cremations. Another study, this time from Norway, found "no measureable increase in the amount of mercury in the soil surrounding the crematoria over background levels" after performing some 70,000 cremations over a 30-year period.

4.0 CONCLUSIONS

Based on the additional literature reviewed for this addendum, the U.S. EPA emission rate of 1.5 grams per cremation used in the original study is representative but not necessary conservative. It is possible that the mercury content of a single cremation could reach 8.6 grams (depending on the mass of dental amalgam in the deceased teeth). For ease of calculation, one might consider that worst-case emissions could be an order of magnitude (10 times) greater than the original 1.5 gram assumption (i.e., 15 grams per body). Based on that assumption and continuous presence of mercury at that level in all cremations, the estimated maximum ground-level mercury concentration in air could be 10 times greater than the value presented in CEC's original report. Nevertheless, even at that higher emission rate, the health risk would still be over seven times below the EPA's risk screening threshold for residential exposure. Given the very conservative nature of this analysis, it is felt that the original conclusions regarding the lack of significant health risk associated with residential inhalation exposures are confirmed and strengthened.

Based on the additional literature reviewed relative to soil concentrations, the original assumption that inhalation would be the primary exposure pathway has been supported. Residential exposures to deposited mercury in soils are not expected to be significant relative to inhalation exposure.

We hope that this additional information helps to provide additional support to CEC's statements regarding the lack of significant health risks associated with exposure to atmospheric mercury emissions from the proposed cremator exhaust.

Very truly yours,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

Kristian A. Macoskey, QEP
Principal

Emory T. McLean, P.E.
Vice President

Enclosures

CREMATOR CLEARANCES

	RECOMMENDED		MINIMUM	
TOP: (2)	2 FEET	[610 mm]	6 INCHES	[152 mm]
CABINET SIDE:	4 FEET	[1.22 m]	4 FEET	[1.22 m]
OTHER SIDE:	2 FEET	[610 mm]	6 INCHES	[152 mm]
FRONT:	9 FEET	[2.74 m]	8 FEET	[2.44 m]
REAR:	3 FEET	[0.91 m]	32 INCHES	[812 mm]
STACK:	6 INCHES	[152 mm]	6 INCHES	[152 mm]

1. FOR CLEARANCES OTHER THAN THOSE SHOWN, OR FOR SPECIAL REQUIREMENTS, CONSULT YOUR MCD REP.
2. FROM HIGHEST POINT ON UNIT.
3. CONTROL CABINET MOUNTS ON UNIT'S LEFT OR RIGHT SIDES, OR REMOTELY. (SEE PLAN VIEW, SHEET 1).
4. REAR OF UNIT REFERS TO THE "BACK PLATE", RATHER THAN THE BACK OF THE *"WHISPER SHIELD"*. (SEE PLAN VIEW, SHEET 1).

CREMATOR REQUIREMENTS

FUEL: A PRESSURE REGULATOR ADJUSTABLE TO 7" [178 mm] W.C. FOR NATURAL GAS, OR 11" [279 mm] W.C. FOR LP GAS.

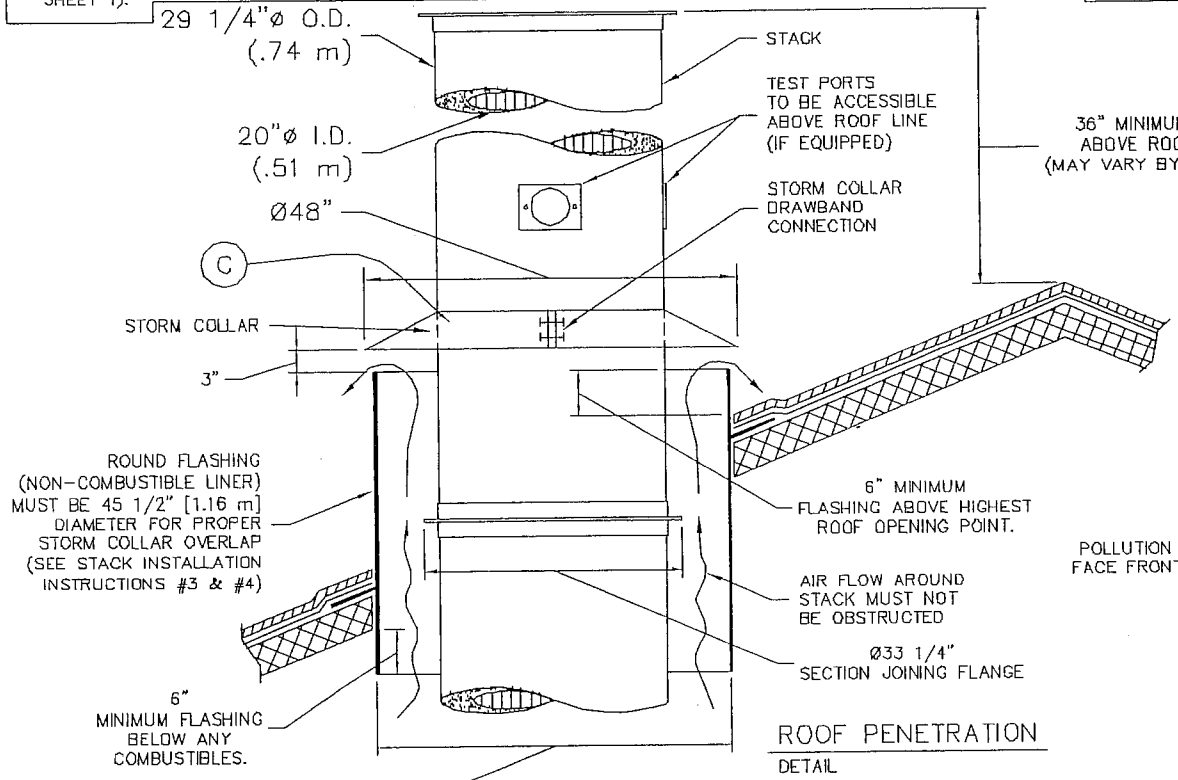
CAPACITY: RANGES FROM 2.0 TO 3.0 MILLION BTU/HR [2.1 TO 3.1 MILLION KILOJOULES/HR] DEPENDING UPON AMOUNT OF BURNERS.

