel used is measured in British thermal units (Btu or BTU). This standard unit of energy is employed in the United States, and sometimes in the U.K., It represents the amount of heat energy necessary to raise the temperature of one pound of pure liquid water by one degree Fahrenheit at the temperature at which water has its greatest density (39 degrees Fahrenheit). The Btu is a measure in the so-called English system of units (the foot-pound-second system) (Rouse, N.D.). A Btu is a quantitative specification for the energy-producing or energy-transferring capability of heating and cooling systems such as furnaces, ovens, refrigerators, and air conditioners. In the case of crematoria, regulations require furnaces to cremate within a particular temperature window to help mitigate unwanted pollution problems. This is achieved by following manufacturer's specifications and guidelines. However, the temperatures range between 1400°f - 1800°f. (Matthews International, 2011). Accomplishing this requires a certain amount of Btu's in conjunction with electricity to run each furnace within specified parameters.

In 1999, Bernd H. Hanek performed a study entitled "A National Methodology and Emission Inventory for Residential Fuel Combustion." Essentially, the 1999 National Emission Inventory (NEI) contains State-reported area source residential fuel combustion emission estimates. The approaches and methodologies used to develop residential fuel combustion emission inventories are not consistent among States. Therefore, the emissions reported to the NEI by States are not consistent or compatible. In response to this, an innovative methodology was developed by Hanek and funded by the Emissions Inventory Improvement Program (EIIP) to calculate consistent residential fuel combustion criteria pollutant emissions on a national, state, and county level for the following fuels: natural gas, liquefied propane gas, kerosene, fuel oil, anthracite and bituminous coal (In this study, anthracite and bituminous coal are omitted). Once apportioned to the county level, emissions were calculated by multiplying the fuel consumption by the applicable emission factors. This approach provides for a consistent residential fuel combustion emission inventory.

The following table identifies the emission factors of natural gas, liquefied propane gas, kerosene and distillate fuel oil. This, as a result, assists the reader in better understanding the overall effects each particular fuel has in regards to residential usage. Although not crematory centric, the information is important, as these are the primary fuels used in the crematory process as well as many other industrial activities.

Table 2.2.

Comparison of 1999 Project Calculated Emissions and 1999 NEI v2 Reported Emissions for all States

Fuel Type								
Pollutant	Natural Gas		LPG		Distillate Fuel Oil		Kerosene	
	EIIP	NEI	EIIP	NEI	EIIP	NEI	EIIP	NEI
CO	94,580	97,747	9,906	2,718	14,476	39,626	1,976	670
NO2	222,263	362,287	40,241	9,908	52,638	161,703	7,148	2,447
SO2	1,419	1,662	310	61	124,578	130,290	16,914	3,762
VOC	13,005	16,645	1,517	591	2,076	7,699	284	171
PM10 Filterable	4,493	9,215	526	50	3,158	5,505	445	14
PM 2.5 Filterable	4,493	9,215	526	17	2,427	4,209	342	11
PM Condensable	13,478	0	1,579	0	3,802	0	535	0

Note. The principal source of emission factors was the EPA's *Compilation of Stationary Source Emission Factors*, commonly referred to as AP-42.

* All emission factors are based on natural gas having a heat content of 1,020 Btu/ft3. The CO and NO_x emission factors are specific for uncontrolled residential furnaces. The SO_2 and VOC emission factors are applicable to all units burning natural gas. The SO_2 emission factor assumes that the sulfur content of natural gas is 2,000 grains/10^6 ft^3. The filterable PM10 and PM2.5 emission factors are identical as all PM from natural gas combustion is assumed to be less than 1.0 micrometer in diameter.
**Similar to Natural Gas. Emission factors have been converted from lb/106ft3 to lb/103 gallons.
*** The CO, NO_x, SO_2, and PM filterable emission factors are specific to residential furnaces.
The PM 10 emission factor is for commercial boilers but is more consistent than the residential
combustion-specific emission factor in AP-42. In addition, the residential fuel combustion-specific PM 10 emission factor is based on newer burner designs. In addition, AP-42 states that pre-1970's burner designs may have PM 10 emissions up to 3.0 lb/10^3 gal. Therefore, it was decided to use the 1.08 lb/10^3 gal emission factor. The emission factor for filterable PM2.5 is specific to commercial/institutional boilers having a design capacity <10 million Btu/hr. Based on capacity, this was determined to be the boiler size range most similar to those that may be found in residential settings.
**** AP-42 does not contain kerosene-specific emission factors. Therefore, distillate fuel oil
factors were multiplied by the ratio of kerosene to distillate fuel oil heat contents (135,000 / 140,000). In addition, the same assumption regarding fuel oil sulfur contents

was used (0.30%w). Table 4 contains the emission factors for residential kerosene combustion, which are approximately 4 percent lower than the emission factors for distillate fuel oil combustion.

Two more examples may be illustrative. One Crawford model, the Elite Cremation System Model C1000H, uses 1,200,000 Btu per hour and uses 12 gallons of LP fuel per hour. Per cremation, this adds up to at least 2,000,000 BTUs used or about 20 gallons of fuel. A second Crawford model, the Ultimate Cremation System Model C1000S, estimates 2,100,000 BTUs per hour and uses 21 gallons of LP fuel per hour. In sum, this means that almost 3,000,000 BTUs are used – over 25 gallons of fuel – per cremation (Energy Use, 2017). To gain a clearer perspective, the following table refers the amount of fuel being used to heat a home.

Table 2.3.

Fuel Usage Comparison: Home versus Crematory

Climate	Square Feet	BTUs per Sq Ft	BTUs Per Hour
Warm Climate	2,500	30	75,000
Temperate Climate	2,500	40	100,000
Cold Climate	2,500	50	125,000
Very Cold Climate	2,500	60	150,000
Crawford model, the Ultimate Cremation System Model C1000S	1 Furnace	n/a	2,100,000

Note. Based on Energy Use, 2017, every 100,000 to 120,000 BTUs per hour = 1 Gallon of fuel. Based on this information, the Crawford cremator will use the same amount of fuel in one hour as a 2.500 square foot home in a very cold climate will in 14 hours. Also, the home is minus emissions. Information adapted from Energy Use, 2017 and How Much Does it Cost to Install a Furnace, 2017.

The primary reason for using these examples is to establish a baseline in fuel usage that is easily understood. Also, it should be noted that although the fuel being used may differ in the volume exhausted, the primary dissimilarity is the emissions expelled, as pointed out in Haneke's study with the EIIP. In the case of the home furnace, the emissions are irrelevant in comparison to that of crematoria. Moreover, crematoria not only use more fossil fuels, but the risks involved in the emissions have been proven to be significant. In further chapters, the specifics surrounding both fossil fuel usage as well as emissions will be broken down.

Environmental Communication

In the simplest terms, environmental communication is communication about environmental affairs (International Environmental Communication Association, 2017). Environmental communication is also an interdisciplinary field of study that examines the role, techniques, and influence of communication in environmental affairs (International Environmental Communication Association, 2017). It monitors the activity, and in doing so, it draws its theory and methods primarily from communication, environmental studies, psychology, sociology, and political science (International Environmental Communication Association, 2017).

One of the central concerns of this work involved community engagement. The lack of publicly available studies of crematoria emissions is a related issue. The evidence produced by the studies that have been performed need to be documented and shared with businesses and the general public.

Environmental studies are always controversial for reasons far too numerous to discuss (International Environmental Communication Association, 2017). To examine any part of any business, social or personal constructs, religious ideology, and political affiliation will have Paracletes and adversaries. Nonetheless, it is important to understand how the cremation process influences emissions and the environment.

Disclosure is compelling. For example, the moment at which a diagnosis is delivered to a family and patient, particularly when it is dangerous, is an important social moment. It not only dictates the clinical pathway, but it also rewrites the patient narrative, shifts their identity, predicts potential outcomes, and foregrounds mortality. It may provide a sense of relief, or one of despair (Jutel, 2016).

In the funeral industry, disclosing a death is also very powerful. At that moment, the family is immediately required to pick a method of disposition. This would include but not be limited to, finances, distance, time, religious ideology, possibly secular politics, and much more. However, without focusing on those details, would it make a difference to the family’s choice of disposition if they were staunch environmentalists? It is hard to say this without extensively researching the topic. Moreover, would understanding the ramifications of cremation versus all other methods of disposition change the way the funeral industry would approach crematoria in general? Without environmental communication, the answers can only be assumed, and a key component of this interdisciplinary study is to discern and promote best practices.

Community Concerns

On June 22, 2010, the Weatherford, Texas Planning and Zoning Board approved a Conditional Use Permit for Galbreaith-Pickard Funeral Chapel to install an incinerator with a 19-foot smokestack so that cremations can be completed on-site. Galbreath-Pickard is located on the corner of First and Elm streets. It is next door to North Side Baptist Preschool. Couts Christian Academy is across the street, at 802 N. Elm.

Weatherford ISD has two campuses close by — Bowie Learning Center across the street and Seguin Elementary School a few blocks away (Bays, 2011).

Conditional Use Permits, depending upon location, are given when the request to operate a crematory passes the Planning and Zoning Board. The next step typically, and in this case, is contingent the city council. What surprises many residents across the US as well as other countries, is that when the Conditional Use Permit is granted, it is usually difficult to reverse the progress of the crematoria receiving full licensure to operate. Essentially, when issued a Conditional Use Permit, the crematory can be installed and used. Therefore, once in use, it can be difficult to stop the crematory from operating. Ergo, a full licensure to operate will be issued.

If living in a residential neighborhood adjacent to a proposed crematory, based on the scientific evidence of mercury, particulate matter (pm), pccd/f's, and more, it may cause additional concerns amongst the community. In the case of Weatherford, Texas, the public is worried about potential health issues, in particular children, newborns, and pregnant women and agitated with the Planning and Zoning Board for issuing the Conditional Use Permit (Bays, 2011). It is the opinion of many Weatherford residents that to operate a crematory; it needs to pass both the Planning and Zoning Board and City Council before receipt of an operational permit (Bays, 2011).

Although this example is one of many and will continue to grow, this study is razor focused on emissions and issues surrounding them. This research is not designed to lean towards the consumer or the funeral industry, rather, it is intended for use as an environmental reference. In an attempt at objectivity, it is necessary not to forget the communities of which crematoria's reside. As the funeral industry continues emission studies, more data will lead to strengthened answers. At this point, as stated earlier, we are in the infancy stage of analyzing environmental emissions with crematoria (Hanna & Greenstone, 2011). Emission studies are the primary focus of this research. Although not limited to, the studies used for data mining this research will denote a well represented and structured detail of mercury, pccd/f's, community engagement, and remediation solutions.

Emission Studies

The word emission suggests a discharge of gas (Merriam-Webster, n.d.). In the crematorium, what is emitted is the primary concern. As this research develops, the bioaccumulation of mercury has been established as the chief interest. This is represented by numerous studies including, the Kwai Chung Crematoria in 1998, the 2000 Dane County, Wisconsin Reindl Study, Dr. Sandra Myers, an Associate Professor in the School of Dentistry at the University of Minnesota-Twin Cities research on emissions resulting from dental amalgams, and the 2010 and Takaoka, Oshia, Takeda, and Morisawa of Atmospheric Chemistry and Physics study in Japan. Although far less studied, the bioaccumulation of pccd/f's is gaining attention as represented by Mari and Domingo's research of toxic emissions from crematories in 2009 (Mari & Domingo, 2009).

As demonstrated by these studies, the significance of the resulting data concentrates on bioaccumulation of mercury and pccd/f's, occupational and environmental effects from crematoria, community engagement through awareness, and the use of remediation protocols to minimize the effects of crematory emissions.

Information on occupational exposure to individuals working in crematories is particularly scarce (Mari & Domingo, 2009). To the best of our knowledge, only a study in the UK has examined this potential exposure (Maloney et al., 1998). For example, measuring the levels of mercury in the hair of crematory workers is one way in which science can determine the risks towards employees. However, others such as Dummer et al. (2003) are investigating the potential for stillbirth, neonatal death, and a lethal congenital anomaly among babies of mothers living close to both incinerators and crematories in Cumbria, Northwest England. Even though it is important to understand the emissions of a crematory, it is just as necessary to identify the cause and effects.

Community engagement is a critical regardless industry. In the proposal of crematoriums across North America, research on emissions has brought forth concern. Analyzing a limited feasibility study conducted in Littleton, Massachusetts, the Shipley's Choice Homeowners' Association Court of Special Appeals of Maryland case, the Grinnell, Iowa community study will expound upon community engagement and the apprehensions. The concern of the residents of these communities involves vaporized metallic mercury and other toxic emissions to be placed in a residential neighborhood (Clower, R., and Clower, N., 2009).

Based on community concerns, residents are trying to seek remediation solutions, such as supplemental filtration systems (Clower, R., and Clower, N., 2009). Craft in June of 2011 pinpointed four issues related to mercury emissions from crematoria:

1. Emission estimates
2. Dispersion modeling results
3. Acute risk calculations, and a
4. Partial effort to identify risk reduction measures (Reindl, 2007).

To combat these issues, this study will illustrate upon the use of Selenium Ampoules, corpse testing for dental amalgams of which those containing mercury would go to cremators with mercury control equipment, and generic control technologies for mercury emissions used in solid waste incineration. In the US, there are no known mercury control systems in use at crematoria (Reindl, 2007). Craft in 2012, as contracted through the California Air Pollution Control Officers Association evaluated in detail six potential systems:

1. Co-flow filter
2. Gas scrubbers
3. Honeycomb catalytic absorber
4. Sodium bicarbonate and activated carbon control system, and a
5. Solid-bed filter, using absorbents such as cokes or zeolites.
6. Electrostatic Precipitators

In addition to reviewing these remediation techniques, it is essential to discuss alternative technologies to cremation. These will include traditional burial, sea burial, green burial, promession, and alkaline hydrolysis[1]. Upon conclusion, available options towards environmental responsibility are recognized.

Summary

To summarize, there are four core elements of this literature review. The review examined the origins and process of modern cremation. In doing so, the reality of cremation as a safe alternative to other forms of disposition was not clear. Although the technology did not exist at the time of LeMoyne, environmental concerns continue to resonate amongst communities (Reindl, 2007). As modern cremation services continue to grow, so does the technology.

The second element of this literature review analyzes the types and amounts of energy used in cremation. This involves fossil fuel use. Alongside technology, some fossil fuels used in cremation are based on efficiency. In other cases, geographical location of the crematoria dictates the kind of fossil fuel employed (Marshall, 2009). This, critical in understanding today's modern cremation practices, is necessary (Matthews Cremation, 2011). Although this study will not trace the origins of energy step-by-step, one of the goals of the dissertation is to identify fossil fuel use and the larger picture it encompasses. The research may find alternative technologies that may or may not consume fossil fuels at a more efficient rate.

Given the previous points, I discussed the third core element, "what toxic emissions are the by-product of cremation?" This is the primary focus of the study as it is the one attribute of cremation that causes the most controversy. As noted, modern cremation has increased in technological advances. However, recent studies have identified bioaccumulation, which is the increase in concentration of a pollutant from the environment to the first organism in a food chain, as hazardous to both the earth and humans (Reindl, 2007). Therefore, those particular studies will be further reconnoitered, thus finding consistencies.

Altogether, the first three core elements will support the fourth - Community Engagement through Environmental Communication. The publication of an emissions study is not enough to affect change. Rather, that information must be communicated to community stakeholders in a manner that allows them to make an informed decision about the location of crematoria. The results of this study will not determine the outcome; it may suggest further industrial enhancements to minimize emissions.

Lastly, by including remediation techniques, technologies may be identified that could be used to reduce the risks associated with crematoria. This will shed light on the cremation process and how it can be accomplished with environmental responsibility at the core. As previously noted, no known crematoria in the United States currently implement emission solutions (Reindl, 2007). Therefore, by acknowledging the potential options to remediate environmental risks, it is possible the funeral industry will look more carefully and collectively into tendering solutions.

In sum, this research will collectively isolate the necessary information required for manufacturers, the funeral industry, the general public, and governmental institutions, identifying challenges that arise from constructed crematories. The data will extend potential solutions without offering bias assisting crematoria towards recognizing the risks of emissions alongside progressive answers. In section three, ‘Project Methodology,’ the quantitative portion of this research is addressed. The archived data from global sources alongside a speculative analysis will create a clear, concise picture of toxic emissions and crematoria.

Chapter Three: Project Methodology

In this section, I will outline the research strategy, research method, and research approach, methods of data collection, selection of the sample, research process, and type of data analysis, ethical considerations and the research limitations of the project.

Research Strategy

Using publicly available data from four crematoria around the world, I examined various factors associated with emission rates. To provide context, I also reviewed documents associated with various crematoria technologies and the number of cremations performed in 2017 in those specific regions. Using both streams of descriptive, yet rare data; I will analyze relationships to examine potential ways to improve the process. Given the low number of observations available publicly, the study's focus is exploring for relationships - not cause and effects. Also, based on the limited amount of assessments and the lack of testing protocols, it is important to understand that the results are provisional and inferential as publicly found information is limited.

Research Method

This study aims to educate both funeral industry practitioners and the general public about toxic emissions from crematoria as well as introduce sustainable practices to offset toxic emissions. Therefore, the aim is to classify features, count them, and infer the data in an attempt to explain what is being observed, in this case, Mercury bioaccumulation. Also, where data is available, pcdd/f's, another toxic emission will be measured.

Due to the lack of publicly available data for crematory emissions, Table 3.1 identifies the number of cremations held in each cases studies country for the year 2017. This will be used to estimate how much particulate matter might be generated by cremations that the regions selected typically or may perform in a particular time. The data publicly provided by The Cremation Society of Great Britain (www.cremation.org), alongside the data collected from the crematorium selected for the study, will present to the reader, outputs that are clear in its definition, logical, and adequate for the figures available. This skeptical inquiry will be used to support what factors influence rates of toxic emissions by crematoria, educating the public about toxic emissions from crematoria as well as introduce sustainable practices to offset toxic emissions. Skeptical yet descriptive, this study will also be used to determine whether further studies are necessary as the rate of cremation increases worldwide.

The quantitative correlational research aims to systematically investigate and explain the nature of the relationship between variables in the real world. Often the quantifiable data (i.e., data that we can quantify or count) from descriptive studies are frequently analyzed in this way.

Correlational research studies go beyond simply describing what exists and are concerned with systematically investigating relationships between two or more variables of interest (Porter & Carter, 2000). Such studies only describe and attempt to explain the nature of relationships that exist, and do not examine causality (i.e., whether one variable causes the other).

Research Approach

In order to properly approach the research, numerous questions need to be asked. To begin, the researcher uses the data seeking out the mercury rates of emissions in the study population. Using the archived data, other emissions will also be included but not be limited to pccd/f's, sulphur dioxide, and more. Do these emissions meet the regulations of the regions where the studies took place? What mercury emissions output may contribute to bioaccumulation? What factors may influence rates of toxic emissions by crematoria? Are mechanical remediation equipment required in the regions of the studies participants? Lastly, does the choice of crematorium fuel influence emissions?