ELECTRICAL: 230 VOLT, 3ø, (40A BREAKER) AND 115v (10A BREAKER). OR 230 VOLT, 1ø, (70A BREAKER) AND 115v (10A BREAKER) 50/60 HERTZ

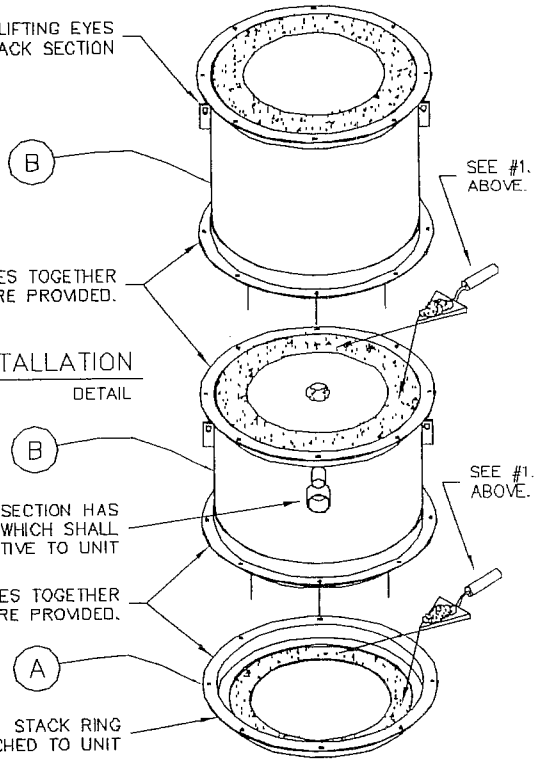
AIR: LOUVER NEAR THE REAR OF THE UNIT CAPABLE OF PASSING 2,500 CU FT/MIN [70.8 CU M/MIN] OF FREE AIR (36" X 36") [914 mm X 914 mm].

STACK INSTALLATION INSTRUCTIONS

1. APPLY A 1/2" THICK MORTAR JOINT TO EXPOSED REFRACTORY SURFACE IN STACK RING. LOWER THE BASE STACK SECTION (B) ONTO STACK RING (A) AND FASTEN WITH HARDWARE PROVIDED (NO MORE THAN (2) STACK SECTIONS SHALL BE LIFTED TOGETHER). REPEAT PROCESS FOR REMAINING STACK SECTIONS. IF SECTIONS OF VARYING LENGTHS ARE SUPPLIED, ASSEMBLE AS TO AVOID FLANGES & LIFTING EYES INTERFERING WITH RAIN COLLAR LOCATION.
2. INSTALL STORM COLLAR ON STACK, 3" [76 mm] ABOVE NON-COMBUSTIBLE LINER (FLASHING), ALLOWING FOR PROPER VENTILATION (SEE DETAIL).
3. APPLY A 1/4" [6 mm] BEAD OF HIGH-TEMPERATURE SILICON SEALANT (PROVIDED BY MCD) TO THE JOINT BETWEEN THE STORM COLLAR (C) AND THE STACK (B).
4. STORM COLLAR IS FURNISHED BY MCD. THE NON-COMBUSTIBLE LINER (FLASHING) TO BE PROVIDED BY THE OTHERS.
5. IF FIFTY PERCENT OF THE STACK LENGTH IS ABOVE THE ROOF, GUY WIRES MAY BE REQUIRED. CONSULT WITH YOUR MCD REP.
6. RAIN CAP NOT REQUIRED.



ROOF PENETRATION
DETAIL



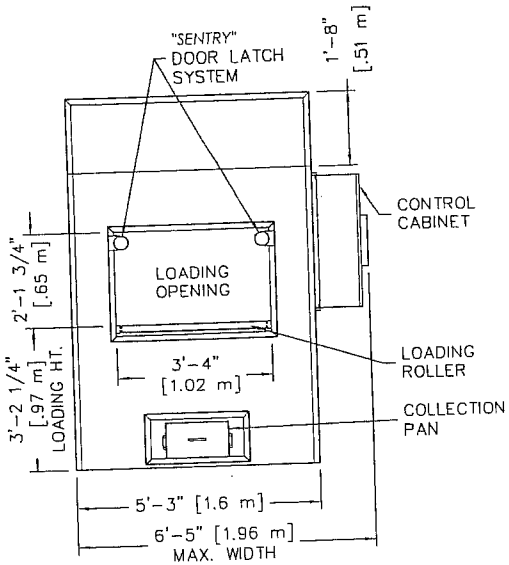
STACK INSTALLATION
DETAIL

Matthews CREMATION DIVISION
2045 Sprint Boulevard
Apopka, Florida 32703
USA

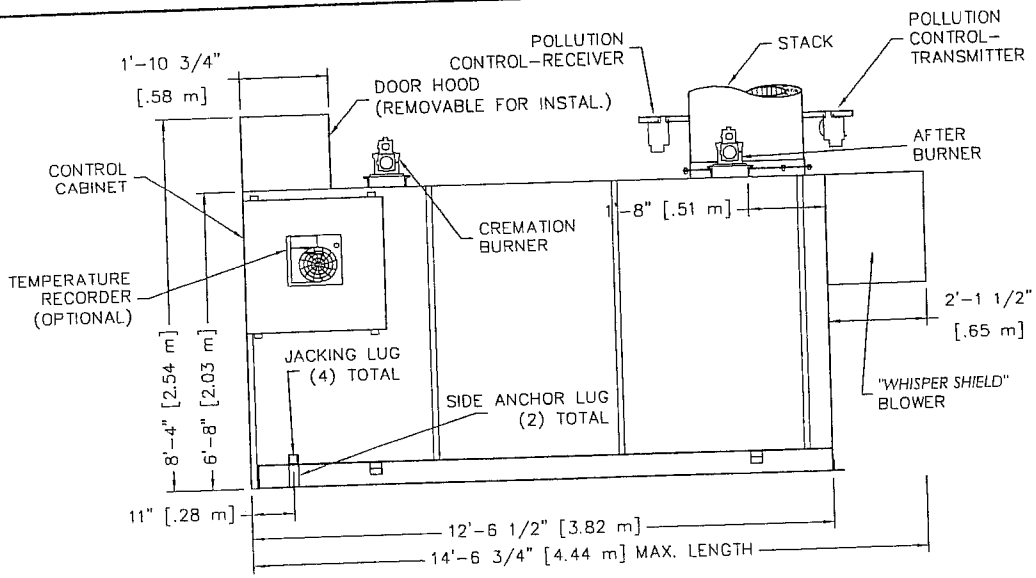
POWER-PAK II

STACK DETAILS, CLEARANCES & INSTALLATION INSTRUCTIONS. REFRACTORY STACK DETAIL

DATE:	08-18-05	SCALE:	1/2"=1'
DRAWN:	JG	PLOT SCALE:	1:24
APRVD:		SHEET:	2 OF: 2
DWG FILE:	PPII-MarketingStackRefS2R2		
DWG #:	0000140		



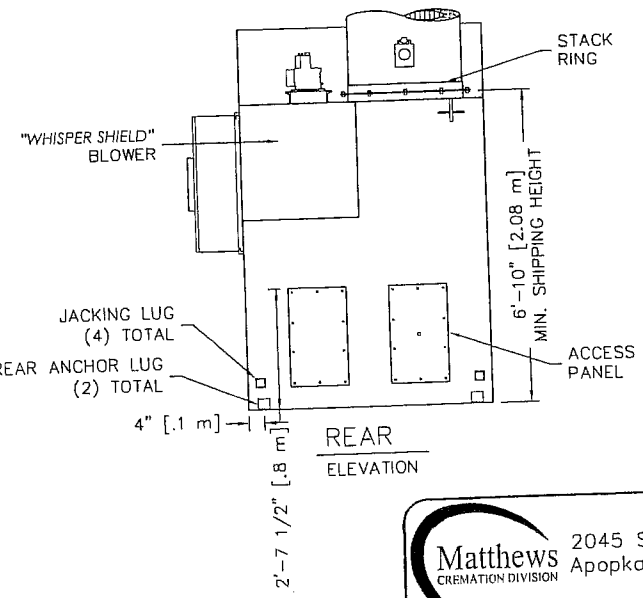
FRONT ELEVATION



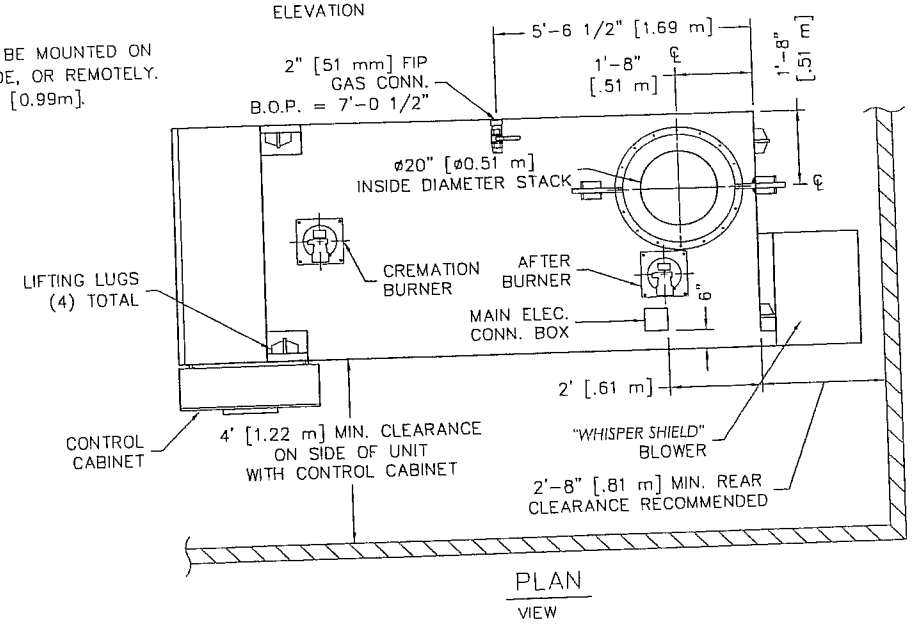
RIGHT SIDE ELEVATION

NOTES:

1) CONTROL CABINET CAN BE MOUNTED ON THE LEFT OR RIGHT SIDE, OR REMOTELY.
2) CHAMBER WIDTH IS 39" [0.99m].



REAR ELEVATION



PLAN VIEW

Matthews CREMATION DIVISION
2045 Sprint Boulevard
Apopka, Florida 32703
USA

POWER-PAK II

PLAN & ELEVATIONS INCL: CLEARANCES, REQUIREMENTS & RECOMMENDATIONS

DATE:	10-26-06	SCALE:	1/4"=1'
DRAWN:	JG	PLOT SCALE:	1:48
APRVD:		SHEET:	1 OF: 2
DWG FILE:	PPII-MarketingPlanElevS1R4		
DWG #:	0000140		

Matthews INTERNATIONAL
Cremation Division

The Standard of Excellence in Cremation

Mercury Emissions and the Cremation Process - 2008

By Paul Rahill Matthews Cremation Division

Concern for the well being of the environment is evident from all the discussion taking place in almost every facet of our daily life. It is almost impossible to pick up a newspaper or turn on a television or talk radio without the topic of the environment being discussed.