Study Population and Sampling

The study population includes 77 (number of separate cremations) over the course of a 24 hour period at four separate locations. In order to do a statistical analysis, much more data is required. Nonetheless, using this data with their countries overall death and cremation rate, the information will be hypothesized to predict the amount of toxic emissions being released into the atmosphere. The following table outlines the archived data's locations and variables:

Table 3.1

Global Crematorium Emissions Study Population: One Day Observation

Crematorium	Location	Number of Factors	Unit of Analysis	Number of Cremations	Study Length
1 Mount Pleasant Group of Cemeteries	Canada	12	µg/m3	4	1 Day
2 Parndon Wood Crematorium	England	6	µg/m3	3	1 Day
3 Mercury Emission from Crematories in Japan	Japan	1	µg/m3	14	1 Day
4 Kwai Chung Crematorium	Hong Kong;	12	µg/m3	56	1 Day

Note. Details on various aspects of these data available in the appendix.

Presentation of Data

In Table 3.1 an overview of the crematoria being studied is presented. The total number of cremations, unit of analysis, and study length is used as a baseline for the overall cremation statistics related to those countries being researched. The following table demonstrates the number of crematorium in each country where the facilities of study are located. This is to assist the reader towards a clearer understanding of potential magnitude of toxic emissions being produced by the process of cremation.

Table 3.2

Cremation Statistics

	Canada	Hong Kong	Japan	United Kingdom
Overall Death Rate	259,995	46,662	1,376,865	600,598
Number of Crematorium	261*	6	1,460	3,204
Cremation Rate	65%	89.90%	99.97%	77.05%
Total Number of Cremations	168,997	41,949	1,376,452	462,761
Rough Estimates of Particular Matter	**	**	**	**

Note. Cremation statistics. (n.d.). Retrieved from http://www.cremation.org.uk/statistics.

*excludes Quebec, Canada.
** Using the data provided by The Cremation Society of Great Britain and from the selected crematorium, rough estimates of Total Particulate Matter, Mercury, and Furans will be determined. Also, all results will be based on a specific time interval.

Research Sites

In this research, four separate emission studies conducted by consulting/engineering firms were performed using a total of 77 cases. This represents 24 cremators and 15 stacks in total. The reason why multiple cremators will link to one stack is to accommodate the current architectural limitations of the roofing and to minimize expenses on expansion. This is important to know because it is unknown if this affects the overall efficiency of the cremators technological stack design. In doing so, each deliverable was designed per the specifications of each crematorium's locale, including defined regulatory statutes.

The primary focus of this study is mercury. Other concerns, where tested, include pccd/f's, total particulate matter, organic compounds and carbon monoxide, cadmium, hydrogen sulphide, hydrogen chloride, sulphur dioxide, and arsenic. The results of all the studies are represented in concentrations in Micrograms Per Cubic Meter ($\mu g/m^3$), a derived metric SI (System International) measurement unit of density used to measure volume in cubic meters in order to estimate weight or mass in micrograms (Aqua-Calc., 2019). The concentration of an air pollutant (eg. ozone) is given in micrograms (one-millionth of a gram) per cubic meter air or µg/m3 (European Environment Agency, n.d.).

Mount Pleasant Group of Cemeteries

Church & Trought (CTI), A Trinity Consultants Company, was retained by Mount Pleasant Group of Cemeteries (MPGC) to conduct Ontario Ministry of the Environment (MOE) compliance source testing as identified as a condition of the Environmental Compliance Approval (ECA). This was issued in 2013 (Church & Trought, 2014).

The facility contains one Facultatieve Technologies FTIII cremator unit for human remains, equipped with a primary and secondary chamber. A continuous emission monitoring (CEM) system measures and records the temperature, oxygen, and carbon monoxide of the primary and secondary chambers. These measured parameters are indicators of the efficiency of the combustion process. The flue gas from the secondary chamber pass through a cooler before proceeding to the fuel gas treatment system consisting of a sodium bicarbonate and powdered activated carbon injection system. The cooled and treated gas subsequently flows to the pulse-jet type baghouse, and finally discharges to the outside through a stack (Church & Trought, 2014).

Table 3.3

Mount Pleasant Group of Cemeteries Emissions Data

Cremator	Fuel	Remediation	Toxic Emissions
FT-III Cremator by Facultatieve Technologies	Natural Gas	Pulse Bag Filter (Remediation Process)	Total Suspended Particulate Matter Selected Metals (i.e. mercury) Semi-volatile Organic Compounds Volatile Organic Compounds Hydrogen Chloride Nitrogen Oxide Sulphur Dioxide Carbon Monoxide Carbon Dioxide Oxygen Total Hydrocarbons Compounds Odour

Note. The ECA identified the following contaminants to be tested on the gas exhausting the pollution control equipment of the human cremation unit. All testing used the Pulse Bag Filter. The dependent variables are measured in Micrograms per cubic meter (µg/m3). Testing consisted of 12 separate cases at 1 hour 30 minutes each, maximum 4 per day utilizing the one cremator (based for 40 cremations per month) on-site between June 23, 2014 and June 26, 2014 in accordance to the conditions set forth by the Ontario Ministry of the Environment (MOE). The cremator employed an abatement system.

Parndon Wood Crematorium

Davies & Co (Engineering) Limited was contracted by Parndon Wood Crematorium in Harlow, Essex, England to perform emission testing on two cremators and the associated flue gas abatement system. The work on site involved monitoring the flue gas components after the flue gas abatement system fitted to the cremator with the plant operating normally. The crematorium being tested comprises two cremators, No. 1 of model type FTIII with a wider hearth and No. 2 of model type FTII, both manufactured by Facultatieve Technologies, and both fitted with two nozzle mix burners utilizing natural gas as the support fuel (Davies & Co., 2016).

The waste gases from both cremators combine and are ducted to a flue gas treatment plant. The treatment plant comprises of a shell and tube boiler to cool the flue gases, a reagent feeder station that introduces a blend of activated carbon/sodium bicarbonate to react with cooled gases, and a bag filter to clean the treated gases. The waste heat from the boilers in the form of warm water is dissipated to the atmosphere via a finned tube air blast cooler situation outside the crematory. The measurements were undertaken to enable comparisons to be made in the operation of the cremators and associated abatement system.

The cremators and flue gas abatement system were manufactured, installed and commissioned by Facultatieve Technologies Limited to meet the requirements of the Environmental Permitting (England & Wales) Regulations 2010 (EPR 2010) as relevant (Davies & Co., 2016). In chapter four, the total skeptical emissions for the crematory will be mathematically determined. The total number will then be converted into micrograms per cubic meter and ultimately tons per year.

Table 3.4

Parndon Wood Crematorium Data

Cremator	Fuel	Remediation	Toxic Emissions
FT-II Cremator by Facultatieve Technologies	Natural Gas	Pulse Bag Filter (Remediation Process) both furnaces	Total Particulate Matter Hydrogen Chloride Mercury Carbon Monoxide Total Organic Compounds Oxygen
FT-III Cremator by Facultatieve Technologies	Natural Gas	Pulse Bag Filter (Remediation Process) both furnaces	

Note. The two cremators and associated flue gas abatement system at Parndon Wood Crematorium, Harlow, Essex, CM19 4SF were monitored on the 15th March 2016 to the requirements given in the Process Guidance Note PG5/2 (2012) for emission releases to atmosphere. The dependent variables are measured in Micrograms per cubic meter (µg/m3). Three separate 1 hour tests were conducted on 2 separate cremators to the requirements given in Process Guidance Note PG5/2 (2012) (England and Wales) for emission releases to atmosphere. Both cremators employed an abatement system. Results based on batch process system and filtered particulate matter.

Mercury Emission from Crematories in Japan

In Japan, 99.9% of dead bodies are cremated, the highest percentage in the world, and more than 1,600 crematories are in operation (Takaoka et al., 2010) I obtained data from seven facilities. The Department of Urban and Environmental Engineering, Graduate School of Engineering, Kyoto University, Nishikyo-ku, Japan used continuous emission monitoring to measure the mercury concentrations and investigate mercury behavior (Takaoka et al., 2010).

For religious reasons, mercury emissions from crematories in Japan are not regulated by the Air Pollution Control Act or the Waste Management and Public Cleansing Act (Takaoka et al., 2010). However, examining mercury emissions from crematories is needed to determine their environmental impact and to take measures to reduce or monitor them if necessary.

In this study, four of the seven crematories implemented bag filters, one utilized an electrostatic precipitator, and the other two had no remediation equipment installed. Each decedent's case was tested individually for mercury emissions. Upon conclusion of the testing, the Japanese study allows for the Department of Urban and Environmental Engineering to have a better understanding on how the fuel used, remediation equipment implemented and the decedent themselves influence the total rate of toxic mercury emissions. In chapter four, the data will be represented.

This table gives an overview of the variables identified in the study. The fuel selected for the use of cremation and whether remediation techniques were implemented is also shown. The data can be used to further determine what impact fuel and remediation usage has on the environment, in particular, toxic emissions, if any. As cremation grows globally as the primary method of final disposition, the ability to compartmentalize each aspect of the cremation process is better served now than in the future.