The human impact on our environment is being studied in every area of life. But the concern is not stopping there. We also continue to research what impact we are having *after* life and for the purposes of this article, specifically from the cremation process.

Great advances have been made in the reduction of particulate matter (PM), visible emissions (VE) and carbon monoxide (CO) from the cremation process. Particulate matter and carbon dioxide are the two most commonly regulated pollutants from cremation equipment. The most extensive cremation equipment emissions research ever undertaken confirmed that the design and operation of typical North American crematories provided significantly better emissions than regulations required, and even exceeded expectations with older operating systems.

Now the focus has turned to mercury emissions. Some concerns over mercury emissions from crematories in the United States and Canada continue to be voiced. The good news is that the internet has provided easier access to articles on the topic of mercury emissions. Unfortunately, much of what we see on many topics found on the web is not fact based but rather opinions, theories or consultants quoting consultants.

The United States Environmental Protection Agency (EPA) describes mercury as a "naturally occurring element that can be found throughout the environment". Although naturally occurring, different human activities can increase or decrease the amount of mercury that is moving between the atmosphere, bodies of water and soils.
Mercury may be a naturally occurring element but over-exposure to it is not a good thing for humans.

According to the US EPA (chart ES-6) some of the top human activities most responsible for recycling mercury in the environment are: municipal incinerators, breaking of fluorescent tube lamps, dental facilities, production and disposal of batteries, household trash disposal and residential heating (oil). The operation of crematories is one of the lowest sources.

The most notable way that mercury enters the cremation cycle, and therefore crematory emissions, is through silver amalgam dental fillings found in some dead human bodies.
Silver amalgam fillings contain mercury alloys that when introduced through dead humans into the cremation process of intense heat, often exceeding 1800F, results in the volatilization of mercury and its emissions into the atmosphere.

Silver amalgam dental fillings containing mercury have been common for many years, but their use appears to be in significant decline. Within the last 10 years, the percentage of fillings containing mercury has already declined by 30%, a tremendous decrease.

So what factual data do we have regarding mercury emissions from cremation equipment?

Testing for mercury in crematoria emissions was recently completed in the United Kingdom. The test protocols, procedures and final results from this endeavor were reviewed with the governing environmental authorities (DEFRA and SEPA) in the United Kingdom.

This testing was likely the most extensive mercury emissions test of its kind ever conducted on human cremations for this specific purpose. Determining the baseline mercury emissions from human remains that contain silver amalgam dental fillings was the sole focus of this research.

Testing protocol and supervision was developed and conducted by Dr. Ian M. Dale, forensic scientist. Dr. Dale is with Glasgow Occupational Health, Royal Infirmary, Glasgow Scotland.

Testing was conducted under British testing standards BSEN13211-2001, for the monitoring and control of trace elements. The mercury testing equipment used was a NEM-5 calibrated continuous measuring instrument as provided, calibrated and operated by Pelican Scientific LTD.

Fifty four (54) total human cremations were tested at two separate locations in the UK. All testing was conducted under normal operating conditions for the cremation equipment.

Test results were submitted to and reviewed with DEFRA - United Kingdom Department of Environment Food and Rural Affairs as well as SEPA- Scottish Environmental Protection Agency. Both agencies accepted the test as being conducted in compliance with the British testing standards BSEN13211-2001.

Testing for mercury in crematoria emissions was also conducted in the United States by the USEPA, United States Environmental Protection Agency. The test protocols and procedures were submitted by Midwest Research Institute and were reviewed and approved by the USEPA.

This USEPA testing was the most extensive comprehensive emissions test of its kind ever conducted on human cremations. In addition to testing for numerous possible emissions, various temperatures were also tested to determine the impact of temperature on emissions output. Determining the baseline mercury emissions from human remains that contain silver amalgam dental fillings was only one outcome of this research.

Testing was conducted using USEPA test methods, specifically EPA Method 29 for metal emissions sampling.

Nine (9) human cremations were tested at The Woodlawn Cemetery in the Bronx, New York, USA. All testing was conducted under normal operating conditions for the cremation equipment.

Test results were submitted by EPA's contractor, Midwest Research, to USEPA and reviewed by their staff. EPA accepted the test as being conducted in compliance with testing standards. The data was published by USEPA as the established baseline for mercury emissions and posted to the National Emissions Database as a reference for all interested parties.

Test Data Summary

UK TEST-1 (Craigton Crematorium/Pelican Scientific)

- Conducted in October 2006
- 23 cremations total
- Normal operating conditions
- 10 cremations suspected to have no silver amalgam fillings
- Average mercury release per cremation over 23 cremations - .128 grams per body
- Average mercury release per cremation for only the 13 cremations believed to contain silver amalgam fillings - .227 grams per body

UK TEST – 2 (Linn Crematorium/ Pelican Scientific)

- Conducted in September 2007
- 31 cremations total
- Normal operating conditions
- 21 cremations suspected to have no silver amalgam fillings
- Average mercury release per cremation over 31 cremations - .323 grams per body
- Average mercury release per cremation for only the 10 cremations believed to contain silver amalgam fillings – 1.001 grams per body

USEPA TEST – 1 (Woodlawn Crematorium/ Midwest Research Institute)

- Conducted in June 1999
- 9 cremations total
- Normal operating conditions
- 2 cremations suspected to have no silver amalgam fillings
- Average mercury release per cremation over 9 cremations - .456 grams per body
- Average mercury release per cremation for only the 7 cremations believed to contain silver amalgam fillings – .584 grams per body

We can use all this reliable test data to project a worst case scenario by averaging only the 30 tests where mercury emissions were present, only those bodies that contained silver amalgam fillings. In other words, this average would assume that 100% of the cremated population has some silver amalgam fillings. We know of course that this is a gross overstatement.