Table 3.5

Mercury Emission Data from Crematories in Japan (Various Locations)

Cremator	Fuel	Remediation	Toxic

			Emissions
Furnace 1	Natural Gas	Pulse Bag Filter	Mercury
Furnace 2	Natural Gas	Pulse Bag Filter	
Furnace 3	Kerosene	Pulse Bag Filter	
Furnace 4	Natural Gas	Electrostatic Precipitator	
Furnace 5	Kerosene	-	
Furnace 6	Kerosene	-	
Furnace 7	Natural Gas	Pulse Bag Filter	

Note. Emission testing performed by the Department of Urban and Environmental Engineering, Graduate School of Engineering, Kyoto University, Nishikyo-ku, Kyoto, 615-8540, Japan. The study was inspired in coordinance with The United Nations Environment Programme (UNEP) and their goal of a worldwide reduction in mercury. Manufacturer of furnaces is unknown. The dependent variables are measured in Micrograms per cubic meter (µg/m3). Seven crematory furnaces were tested using continuous emission monitoring to measure the mercury concentrations and investigate mercury behavior. The annual amount of mercury emission from crematories in Japan was estimated by using the total number of corpses cremated in correlation to this studies sampling. The cremators fuels sources were Natural Gas and Kerosene. Five of the cremators employed abatement systems. Each case was sampled from start to finish and the burn times varied case to case and were dependent size of body, gender, and container used.

Kwai Chung & Cape Collision Crematorium

In Hong Kong, the Regional Services Department (RSD) is responsible for the operation of crematoria in the new territories. In order to cope with the increasing demand for cremation services, RSD have an intention to re-new and expand the existing facility of Kwai Chung Crematorium. Hyder Consulting Ltd were commissioned by Architectural Services Department (Arch S D) to undertake an environmental study for the project (Architectural Services Department, 1998). In addition, Cape Collision Crematorium, a large facility with 10 cremators was also included. Together, the outcome of the study was used to compile an Air Pollution Control Plan (APCP) and the necessary information which in turn ensured the design of the proposed crematorium as environmentally acceptable. The data, including 12 dependent variables and one independent variable, will be used for future developments of crematorium, not just Kwai

Chung. Using these guidelines, the facility will be developed so that the operators can achieve the environmental standards recommended by the Environmental Protection Department (EPD) (Architectural Services Department, 1998), and increase professional standards.

Upon conclusion of Hyder Consulting's research, the existing crematory will be demolished and replaced by a more efficient system of cremators, implementing a single stack system, creating operations more efficient and environmentally acceptable. The criteria are based on the ambient air quality guidelines of the World Health Organization (WHO) for mercury, cadmium, and hydrogen sulphide, the Canadian National Air Quality Objectives for hydrogen fluoride, the California Air Resources Board (CARB) for hydrogen chloride, the risk assessment guidelines of the California Air Pollution Control Officers Association (CAPCOA) for nickel and arsenic (Hyder Consulting, 1998). Upon further investigation, the equipment tested did not include remediation process nor were the manufacturers of the cremators identified.

Table 3.6

Kwai Chung Crematorium Data

Cremator	Fuel	Remediation	Toxic Emissions
Twin Cremator (Linked to one	Light Diesel	None	Sulphur dioxide Nitrogen dioxide

stack)			Carbon dioxide
Twin Cremator (Linked to one stack)	Light Diesel	None	Lead Mercury Cadmium Nickel Arsenic Hydrogen sulphide Hydrogen chloride Hydrogen fluoride Organic compounds

Note. Environmental guidelines from monitoring and management of the facility have been developed so that the operators can achieve the environmental standards recommended by the Environmental Protection Department (EPD). The resultant air pollutant concentrations at air sensitive receivers (ASRs) in the vicinity of the crematorium should comply with the Air Quality Objectives (AQO) stipulated by the Air Pollution Control Ordinance (APCO). The dependent variables are measured in Micrograms per cubic meter (µg/m3). This study utilized outdoor air sensitive receivers (ASRs) in the vicinity of the crematorium and complied with the Air Quality Objectives (AQO) stipulated by the Air Pollution Control Ordinance (APCO). The emission samples from the ASRs were 1 Hour, 8 Hours, 24 Hours, 3 Months, and 1 Year from 1997-1998.

In both the Kwai Chung and Cape Collision Crematorium data, two differences occur. First, light diesel is used. Second, no abatements are in place. In this situation, the emissions that potentially exist may or may not differ from crematory's that use natural gas, propane with a combination of remediation or without. Also, the toxic emissions could differ simply based on the clients they serve. These are all aspects we need to analyze in chapter four when the results are identified.

Table 3.7

Cape Collision Crematorium Data

Cremator	Fuel	Remediation	Toxic Emissions
Cremator 1,2,3, & 4 (Linked to one stack)	Light Diesel	None	Sulphur dioxide Nitrogen dioxide Carbon dioxide Lead Mercury

Cremator 5,6,7, & 8 (Linked to one stack)	Light Diesel	None	Cadmium Nickel Arsenic Hydrogen sulphide Hydrogen chloride
Cremator 9 & 10 (Linked to one stack)	Light Diesel	None	Hydrogen fluoride Organic compounds

Note. Environmental guidelines from monitoring and management of the facility have been developed so that the operators can achieve the environmental standards recommended by the Environmental Protection Department (EPD). The resultant air pollutant concentrations at air sensitive receivers (ASRs) in the vicinity of the crematorium should comply with the Air Quality Objectives (AQO) stipulated by the Air Pollution Control Ordinance (APCO). The dependent variables are measured in Micrograms per cubic meter (µg/m3). This study utilized outdoor air sensitive receivers (ASRs) in the vicinity of the crematorium and complied with the Air Quality Objectives (AQO) stipulated by the Air Pollution Control Ordinance (APCO). The emission samples from the ASRs were 1 Hour, 8 Hours, 24 Hours, 3 Months, and 1 Year from 1997-1998.

Data Collection

In this study, documents and records from the crematoria, as noted in Figure 3.1, will be collected. This will consist of examining existing data in the form of databases, tables, reports, etc. For example, to understand the amount of mercury emissions from the population of the study, the outputs will be compared to that of the overall cremation rates of the region. Based on the results, the data collection will allow for the variables to be analyzed side by side. Also, this type of data collection, even with the limited nature of the data itself, will solely rely on the information collected by the independent testing resources.

Data Analysis

The crematoriums selected in this study were chosen based on the specifics of emission testing. Irrespective of geographical location, crematoriums operate likewise. What typically separates them from each other are the volume of cremations being performed annually, what kind of fuel being used, and whether or not remediation equipment has been installed. In this research, 24 cremators were subjected to emission performance reviews by consultants and engineers to test the total output of pollutants.

Based on the goal of this study, the selected cases met the requirements towards determining what factors may influence rates of toxic emissions by crematoria. Also, the aim of this study is to educate the public about toxic emissions from crematoria as well as introduce sustainable practices to offset toxic emissions. Having an equal mix of cremators utilizing remediation equipment as well as not, allows for the data to present significant differences and comparisons. This, as a result, assists the data to indicate what factors do influence rates of toxic emissions and why. Also, the results of the data can more effectively assist the introduction of sustainable practices to offset the pollution caused by cremation.

Due to the lack of global emission testing of crematoria offered publicly, this study will focus on the data available compared to that of the overall cremation rate in those geographical regions. The variables will include the furnace, remediation equipment, and the fuel used for the cremation process and the overall cremation rate. Other variables will include various types of toxic emissions. The main reason for using this analysis is to understand the relationship between variables where available. For instance, some crematoria have implemented remediation equipment whereas others have not. Also, it should be noted that the actual make of the furnace will not be analyzed. However, by identifying the furnace as the means for cremation, it eliminates other means such as funeral pyres as a representative of data. Essentially, only the crematoria that had scientific inquiries were used for this analysis.

Statistical studies will not be performed due to the lack of data publicly available. Rather, the information will be deduced using calculations to convert the total into pounds per cubic meter to better determine the total forecast of toxic emissions in comparison to that of industrial waste incineration.

Implications of Study

The main aim in this study was to address the minimal research evidence on the emissions of crematorium which can be used to determine the influential factors surrounding the release of specific pollution. This was done by collecting data from the consultants and engineers who were contracted to perform the emission studies at the participant's crematories.

Accordingly, the first major practical contribution of the present research is that it provides much needed empirical data on the actual cause and effect of the process of cremation. Furthermore, no comparable studies were found on the subject of emissions and crematorium. Therefore, this research will allow policy-makers, trainers, consultants and others to design initiatives, tools and actions based on what crematoriums actually do and where they are now in terms of their bioaccumulation (rather than what they think they are doing).

This study, albeit skeptical, is of an exploratory and interpretive nature, raising opportunities for future research, both in terms of theory development and concept validation. More research will in fact be necessary to refine and further elaborate the research findings.

Ethical Considerations

In this research, archival data was used and no human subjects participated in the study. However, based on this research, my professional reputation may be at risk.

Limitations of Study

In this research, the limitations were sample size, including what emissions were tested for at each selected crematory. Unfortunately, limited international investigations of crematoria exist. Therefore, performing an objective analysis in collaboration with the overall cremation rate will assist in discoveries.

Delimitations of Study

In this research, I reduced the scope of the study by utilizing data specifically related to fire-based cremation. Water-based cremation and traditional burial methods do not affect the environment via stack emission. Therefore, I chose this direction to answer questions surrounding the environmental concerns with crematoriums and whether the data's relevance can assist current professional standards. This depth of research specifics will address the complexities in the questions at issue.

Summary

In summary, I use a quantitative approach in this analysis. The research focused on four contracted studies on crematoria, collecting mathematical data on emissions, and examining these data for systemic insights. This process allows me to test for potential influences on toxic emissions from crematoria. As stated earlier, this research may allow policy-makers, trainers, consultants and others to design initiatives, tools and actions based on what crematoriums actually do, suggesting sustainable practices towards lowering the pollution at crematoria.

Chapter 4: Results

Data analysis, whether quantitative or qualitative, is intended to summarize a mass of information, to answer the research questions, tests the hypotheses, examine the foreshadowed problems, and explore the conjectures. Although speculative, this study is focused on emissions of mercury and pcdd/f's where available. The data has been approached, collected, and interpreted systematically.