The average mercury emissions from these documented tests, under a worst case scenario, would be .568 grams of mercury emitted per body cremated.

It is very interesting to note that this average of .568 grams is almost identical to the USEPA test average of .584 grams per body. This current information confirms that the mercury emissions information located in the USEPA National Emissions database is accurate for determining the mercury emissions impact of cremation.

These three testing projects represent some of the most in depth environmental testing performed on cremation equipment anywhere to date. Relying on factual test data for important environmental decisions is critical if we are to make responsible decisions that will affect the communities we serve.

Mercury use in the dental profession is already significantly in decline. However we should continue to scrutinize the input of all types of materials into crematories while looking for and encouraging alternative materials to be used whenever possible.

Important environmental questions will continue to come up and it is important to address them by relying on the factual information that is available to us. Being a good environmental neighbor requires us to be fact based, informed and involved.

Paul Rahill is the President of the Matthews International Cremation Division (MCD) headquartered in Orlando, Florida.
He also serves as the environmental advisor and liaison for the CANA (Cremation Association of North America) Board of Directors.
Paul can be reached at prahill@matw.com .

Washington County
Planning Commission
100 West Beau Street, Suite 701
Washington, PA 15301-4470

Phone: 724-228-6811
Fax: 724-250-4110

RECEIVED
MAR 14 2011

March 11, 2011

Peters Township
Township Council
610 East McMurray Road
McMurray, PA 15317

RE: Proposed Zoning Ordinance Amendment Section 201 – Definitions

Dear Council:

We have received and reviewed the proposed zoning ordinance amendment of which involves changes to Section 201 – Definitions.

We have no comments regarding the proposed ordinance amendment.

Since there are many variables involved in a zoning ordinance amendment, an opinion should be rendered by your municipal solicitor.

We would like to remind you that within 30 days of the enactment a copy of the adopted amendment is to be forwarded to the office.

If you have any questions or comments do not hesitate to contact our office.

Sincerely,

Jason E. Theakston
Land Use Planner

xc: Ed Zuk
File

Patricia Moore
Peters Township Environmental Quality Board
104 Soft Shadow Lane
Venetia, PA 15367

March 15, 2011

Peters Township Council
610 East McMurray Road
McMurray, PA 15317

To Members of Council,

The Peters Township Environmental Quality Board (EQB) is very concerned with air quality issues in the southwestern Pennsylvania region. We face myriad assaults on the air we breathe over some of which we have no control as we are downwind of whatever activities are occurring in other states west and southwest of Pennsylvania. According to a recent Heinz Endowment study most of our region's poor air quality is locally produced and primarily a result of coal-fired electric generating plants. While recognizing this is the most significant source of air pollution the EQB thinks it prudent to address other sources and potential sources of toxic emissions.

The crematory opposition group (PTRACO) has, in the EQB's opinion, addressed this issue in an emotionally charged but not necessarily wholly scientific manner. Unfortunately, they have misrepresented the EQB comments made during our March 8 meeting attended by one of their members. We would wish that this collective passion for air quality issues could be applied to encouraging our state and federal representatives to forcefully address and embrace clean energy alternatives.

This is not to say there are not legitimate air quality concerns associated with crematory emissions, and as a neighborhood is adjacent to and downwind from the funeral home/crematorium site, every effort should be made to protect the residents from these emissions. It appears that we do have the authority to enact fairly strict air pollution ordinances. The EQB suggests that Council explore all options in this regard including researching ordinances from other Pennsylvania municipalities and requiring the most recent technology be used to eliminate toxic emissions. The Department of Environmental Protection does regulate crematoriums requiring the "removal of medical devices and potentially hazardous remedial devices". Whether this could include mercury dental fillings should also be researched.

There are quite likely more hazardous emissions from the tailpipes of the countless automobiles and trucks traveling Route 19 and the hundreds of gas fueled power and riding mowers used by area residents. The general consumption oriented lifestyle of typical suburbanites also contributes to unhealthy air quality. But if we are able to prevent, through regulation, one more potential hazard why would we not?

Sincerely,

Pat Moore
Environmental Quality Board

CC: Michael Silvestri
Kim Zachary
EQB members
Kevin Laster

Silvestri, Michael A.

From: Samuel Hazo [samuelhazo@gmail.com]
Sent: Thursday, March 17, 2011 1:01 AM
To: Zuk, Edward J.; Silvestri, Michael A.
Subject: Copy of my last email - You're in it, so know what it says

Dear Peters Township Residents,

I have spent the past few days accumulating the most important "facts" that need to be disseminated, as there are some misnomers floating around out there. Additionally, I will explain the purpose of this Monday's Council meeting.

First, Monday's Council meeting: 7:30 PM, 3/21/2011, Township Offices (by the Library and Police Station)

This is a public hearing at which Council will hear people either for or against a crematory and/or Mrs. Belusko's proposed ordinance. It is my understanding that "Crematorium" is the entire subject of the meeting. Also, Ed Zuk explained to me today that Council will NOT be voting at the meeting, they only will be there to listen. (If that changes, I'll tell you.) My advice... BE THERE. Unfortunately, I can not speak because I am conducting a concert that evening and there is no way for me to get out of it. Besides, I addressed Council last Monday and I'm saving my best for the Zoning Board when the agenda item comes up. THIS IS YOUR CHANCE!!!! They need to hear more voices and see more faces. Also, under normal conditions, Council would only want to hear facts. However, I think that in this case, letting them know what's in your heart is just fine. They set it up to be a "public hearing." ...So, let 'em "hear the public!"

LATEST FACTS: (a/k/a "Crematories for Dummies")

1. The township is truly in a legal bind. Each of 12 attorneys, with whom I have spoken, has said the same thing: The Peters Twp. ordinances in regard to crematories are very open to challenge. Peters must provide for all legal uses, and presently they go as far as to specifically exclude crematories. Hence, don't be shocked if Mrs. Belusko wins the legal battle in the ordinance challenge.

2. This doesn't mean that a crematory is starting up tomorrow. It simply means that Peters must allow for this use somewhere within its borders. The township must define the location, as well as the standards for application and use. As well, there are other hurdles that Mrs. Belusko must clear before she can operate a crematory, and it's our job to make those hurdles 20 stories high. The Kulpmont Air Protection petition that you all just signed is a big one.

3. Don't expect Planning Director Ed Zuk or Township Manager Mike Silvestri to exhibit anything but a poker face. They must do that regardless of their personal feelings, either way. It's their job! Allow this analogy... In-and-Out Burger is a "Legal Use" business. Suppose Ed Zuk and Mike Silvestri hate In-and-Out Burger. Suppose they hate the food, logo, management style, speech patterns, etc. Also, they know that all of Peters hates In-and-Out Burger too. Then, someone applies to open an In-and-Out Burger here. The residents are screaming at Ed and Mike, "Why don't you stop this?" ...Crematories are a legal use. Yes, there are a million valid reasons why we don't want them here, but they can't be subjected to bias from the Planning Director or Township Manager any more than In-and-Out Burger. If Ed or Mike spoke their mind, heart or anything else except the ordinances they were sworn to uphold, the township would have deeper legal issues.

4. If we take away Mrs. Belusko's votes, we take away the crematory. The PT Zoning Hearing Board is the deciding body on all building and zoning issues. If they vote down a crematory, for any number of reasons that

they feel are substantive, then Mrs. Belusko can't have one. I'll inform you of when the Zoning Hearing Board will be voting on the crematory issue. ...No sure date right now.

5. People have asked if I maintain a website for PTRACO. I do not. The individuals who recently created PTRACO formed it autonomously from me. I use these emails to communicate to those who signed up for them. ...And the Crossgates people who didn't sign up for them, but asked to get them anyway. :-)

6. Final fact... People asked if I have hit the crematory advocates with everything I have. ....Nope.

I REALLY LOOK FORWARD TO HEARING HOW THE MEETING WENT!

Gratefully,

Samuel Hazo

March 3, 2011

Dear Peters Township Official,

As a concerned Peters Township (PT) resident, it is with extreme concern that I write this letter to you regarding the proposed crematory to be located in Peters Township. I have outlined concerns on the first page and have detailed information to follow. In addition I have included several scientific documents for your review. I urge you to read these documents and give them serious consideration prior to making any decision about the crematorium as a crematorium has environmental and health risks as well as a negative effect on property values. You need to represent the best interests of Peter Township as you bear the ultimate responsibility for the safety and well being of the residents of Peters Township.

Please consider the following key points:

1) Based on data from Cremation Association of North America (CANA), the demands for cremation are projected to rise such that nearly half of all Americans will choose cremation.
2) No federal, state, or local regulations or ordinances exist to effectively control the pollutants from crematories.
3) According to "Dust in the Wind? The Bell Tolls for Crematory Mercury" published in 2010, it is documented that cremation is a significant source of mercury emissions. According to the US EPA website, mercury is a neurotoxin known to cause serious damage to the brain, kidney, and lungs.
4) A Penn State study determined that property values decrease within the vicinity of crematoriums. A conservative estimate of roughly $5 million would be lost tax revenue to the township due to declining property values of approximately 411 homes within 0.5 mile radius of the crematory.
5) To amend the zoning ordinance or grant a variance or special exemption to allow the proposed crematory is contrary to the premises of the current zoning ordinances.

Due to these significant risks to the community, PT should consider the following:

1) Independently investigate the concerns set forth in this letter by utilizing field experts.
2) Independently investigate the crematory's claims as well as the claims from the manufacturer of the proposed equipment.
3) Investigate other townships' ordinances (definitions, regulations, and other quality control measures) to control avoidable pollutants related to crematories.
4) Enact a moratorium if PT is actively investigating the concerns associated with crematories or enact strict ordinances (ie. Air quality, etc.) to protect its residents.

Bottom Line:
There are significant and legitimate concerns that the proposed crematory will pollute the environment, lower property values, and affect the health of nearby residents. A crematorium is incompatible land use more appropriately located in a less populated area away from homes and children (at least a mile radius). I am not willing to wait for the industry and regulations to catch up with what science has already proven as my home and family's health are at risk. When purchasing our home, we relied on the current zoning regulations and oppose any variance or rezoning to allow for a crematorium. It is a constitutional right to "enjoy and profit" from one's property as no property owner has the right to make one's land less valuable or hinder one's constitutional right to enjoy it.

It is expected that as PT council members and fellow residents you represent the best interests of PT.

Sincerely,

Cheryl Ferris, PhD

Projected Trends: **Nearly half of Americans will choose cremation in the near future.**

The demand for cremation is rising and current projections estimate nearly 1.5 million cremations will take place by 2025. According to CANA, nearly half of Americans plan to be cremated when they die.

Regulations: Crematories are severely under regulated by the US FDA and PA DEP. In addition, no local ordinances exist to control for the lack of federal and state regulations related to pollutants.

Currently, the US EPA does not regulate crematories. In 2005, it was estimated that crematories emitted into the environment almost 3,000kg (6,613 lbs.) of mercury in the United States. This estimate will only increase as more bodies are cremated in the future.