In November 1990, the Clean Air Act was revised by Congress and signed into law by President George H. W. Bush. Its amendments were designed to curb four major threats to the environment and to public health: acid rain, urban air pollution, toxic air emissions including mercury, and stratospheric ozone depletion. The 1990 Clean Air Act Amendments required the issuing of federal technology-based standards for major sources and for certain area sources. Section 112 required that EPA establish emission standards for major sources that would result to the maximum possible degree of reduction in emissions of hazardous air pollutants. These standards are referred to as "maximum achievable control technology" or "MACT" standards.

As a result of the MACT regulation, from the years 2003 to 2014, the air release of mercury in the U.S. decreased by 45%. The most efficient way to remove mercury from combustion gases is by means of dry scrubbing, followed by activated carbon injection and a fabric filter baghouse. Whether this is the result of only those remediation techniques being used or it can potentially differ for industry. In the crematorium, data will be representative of some of those emission reducing abatements, including pulse bag filtration and electrostatic precipitator.

The Hg sectors primarily focus on regulatory categories and groups of interest to the international community. In order to maintain a consistent comparative analysis, this study will use the MATS proposal towards Hg emissions and Hazardous Waste Incineration. The following table shows the 2014 NEI mercury emissions for Hazardous Waste Incineration in comparison to 1990. Also shown are the previous 2 triennial NEI years along with the most recent 2005 emissions, which were used in support of the MATS rule.

Table 4.1

Trends in NEI Mercury Emissions

Source Category	1990 (TPY***) Baseline for HAPS* 11/14/2005	2005 (TPY***) MATS** proposal 3/15/2011	2008 (TPY***) 2008 v3	2011 (TPY***) 2011 v2	2014 (TPY***) 2014 v1	2014 emissions as % of U.S. Total
Hazardous Waste Incineration	6.6	3.2	1.3	0.7	0.8	1.45%

*Note.**Hazardous Air Pollutants (HAPS)

**Mercury and Air Toxics Standards (MATS)
***Tons Per Year (TPY)

Based on the emissions in TPY for the category of Hazardous Waste Incineration, it is important to allow for meaningful comparisons. The concentrations of chemicals in air are typically measured in units of the mass of chemical, micrograms in this case, per volume of air (cubic meter or cubic feet). However, concentrations may also be expressed as parts per million (ppm) or parts per billion (ppb) by using a conversion factor. The conversion factor is based on the molecular weight of the chemical and is different for each chemical. In this study, we will be using the molecular weight of mercury (Hg).

In order to bring clarity to the overall dataset, it is important to calculate the total lb/yd^3 per year for each country where the crematoriums reside. All results are estimated based on the data collected. Although inferential in nature, the findings can be used to further the conversation of crematorium emissions and the procedures needed to offset the mercury bioaccumulation imprint. Furthermore, the information can be used to infer the amount of total emissions of Mercury already produced based on the overall numbers of cremations per year. This can be seen in the last table of this chapter. Lastly, by converting to lb/yd^3, the results can be compared to that of Hazardous Waste Incineration.

Table 4.2

Canadian Crematorium Estimated Emissions

Yearly Death Rate	Estimated Percentage of Cremations	Estimated Number of Crematoria	Projected Mercury Emissions µg/m^3	Mercury Emissions Converted to lb/yd^3 per year
259,995	0.65	261	1,299,975	2.191

Note: All conversions received from https://www.aqua-calc.com/. See appendix for calculations.

Overview: Table 4.2.

Using the data extrapolated from the Mount Pleasant Group of Cemeteries emissions with the application of mathematical calculations as demonstrated in appendix Table 4.2, skeptically, the total annual mercury emissions for the year 2017 in Canada was 2.191 lb/yd^3. Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower.

Table 4.3

Japan Crematorium Estimated Emissions

Yearly Death Rate	Estimated Percentage of Cremations	Estimated Number of Crematoria	Projected Mercury Emissions µg/m^3	Mercury Emissions Converted to lb/yd^3 per year
1,376,865	0.9997	1460	4,681,134.10	6.068

Note: All conversions received from https://www.aqua-calc.com/. See appendix for calculations.

Overview: Table 4.3.

Using the data extrapolated from the Japanese Crematoriums (various locations) emissions with the application of mathematical calculations as demonstrated in appendix Table 4.3, skeptically, the total annual mercury emissions for the year 2017 in Japan was 6.068 lb/yd^3. Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower.

Table 4.4

United Kingdom Crematorium Estimated Emissions

Yearly Death Rate	Estimated Percentage of Cremations	Estimated Number of Crematoria	Projected Mercury Emissions µg/m^3	Mercury Emissions Converted to lb/yd^3 per year
600,598	0.7705	3204	10,570,524.80	13.62

Note: All conversions received from https://www.aqua-calc.com/. See appendix for calculations.

Overview: Table 4.4

Using the data acquired from the Parndon Wood Crematorium emissions with the application of mathematical calculations as demonstrated in appendix Table 4.4, skeptically, the total annual mercury emissions for the year 2017 in the United Kingdom was 13.62 lb/yd^3. Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower.

Table 4.5

Hong Kong Crematorium Estimated Emissions

Yearly Death Rate	Estimated Percentage of Cremations	Estimated Number of Crematoria	Projected Mercury Emissions µg/m^3	Mercury Emissions Converted to lb/yd^3 per year
46,622	0.899	6	223,977.60	0.38

Note: All conversions received from https://www.aqua-calc.com/. See appendix for calculations.

Overview: Table 4.5

Using the data gathered from the Kwai Chung and Cape Collision Crematorium emissions with the application of mathematical calculations as demonstrated in appendix Table 4.5, skeptically, the total annual mercury emissions for the year 2017 in Canada was 0.38 lb/yd^3. Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower.

Table 4.6

Overall Estimated Data from Study

Country	Estimated # of Cremations per year (2016)	Projected Mercury Emissions (µg/m3) per Year	Projected Dioxin and Furan Emissions per Year	% Above or Below Standard for Mercury*	% Above or Below Standard for Dioxins and Furans**	lb/yd^3***
Canada	168,997	844985	4,140,426.50	148% Above	22,172.73 % Above	2.191
United Kingdom	462,761	8,144,593.60	-	550.61 % Above	-	13.62
Japan	1,376,452	4,649,336.80	-	483.95% Above	-	6.068
Hong Kong	41,949	201,355.20	-	40.74% Below	-	0.38
Total	2,050,159	13840270.6	4,140,426.50	-	22,172.73 %	22.259

Note. All data received from crematorium studied. The overall estimated numbers for each country was extrapolated from the crematorium tested.

*EPA Standard for Exposure to Mercury µg/m3 is 8.1.
** EPA Standard for Exposure to Dioxins is 0.11.
***lb/yd^3 Standard unit of measurement for Waste Incineration Emissions for this study

Overview: Table 4.6

Using the data from the research sites emissions with the application of mathematical calculations as demonstrated in the Appendix, tables 4.2-4.5, skeptically, the total annual mercury emissions for the year 2017 in their respective countries and was 22.259 lb/yd^3. Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower.

Table 4.7

Summary of Historical Cremation Data Mercury Emissions – US vs. Canada 1980-2002

Years	Cremations US	Cremations Canada	Total Cremations US and Canada	****Mean of 31.2 µg/m^3(Total US and Canada)	Total
1980	193343	32423	225766	7043899	7043899
1981	217770	34884	252654	7882805	7882805
1982	232789	37222	270011	8424343	8424343
1983	249182	41887	291069	9081353	9081353
1984	266441	44630	311071	9705415	9705415
1985	289091	49216	338307	10555178	10555178
1986	300587	54482	355069	11078153	11078153
1987	323371	53867	377238	11769826	11769826
1988	332183	57568	389751	12160231	12160231
1989	352370	60087	412457	12868658	12868658
1990	367975	62797	430772	13440086	13440086
1991	400465	66087	466552	14556422	14556422
1992	415966	64557	480523	14992318	14992318
1993	448532	70017	518549	16178729	16178729
1994	470915	75489	546404	17047805	17047805
1995	488224	79206	567430	17703816	17703816
1996	492434	81960	574394	17921093	17921093
1997	533773	85196	618969	19311833	19311833
1998	563384	90200	653584	20391821	20391821
1999	596721	101545	698266	21785899	21785899
2000	630800	106747***	737547	23011466	23011466
2001	650776	N/A	650776	20304211	20304211
2002	676890***	N/A	676890	21118968	21118968
Total	8817092	1243320	10167159	317215360	520.04 lb/yd^3

Note. Table adapted from Historical Cremation Data – United States vs. Canada and retrieved from Cremation Association of North America (CANA).

*Figure from the National Vital Statics System
**Figure form the Canadian Statistical Reference Centre
***Preliminary Figure
****Speculative
N/A = Not Available

Table 4.8

Overall Estimated Tons per Year (TPY) from Study

Country	Tons per Year
Canada	2.96
Hong Kong	0.513
Japan	8.19
United Kingdom	13.387
Total	25.05

Note. Mercury and Air Toxic Standards (MATS) = 3.2 TPY

Summary

Throughout the use of data from the research sites and skeptically applying those findings to the historical data (1980-2002) as supplied by CANA for both the US and Canada, the total mercury emissions is predicted to total 520.04 lb/yd^3 or rather 0.2359 ton/td^3. It is important to understand that the total number for estimated mercury emissions totaled the years 1980 – 2002. The number 0.2359 ton/td^3 represents the total for those Based on the 1990 baseline for Hazardous Air Pollutants (HAPS) of 6.6 tons per year and the 2005 Mercury and Air Toxics Standards (MATS) proposed 3.2 tons per year, crematoriums emissions are considerably lower. Also, it is important to recognize (please see Table 1.12) that the cremation rate is roughly 20% higher than the highest one-year total, in this case, the year 2002. With that said, the total number of mercury emissions will certainly be higher than the data represented in this study. Therefore, as more current data is presented, the data can further determine if the mercury emissions are staying within the current guidelines as represented by HAPS and MATS.