Pennsylvania's Department of Environmental Protection's General Plan Approval and/or General Operating Permit for Human or Animal Crematories has shocking omissions. Consider the following:
1) The regulations do not monitor or set any standards for the mercury emissions from crematoriums nor does it require dental amalgams (mercury fillings), breast implants, artificial joints, prosthetics, etc. to be removed prior to cremation. According to "Dust in the Wind? The Bell Tolls for Crematory Mercury" published in 2010, a cremated body with mercury fillings is directly linked to mercury emissions.
2) Crematory operators are not required to be certified or licensed to carry out their operations.
3) The one option for proper functioning of the crematorium is merely observation of odor and smoke color. Once odor and/or colored smoke is detected, the crematorium is already functioning improperly and toxins are released into the environment.
4) Stack tests which determine the presence of particulate matter only are not required to be performed annually and do not have to be performed on the actual unit. This means Ms. Belusko, the owner of the proposed crematorium, doesn't have to test her unit(s) and can simply submit a copy of a stack test performed on an identical unit within the last five years.
5) There are no precautions required in the event of a power outage. If the crematory loses power, the unit stops working and all pollutants are released into the air without any filtering process.

CANA & Ms. Bulseko's Claims: CANA claims their mercury and other pollutants emissions are low, however safe levels of mercury have never been established. Mercury and dioxin emission reports related to Ms. Bulesko's desired equipment, Matthews Power-Pak II, are not listed in her application.

According to CANA's website (www.cremationassociation.org), it states that their mercury emission is low. It should be known that the World Health Organization (WHO) concluded that a safe level of mercury exposure has never been established and the US EPA acknowledges the significant health risks of mercury exposure. CANA also states that the use of dental amalgams is declining; however they fail to mention that the rate of cremation is expected to increase faster than the decrease in the amount of mercury used for dental fillings. CANA objects to removing teeth that contain mercury filings as it is an 'act of mutilation' (according to their website), yet CANA does not view the removal of medical devices as 'mutilation' prior to cremation because any implanted medical device with a battery will explode during the cremation process potentially damaging equipment.

In Ms. Bulesko's application materials to PT, she projected 100 cremations will be performed annually. Does this projection take into account that her proposed facility has two burners in place? (Why would 100 cremations annually warrant 2 burners?) Also in her materials submitted to PT in the review by Civil & Environmental Consultants, Inc. under the vendor list 2.2.1, five pollutants were studied from her equipment of choice, the Power-Pak II. These 5 pollutants are carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, and other nitrogen oxides. Mercury and dioxins are absent from this list. Ms. Bulseko also may claim that she utilizes filtering systems, however while filtration technologies may help to control immediate release of mercury into the air, they still result in mercury wastes that are

potential sources of future emissions. Lastly, according to PA General Operating Permit for Crematories, she can designate one of her burners to cremate animals as humans and animals cannot be cremated in the same unit.

The lack of regulations is not an endorsement of safety. The absence of adequate federal, state, and local regulations protecting residents from toxic pollutants gives PT the opportunity to develop their own.

Risks to Health and the Environment: Mercury and dioxins are by far the most concerning of toxic pollutants that pose a significant risk to health and the environment.

I have enclosed several studies and documents for your review that demonstrate crematories emit pollutants (nitrogen oxide, carbon monoxide, sulfur dioxide, particulate matter, polychlorinated dibenzo-p-dioxins and dibenzofurans, and heavy metals including mercury, cadmium, lead, and nickel) up to a 1.5 mile radius.

Mercury is the most toxic substance on the US Department of Health and Human Services Priority List of Hazardous Substances. Unfortunately it is permanently recycled or bioaccumulative and the most dangerous form of mercury is methylmercury. The publication, "Dust in the Wind? The Bell Tolls for Crematory Mercury," identifies cremation as a significant source of mercury emissions.

While most published concerns regarding crematory emissions relate to mercury, dioxins carry significant concern as well and have been identified to cause cancer among other serious illnesses. A study published in 2003 from Environmental Science Technology concluded that PCDD/F (dioxins and furans) emissions from crematories to the surrounding environment was quite significant and that an immediate control strategy should be implemented in order to eliminate these emissions from crematories. Additionally a Penn State study found that the annual ambient concentrations of cadmium and dioxin/furan at the crematory property boundary exceeded National Air Quality standards by 205% and 2200% respectively.

It is documented by several government agencies that children are the most at risk as they are exposed to pollutants in a form that is most toxic (vapors in the air) at a time when they are most vulnerable (young with developing immune and nervous systems). A recent study by the University of Texas in 2005 concluded that for every 1,000 pounds (453 kg) of environmentally released mercury there was a 43% increase in the rate of special educational services and a 61% increase in the rate of autism.

Property Values: It is documented that property values decrease in close proximity to a crematory. Using estimates from a recent study and conservative estimates on the number of PT houses as well as their current value, it is approximated that close to $5 million would be lost tax revenue to Peters Township.

Pennsylvania State University conducted a study in 2010 to assess the impact of crematory operations in various communities. The study evaluated emissions data and monitored home sales for twenty seven (27) months. The selling price of residential homes located within 0.1 miles of the crematorium declined by 35%, 11% within 0.2 miles of the crematorium, and 1.5% within 0.5 miles from the crematorium.

Using the aforementioned study, PT geographic data, and the mean value of PT homes in 2009 ($267,826) as determined by www.city-data.com, it is estimated that over $3.4 million would be lost tax revenue to Peters Township from declining property values of the homes located within 0.5 miles of the crematory. When taking into account a mean value of $800,000 for the 8 houses (which would likely be more accurate than the stated median) within 0.1 miles of the proposed crematory, almost $5 million would be lost tax revenue to the township from declining property values of the homes located within 0.5 miles of the crematory. This estimated figure is most likely lower than what the actual value may be due to a majority of houses within 0.5 miles of the proposed crematory are considerably more than the mean

value of $267,826. This estimate does not include businesses. This will most likely have a huge financial impact on the township, the community, and the school district.

Specific Township Zoning Ordinances: The underlying premise of the township's zoning code is that the zoning ordinances are to protect the health, welfare, and safety of the community and its residents. To amend the zoning ordinances or grant a variance or special exception to allow the proposed crematory is contrary to the premise for the reasons stated below.