It is clear that cremation is growing. Currently, this has become the primary choice of final disposition in North America. With the growth, more crematoriums are being constructed. Furthermore, those crematories that are presently in business, the cremators may or may not be efficient in emissions management. This, along with the lack of implemented and/or regulated continuous monitoring systems, further data collection is required. Therefore, broader picture, as populations grow, the cremation rate will follow. This will reflect the overall output of toxic emissions created by crematorium. The data we have skeptically generalized is trending upward. Knowing this, a more complete testing regime followed by a transparent public discourse, may be needed.

Chapter 5: Discussion and Conclusions

This study aims to educate the public and funeral practitioners about the potential toxic emissions associated with cremation. Based on the results of the research, it is fair to assume that further emissions studies are needed. The global increase of cremation as the preferred choice of disposition will continue to increase emissions as the projected world population, as referenced in Table 5.2 demonstrates continued growth. Therefore, in this chapter, major findings will be analyzed including implications for action and recommendations for further research.

Major Findings

The decision to research crematorium emissions was done to develop a better understanding of the potential environmental impacts alongside remediation techniques to minimize any potential threats to air quality and bioaccumulation. With an increase in consumer and practitioner awareness, the questions of whether death is a health issues continues to grow. Simply put, the data pointed to other toxic emissions that are not discussed. Now whether this is due to minimized concerns based on lack of knowledge, the number of toxic emissions omitted to the atmosphere from incineration is significant.

In 1999, the EPA with collaboration of the Bronx Crematory conducted a test of emissions. Immediately after the test, crematories were dropped form "low priority" to "very low priority (EPA, 2005)." Testing proved that crematories operate so far below allowable limits for commercial/industrial incinerators, they require no further investigation. The EPA on December 16, 2005, entered its final rule into the Federal Register, 40 CFR Vol. 70 No. 241 Page 74881 Rules and Regulations: "Human crematories are not solid waste combustion units and are not a subcategory of OSWI for regulation (EPA, 2005)." The tests demonstrated that even if included as OSWI, crematories already far exceed the requirements imposed on higher-volume commercial/industrial/municipal units (EPA, 2005).

The data from this study compared to the Bronx Crematory tests performed by the EPA do not consistently meet the same output of numbers. The EPA focused on the toxic emissions from sulfur dioxide, dioxins and furans, and mercury. What the EPA study did not take into account was the type of machines being used across the country, if operators have been properly trained, other toxic emissions, the container and what it is made of, the clothes on the deceased, plastics including body bags, fuel selection, remediation equipment, and the water and soil in the vicinity. Also, when the test took place, the cremation rate in the US was roughly 26% (CANA, 2017). Since then, this number has doubled. Not only has that increased to twice that number, the population has also risen, therefore the increasing potential issues surrounding toxic emissions will also continue to go up.

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. Their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment. This has raised concerns over their potential effects on human health and the environment (Tchounwou, et al., 2012).

Our body is composed of almost every natural element found in nature (Family Wellness HQ, 2012). This is as true for metals as it is for water or carbon. It should also be noted that if the amount of metals in the human body are elevated or below normal levels, possible issues can occur.

For instance, Cobalt is a metal that occurs naturally in many different forms. Small amounts of it are found in most rocks, soil, water, plants, and animals. Cobalt is a component of vitamin B-12, which is required for good health. The largest use of cobalt metal is to make alloys, which retain strength even when very hot. It is also used to help paint dry quickly and possibly used in the production of caskets used for cremation. Cobalt is also used to make artificial body parts such as hip and knee joints (found in cremation). Pure cobalt does not dissolve in water, but will dissolve (or react) with acids. It will burn when exposed to heat. The fumes may be hazardous. Industrial emissions of cobalt and or cobalt compounds can produce elevated, but still low-level concentrations in the atmosphere around the source. Because of its short life expectancy in the atmosphere cobalt and or cobalt compounds are expected to be confined to the local area within which it is emitted (PEGEX, 2017). A confined area could be the geographical location of a crematorium or other industrial facility.

The toxicity of heavy metals on an individual depends on various factors. Dependent where the individual is located geographically, size, age, gender, and profession contribute to the differences. The dose, route of exposure, chemical species, and nutritional status of the living organism dictate the overall potential the toxicity will have. Table 5.1 outlines, but is not limited to, Arsenic, Lead, and Cadmium. These are all heavy metal toxins that can also be emitted via air stack emissions in the cremation process. As we continue to learn more about the potential affects toxic emissions may have, it is important to test for all emissions.

Radiation safety issues and cremation of a patient hosting radioactive seeds which are used for the treatment of various forms of cancer are also concerning. The precautions for dealing with radioactive cases are different than that of the normal cremation. Due to the nature of the seeds, precautionary measures need to be implemented that are not the same as it is for the standard instance. Therefore, it is essential for additional testing to be conducted, outlining each and every component linked to the potential harm for the crematory operator including neighboring facilities to that of the crematorium.

Remediation techniques for industrial incineration vary from electrostatic precipitators, pulse-bag filtration to scrubbers and sometimes a combination of all three. In this study, outside of Hong Kong and two units used by the Japanese locations, either electrostatic precipitators or pulse-bag filtration systems were used. It should be noted that because of the use of remediation equipment, unless the actual cremators are brought in-line with the current systems in place, it is difficult to say without solid before and after studies that the emission controls systems are actually working as designed. Also, if those studies were conducted, they have not been made public. This, as a researcher can be brought forth more skepticism towards crematoriums and the control systems in place to protect the funeral practitioners and community.

Fuel is often overlooked when it comes to cremation. Incinerators, started electrically, run typically in the US on Natural Gas. However, many crematoriums use Propane instead. In this analysis, the primary forms of fuel used were Light Diesel, Kerosene, and Natural Gas. It should also be noted, that in countries such as India for example, wood is still the primary source of fuel to conduct the cremation process. Therefore, if and when continued research is performed, it should always take into consideration the fuels being used.

Table 5.1

Other Heavy Metal Toxins, Sources, and Effects

Heavy Metal	Sources	Effects
Arsenic	Agricultural Soil.	Peripheral Nervous
	Groundwater used for drinking and irrigation.	System
	Production of pesticides, herbicides and	Excessive Perspiration
	insecticides.	Muscle Tenderness
	Semiconductor Manufacturing.	Weakness
	Animal Food.	Changes in Skin Pigment
	Preservation of timber.	Intestinal Pain
	Geological	Burning eyes and throat
	Cremation	Diarrhea
	Waste Incineration	Dizziness
	Manufacturing	Nausea
	Mining	Sensory loss
	Residential Decks	Cardiovascular failure
Cadmium	Dental Acrylics “Cadmium Red” – Dentures	Renal Function
	Cigarettes	Pulmonary
	Mining and Smelting Activities	Cardiovascular tissues
	Pigments and Paints	Bone
	Electroplating	Peripheral Nervous
	Electroplated parts (nuts and bolts)	System
	Batteries (Ni-Cd)	Hypertension
	Plastics and synthetic rubber	Weight loss
		emphysema
Lead	Old lead pigment paints	Developmental disorders
	Batteries	Behavior problems
	Industrial smelting and alloying	Loss of IQ
	Some types of solders	Hearing loss
	Ayruvedic herbs	Poor growth
	Some toys and from products from China	Headache
	Glazes on ceramics (Outside of the US)	Metallic taste
	Leaded fuels	Loss of appetite
	Bullets	Constipation
	Fishing sinkers	Colic
	Artist paints with lead pigments	Frank anemia
	Leaded joints in some municipal water systems	Tremors

Note. Information retrieved from Carson B.L. et al Toxicology and Biological Monitoring of Metals in Humans, Lew Publishers, Chelsea, MI. pp. 272-75, 1986.

Data Interpretation

To conclude, the data brought great meaning towards further studies of crematoriums. The numbers, being quite different each other, point to some potential issues on how emissions studies are performed and what is specifically tested for. By using four different studies from four different geological locations, the amount of emissions released currently and historically should be a focus to determine best practices in analysis.

Implications for Action

The cremation of bodies is a source of mercury emissions into the air. This is related to the use of amalgams in dentistry to fill in cavities in teeth as well as diet, in particular, the consumption of fish. According to Wilson et al. (2012), in 2010 its share of the global emissions was barely 0.2%, i.e. in absolute values on average 4.8 t/year (1.4–14.3 t/year), and, according to Pacyna et al. (2010a, b), in 2005, it was 26 t/year.

In the world, the practice of cremation is related to customs and beliefs, e.g. it is very seldom used in Muslim and Greek Orthodox countries. In Japan, 99.9% of bodies are cremated (Takaoka et al. 2010) and the mercury emissions into the air from persons who died at the age of 66–65 years amount on average to 161 mg/body, while those at the age of 0–59 emit less than 20 mg/body (Takaoka et al. 2010). In Europe, single bodies contain 2–5 g of mercury (Pacyna et al. 2008). The largest contributors to the emissions from this source are the countries of East and South-East Asia, with 16 t/year, and Europe, with 3.75 t/year (Cain et al. 2008; Pacyna et al. 2010a, b).

In this study, the potential amount of mercury emitted per year in lbs/yd^3 totaled 22.259 or 0.01 t/year. The total tonnes per year were much less than the previously mentioned studies. Whether or not this number coincides with Cain, Pacyna, Takaoka or

Wilson's estimation is unknown and purely speculative based on the lack of publicly available data globally. It is also important to realize that their research is also notional, as no reliable and global testing has been done to confirm their estimations.

When comparing this study's findings to that of Solid Waste Incineration, a significant difference exists. The Arctic Monitory and Assessment Programme (AMAP) and the United Nations Environment Programme (UNEP) in 2008 researched global anthropogenic emissions of mercury to air. Waste incineration, waste and other was estimated to release 125 tonnes of mercury annually whereas cremation discharged 25.7 tonnes. These numbers are extremely important. The previously mentioned researcher's numbers may have derived from the results from the AMAP/UNEP study as the numbers fall in line. However, based on the examination of data from the sources publicly available for this study, the number of 0.01 t/y was significantly lower. It should be noted though that the AMAP/UNEP study was done from a global perspective, widely increasing the range of data to be included in comparison to this study.

As the population of our world continues to grow, the impact that humans have on the environment will continue to grow as well. Crematoriums, like alternative industry's where incineration takes place, may be part of this damaging impact. Still, crematoriums need to be monitored carefully to minimize environmental impact. Tables 5.1 and 5.2 show both historical and projected world population figures. Whether Wilson's, Takaoka, AMAP, UNEP, or this examinations data differ, the growth of the world's population may continue to increase toxic emissions.

The Georgia Department of Public Health states in their "Common Health Concerns About Crematory Operations" fact sheet that, "There are no federal or state environmental regulations from crematories. Studies conducted by the U.S. Environmental Protection Agency show that crematory emissions (Substances discharge into the air) are at levels well below regulatory and health guidelines. The capacity, location, odors, noise, and hours of operation of a crematory are governed by local zoning ordinances." Although much of this is true, the fact sheet lists no references to actual studies outside of one for mercury. This is the problem. If we are to provide consumers and practitioner's information, it needs to be accurate, publicly available, recent, and it must include all potential toxic emissions caused by cremation. This, in its essence is why this dissertation was done – to point out all of the possible issues and to broadcast to all readers that we as the public do not have legitimate information based from valid scientific studies.

Table 5.2

World Population (2018 and Historical)

Year	Population	Yearly Change	Yearly Change
2018	7,632,819,325	1.09%	82,557,224
2017	7,550,262,101	1.12%	83,297,821
2016	7,466,964,280	1.14%	83,955,460
2015	7,383,008,820	1.19%	84,967,932
2010	6,958,169,159	1.24%	83,201,955
2005	6,542,159,383	1.26%	79,430,479
2000	6,145,006,989	1.33%	78,706,515
1995	5,751,474,416	1.53%	84,106,191
1990	5,330,943,460	1.81%	91,432,333
1985	4,873,781,796	1.80%	83,074,052
1980	4,458,411,534	1.79%	75,864,867
1975	4,079,087,198	1.97%	75,701,910
1970	3,700,577,650	2.07%	72,196,992
1965	3,339,592,688	1.94%	61,276,032
1960	3,033,212,527	1.82%	52,193,998

Note. Data retrieved from http://www.worldometers.info

In table 5.2, an overview of historical world populations is represented. In table 5.3, the world population is forecasted through 2050. The tables are both important as it directly relates to cremation. With cremation as the primary method of disposition in North America as well as other nations, these numbers alongside crematorium emission tests, could project environmental issues currently unforeseen. This, as a result, can be used to foretell solutions including estimated timelines for delivery.

Table 5.3

World Population Forecast (2020-2050)

Year	Population	Yearly Change	Yearly Change
2020	7,795,482,309	1.09%	82,494,698
2025	8,185,613,757	0.98%	78,026,290
2030	8,551,198,644	0.88%	73,116,977
2035	8,892,701,940	0.79%	68,300,659
2040	9,210,337,004	0.70%	63,527,013
2045	9,504,209,572	0.63%	58,774,514
2050	9,771,822,753	0.56%	53,522,636

Note. Data retrieved from http://www.worldometers.info

According to the World Bank, for every 1,000 people in the world, an average of 7.748 people will die each year and 19.349 will be born. That's a ratio of about 2.5 births for every death. Those figures are from 2014 but both are slowing at similar rates, so the ratio hasn't changed much in the last 10 years. What is important with these statistics, are its ability to forecast funeral industry specific emissions. Also, it is important to note that not all countries track mortality rates. Therefore, future funeral industry emission rates can only be speculative.

Recommendations for Further Research

In order to better understand how to eliminate toxic emissions and prevent environmental pollution, a systematic approach has to be approached in future research.

Government

In the case of crematoriums, local, county, and state governmental entities should begin the process of collecting, and making readily available to the public, information that is currently unavailable. Due to geographical differentiations, how toxic emissions could impact a region may or may not be different. This would include but is not limited to the effects of design and operating conditions on emissions and what characteristics of the process of incineration and combinations within that optimize the effectiveness of emission-control devices. Resources for continuous emission monitors, emissions-control technologies available, operating practices and other techniques that could be used to minimize toxic releases should be documented for crematoriums. Data is needed on the level of emissions to allow for the analysis of why differentials may exist and how to remedy the issues.

Although less studied, the bioaccumulation of pccd/f's is gaining attention as represented by Mari and Domingo's research of toxic emissions from crematories in 2009 (Mari & Domingo, 2009). Pccd/f's and other heavy metal toxins have not been thoroughly tested for. When CANA and the EPA studied Woodlawn Cemetery in the Bronx, New York, in 1999, many of the emissions global communities are concerned about were not studied for, focusing primarily on mercury. The study, possibly comprehensive in 1999, is no longer valid and needs to be re-evaluated. As we continue to learn more about the dangers included with emissions, change is necessary. If states were mandated to collect this information, either through private or governmental testing, the EPA would be able to analyze the true overall effect of the cremation process. Until this is done, the consumer will continue to receive fact sheets such as Georgia's and this is unacceptable.

Data Gathering by Crematoria Operators

To better evaluate the conditions of the crematorium and to facilitate evaluations of the overall contributions of pollution, estimates of dispersion of incinerator emissions into the environment should be gathered. This information should be analyzed on a regional-scale framework in order to be effective for that particular region. Dependent the call volume of the crematory, these estimates will differ. If this data is collected correctly, precise geographic locations of the emission point will be available. This data in turn, should be standardized for uniform reporting to the government, funeral industry and the communities they reside.

Crematory operators are the best resource to train when utilizing modern technology such as continuous monitoring systems. Mari and Domingo in 2009 stated that information on occupational exposure to individuals working in crematories is particularly scarce. With implemented protocols and technology, through proper guidance, information can be obtained by those currently at risk with cremation, the operators.

Health Effects

Increase the use of epidemiologic studies to assess the health effects of incinerators of every type, not just crematoriums. The assessments of health risks attributable to cremation should pay particular attention to mercury, dioxins and furans, particulate matter, and all other potentially dangerous toxic emissions. Lastly, work exposure should be taken seriously. Those who work at the crematorium should be part of a comprehensive plan that assists them in biological monitoring and use that data to assist in efforts to reduce exposures of workers. Testing should be conducted by experts who work with emissions analytics. This would include certified consultants, EPA, air quality agencies that perform stack testing, and more.

Environmental communication is paramount. As previously stated, disclosure is compelling and oftentimes controversial for reasons for too numerous to discuss (International Environmental Communication Association, 2017). If the workers and community are at risk of exposure from toxic emissions created by incineration, it is vital to gather the required information. Community and worker alike deserve to know what risks are involved, and how to minimize or eliminate them from the source.

Social issues

The geographical of the area of the crematorium potentially affected by cremation should not be defined at the outset by a particular community's political or jurisdictional powers. This would include zoning regulations specific to that region. Instead, the assessment area for new crematoriums should be based on the geographic extent over which various effects could reasonably occur. Using the Weatherford, Texas example, a conditional use permit was granted by the Planning and Zoning Board without passing City Council. It is the opinion of many Weatherford residents that to operate a crematory; it need pass both the Planning and Zoning Board and City Council before receipt of an operational permit (Bays, 2011).

Concerned community citizens should be allowed to conduct their own assessments at their own cost. Resources should be available for those in the community to use such as consultants, technical advisers, and possible grant money available for specific considerations. Although emissions from crematoriums may be considered very low priority to the EPA, those who work directly in or with the funeral industry may not feel the same way. From a social perspective, we cannot be quiet and we must authenticate answers.

Uncertainty and Variability

In the literature review, we learn that modern cremation has only been in practice for roughly over a century now. This, as a result has sprung up many different opinions and concerns from communities and practitioners. Although only over century ago, experimentation led to the development of a dependable chamber. Today we have those in abundance and we are seeking answers beyond the machine.

Community members who might be exposed to crematorium emissions are likely to differ in their susceptibilities and activity patterns. Some uncertainties may be specific to the process of cremation and some are characteristic of any process that releases potentially harmful pollutants to the environment. The National Research Council (US) Committee on Health Effects of Waste Incineration, suggest that incineration risk assessments should include the following components of uncertainty and variability analyses:

- An estimate of the variability and uncertainty distributions of all input values and their effects on final estimates.
- A sensitivity analysis to assess how model predictions are related to variations in input data.
- Variance-propagation models that show how the variability and uncertainty of final results are tied to the uncertainties and variabilities associated with the various models, their inputs, and assumptions used through the risk assessment.

Although cremation is not considered solid waste incineration and is also not regulated, a consistent set of testing rubrics need to be put into place. Such as the experimentation to create a dependable chamber, we now need to develop dependable emissions controls.

These recommendations are a start to creating transparency to the cremation process and the potential harmful effects of toxic emissions. If and when future studies are conducted, greater consideration should be given to emission levels achieved in the actual performance of the cremators.

Concluding Remarks

In chapter one, I talked about what cremation is, statistics surrounding the funeral industry, costs, and terminology. Additionally, the aim of the study was determined along with the proposed methodology to be used in this skeptical explorational inquiry. In the literature review, we touched upon briefly on the history of cremation. Also, types of emissions from modern crematoria, fuels used, environmental communication and community concerns were highlighted. Moving onto chapter three, all the data from the research sites were collected and analyzed. Ethical considerations, limitations and delimitations of study were delineated. Lastly, in chapter four the results of the research were discussed, extrapolating the data and displaying the skeptical conclusions of emissions. Furthermore, in order to better understand the data, all figures were converted into tons per year as to compare cremation hazardous waste incineration.

Although the industrial process of modern cremation has been in practice for over a century, it can be said that measures to improve and mitigate impacts to the environment have moved quite slow. Whether this is based on the fact that cremation has not been the primary form of disposition for the last 100 years, or if it is simply economics, due to the rising population and increased demand for the cremation, the direction of the funeral industry and the processes that surround it are going in a new direction.

Leaders imagine an inspiring future and strive to shape it rather than passively watching the future happen around them (Lowney, 2003). Recognizing the importance of dealing effectively with the health aspects surrounding the emissions of incineration is paramount. Therefore, leaders need to be comfortable in this rapidly changing world. It is critical to eagerly explore new ideas, approaches, and the cultures surrounding the funeral industry, including the requirements for the disposition of the decedents. We cannot shrink defensively from the truth by deflecting it. If we depend on our core beliefs and values, then being a good steward to the environment. We are not the product of our environment, but rather the environment is the product of us.

Funerals have occurred longer than our imaginations can fathom. We have recently seen a profound trend towards emphasizing the celebration of life rather than the choice of disposition. Economics change perspectives and create a bottleneck in advancement due to fear of the unknown. In this business environment, firms are solving their issues, embracing the progression of the clientele, trying to stay one step ahead of the trend thus molding it into a source of community involvement and revenue. It is these funeral homes that our leaders our being nurtured. It is at these funeral homes where we need to engage their leaders to consider the ramifications of the trends, especially when documented dangers of the by-products exist. To work with the manufacturers of cremators developing state of the art remediation techniques to further reduce harmful emissions from the incineration process.

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Footnotes

[1]Alkaline hydrolysis (also called biocremation, resomation, flameless cremation, or water cremation) is a process for the disposal of human remains which produces less carbon dioxide and pollutants than cremation. The process is being marketed as an alternative to the traditional options of burial or cremation. Will water-based cremation be any better? If so, will this justify an increase in cost.

Appendix

Institutional Review Board

Creighton UNIVERSITY

Institutional Review Board
2500 California Plaza • Omaha, Nebraska 68178
phone: 402.280.2126 • fax: 402.280.4766 • email: irb@creighton.edu

DATE:	April 24, 2018
TO:	Brad Kuchnicki
FROM:	Creighton University IRB-02 Social Behavioral
PROJECT TITLE:	[1212134-1] Environmental Issues Associated with Crematoria: A Review
SUBMISSION TYPE:	New Project
ACTION:	IRB REVIEW IS NOT REQUIRED
EFFECTIVE DATE:	April 24, 2018
EXPIRATION DATE:	April 23, 2020
TYPE OF REVIEW:	Administrative Review

Thank you for your submission of New Project materials for this project. The following items were reviewed in this submission:

- Creighton - IRB Application Form - Creighton - IRB Application Form (UPDATED: 04/18/2018)
- CV/Resume - BKuchnickiResume2018.pdf (UPDATED: 03/25/2018)
- Other - Kuchnicki_DIP_4_1_2018.docx (UPDATED: 04/8/2018)
- Other - citiCompletionReport5244409.pdf (UPDATED: 03/25/2018)
- Other - Research Design.docx (UPDATED: 03/25/2018)

It has been determined that this project does not involve human subjects under 45 CFR 46.102(f). IRB review is not required.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Christine Scheuring at 402-280-3364 or christinescheuring@creighton.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Creighton University IRB-02 Social Behavioral's records.

Table 4.2 Canadian Crematorium Estimated Emissions (Mathematical Operations)

Calculations:

Solve for Parts Per Billion

Concentration (ppb) = 24.45 x concentration ($\mu g/m^3$) ÷ molecular weight of Hg

Conversion Factor for solving Parts per Billion = 24.45

Concentration in $\mu g/m^{3\,=}$ 1,299,975

Molecular Weight of Hg = 200.59

Concentration (ppb) = 24.45 x 1,299,975 $\mu g/m^3$ ÷ 200.59 = 158,454.50 ppb

Solve for Mass of Emissions

Concentration (mg/m^3) = 0.0409 x concentration (ppb) x molecular weight of Hg

Conversion Factor for solving Mass = 0.0409

Parts Per Billion = 158,454.50

Molecular weight of Hg = 200.59

Mass of Emissions (mg/m^3) = 0.0409 x 158,454.50 x 200.59= 1,299,981.48 mg/m^3

Millimeters Per Cubic Meter Converted to Tons Per Cubic Meter

Tons per cubic meter (t/m^3) = divide the mass / volume value by 1.308e+9

1,299,981.48 Mg/m^3 / 1.308e+9 = 0.0013 t/m^3

Tons Per Cubic Meter to Pounds Per Cubic Yard

lb/yd^3 = multiply the mass/volume by the conversion factor (1685.555)

0.0013 t/m^3 x 1685.555 = 2.191 lb/yd^3 (Mercury Emissions Annually)

Table 4.3 Japan Crematorium Estimated Emissions (Mathematical Operations)

Calculations:

Solve for Parts Per Billion

Concentration (ppb) = 24.45 x concentration (µg/m^3) ÷ molecular weight of Hg

Conversion Factor for solving Parts per Billion = 24.45

Concentration in µg/m^3 = 4,681,134.10

Molecular Weight of Hg = 200.59

Concentration (ppb) = 24.45 x 4,681,134.10 µg/m^3 ÷ 200.59 = 570,585.42 ppb

Solve for Mass of Emissions

Concentration (mg/m^3) = 0.0409 x concentration (ppb) x molecular weight of Hg

Conversion Factor for solving Mass = 0.0409

Parts Per Billion = 570,585.42

Molecular weight of Hg = 200.59

Mass of Emissions (mg/m^3) = 0.0409 x 570,585.42 x 200.59= 4,681,157.53 mg/m^3

Millimeters Per Cubic Meter Converted to Tons Per Cubic Meter

Tons per cubic meter (t/m^3) = divide the mass / volume value by 1.308e+9

4,681,157.53 Mg/m^3 / 1.308e+9 = 0.0036 t/m^3

Tons Per Cubic Meter to Pounds Per Cubic Yard

lb/yd^3 = multiply the mass/volume by the conversion factor (1685.555)

0.0013 t/m^3 x 1685.555 = 6.068 lb/yd^3 (Mercury Emissions Annually)

Table 4.4 United Kingdom Crematorium Estimated Emissions (Mathematical Operations)

Calculations:

Solve for Parts Per Billion

Concentration (ppb) = 24.45 x concentration (µg/m^3) ÷ molecular weight of Hg

Conversion Factor for solving Parts per Billion = 24.45

Concentration in µg/m^{3} = 10,570,524.80

Molecular Weight of Hg = 200.59

Concentration (ppb) = 24.45 x 10,570,524.80 µg/m^{3} ÷ 200.59 = 1,288,445.74 ppb

Solve for Mass of Emissions

Concentration (mg/m^{3}) = 0.0409 x concentration (ppb) x molecular weight of Hg

Conversion Factor for solving Mass = 0.0409

Parts Per Billion = 1,288,445.74

Molecular weight of Hg = 200.59

Mass of Emissions (mg/m^{3}) = 0.0409 x 1,288,445.74 x 200.59= 10,570,524.80mg/m^{3}

Millimeters Per Cubic Meter Converted to Tons Per Cubic Meter

Tons per cubic meter (t/m^{3}) = divide the mass / volume value by 1.308e+9

10,570,524.80Mg/m^{3} / 1.308e+9 = 0.00808 t/m^{3}

Tons Per Cubic Meter to Pounds Per Cubic Yard

lb/yd^{3} = multiply the mass/volume by the conversion factor (1685.555)

0.00808 t/m^{3} x 1685.555 = 13.62 lb/yd^{3} (Mercury Emissions Annually)

Table 4.5 Hong Kong Crematorium Estimated Emissions (Mathematical Operations)

Calculations:

Solve for Parts Per Billion

Concentration (ppb) = 24.45 x concentration (µg/m^{3}) ÷ molecular weight of Hg

Conversion Factor for solving Parts per Billion = 24.45

Concentration in µg/m^{3} = 223,977.60

Molecular Weight of Hg = 200.59

Concentration (ppb) = 24.45 x 223,977.60µg/m^{3} ÷ 200.59 = 28,519.63 ppb

Solve for Mass of Emissions

Concentration (mg/m^3) = 0.0409 x concentration (ppb) x molecular weight of Hg

Conversion Factor for solving Mass = 0.0409

Parts Per Billion = 28,519.63

Molecular weight of Hg = 200.59

Mass of Emissions (mg/m^3) = 0.0409 x 28,519.63 x 200.59= 233,978.78 mg/m^3

Millimeters Per Cubic Meter Converted to Tons Per Cubic Meter

Tons per cubic meter (t/m^3) = divide the mass / volume value by 1.308e+9

233,978.78 mg/m^3 / 1.308e+9 = 0.0002 t/m^3

Tons Per Cubic Meter to Pounds Per Cubic Yard

lb/yd^3 = multiply the mass/volume by the conversion factor (1685.555)

0.0002 t/m^3 x 1685.555 = 0.38 lb/yd^3 (Mercury Emissions Annually)