302 All Zoning Districts
General Intent of Residential Districts
A 1 c - "...protect residential areas against fire hazards, ...smoke,... odor, or other objectionable influences."
A 1 g - "Promote most desirable land use..."

A proposed crematory in this location with all the risks involved is incompatible land use as it is located too close to homes and businesses.

A 1 h - "Promote stable residential development that conserves the value of the land and buildings while contributing to the Township's tax base."

Commercial - B 1 c - "Promote the most desirable use of land...while protecting the character of the commercial areas..."

Based on drawings submitted by Ms. Bulseko, it appears she has plans to grow her business from two to four operating burners. If her plans of two burners, potentially leading to 4 burners, is accurate, this constitutes a negative impact of land use that is too intense for the surrounding area.

Industrial -
C 1 c - "Promote the most desirable use of land...to conserve the value of the land and buildings, and to protect local tax revenues."
C 1 d - "Encourage industrial development...that is free from ...smoke, odor, ..., fire hazards, or other objectionable effects."

600 - Operating Performance Standards
A - "Purpose. No building structure...shall be used...in a manner as to create any dangerous, injurious, noxious or otherwise objectionable fire,... smoke, dust, odor, or other form of air pollution...liquid or solid refuse or waste... or other substance, condition or element in any manner or amount as to adversely affect the surrounding area. ..."
F - "Smoke, ash, dust, fume vapor, gases and other forms of air pollution."
H - "Liquid and solid wastes. There shall be no discharge...into any sewerage system or stream or into the ground of any materials ..."
K - "Odor. There shall be no emission of odorous gases... as to be offensive on adjoining streets or adjacent lots."

Overall Community Concerns: It's not just about the effects of how one crematory can negatively impact its immediate surroundings leading to additional ripple effects throughout the township; it's potentially about how several crematories can negatively impact the entire Township.

Based on Google Earth, it is estimated over 1,100 Peters Township homes, 4 daycares, 3 preschools, recreational trails, waterways, 2 cemeteries, and 2 country clubs located within a mile radius of the proposed crematory. Pollutants will be emitted from the crematory and instantly travel into the immediate air and soon be transported by the wind to surrounding areas eventually ending up in our waterways, our

soil, our Montour trail and creek, and local farms ultimately affecting an even larger section of Peters Township. These effects will be multiplied if several other crematories enter the township.

Expectations of PT Officials: PT is expected to perform due diligence by independently investigating the concerns set forth in this letter. PT as a Home Ruled Community has the opportunity to enact a moratorium provided PT is actively looking into these concerns or to enact strict ordinances (ie. Air quality and set-back distances) to protect its residents and community.

Specifically, it is requested that PT review independent air quality, soil samples, and water quality tests from the environment surrounding local crematories, local stack tests, and directly contact the Pennsylvania DEP in Harrisburg. It is your responsibility to thoroughly investigate Ms. Bulesko's claims as well as those from crematorium manufacturers and engage independent environmental consultants.

It is understood that a crematorium is a lawful business with rights to operate in Peters Township. Peters Township, as a Home Ruled community, has the opportunity to enact a moratorium or enact strict regulations to control avoidable pollutants and place the crematory in the safest location possible far away from homes, businesses, farms, and schools.

In Eastern Pennsylvania, the towns of Kulpmont and West Reading enacted strict air quality ordinances and other restrictive measures that resulted in keeping the crematory at bay. Upper St. Clair and other local township officials have strict definitions, guidelines, and other measures to prevent crematoriums from entering their neighborhoods. I sincerely ask that you consult with their local officials for insight and/or recommendations on this matter.

These websites may prove useful as they have information specific to West Reading and Kulpmont.
http://www.ejnet.org/crematoria/
http://www.actionpa.org/ordinances/

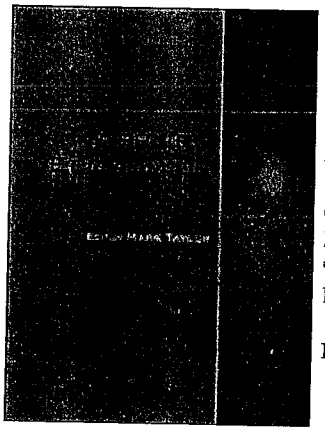
Encl:
Philip Donald Batchelder. *Dust in the Wind? The Bell Tolls for Crematory Mercury.* 2 Golden Gate U. Envtl. L. J. 2008

Agee MD, Crocker TD. *Directional heterogeneity of environmental disamenities: the impact of crematory operations on adjacent residential values.* Applied Economics. 2010; 42(14), 1735-1745.

Palmer RF, Blanchard S, Stein Z, Mandell D, Miller C. *Environmental mercury release, special education rates, and autism disorder: an ecological study of Texas.* Health & Place. 2006; 12 (2), 203-9.

Wang LC, Lee WJ, Lee WS, Chang-Chien GP, Tsai PJ. *Characterizing the Emissions of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans from Crematories and Their Impacts to the Surrounding Environment.* Environmental Science Technology. 2003; 37, 62-67.

Kulpmont Air Pollution Control Ordinance and Set-Back Distance Ordinance



Applied Economics
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713684000

Directional heterogeneity of environmental disamenities: the impact of crematory operations on adjacent residential values

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First published on: 09 June 2010

To cite this Article Agee, Mark D. and Crocker, Thomas D.(2010) 'Directional heterogeneity of environmental disamenities: the impact of crematory operations on adjacent residential values', Applied Economics, 42: 14, 1735 — 1745, First published on: 09 June 2010 (iFirst)
To link to this Article: DOI: 10.1080/00036840701721679
URL: http://dx.doi.org/10.1080/00036840701721679

Applied Economics, 2010, **42**, 1735–1745

Routledge
Taylor & Francis Group

Directional heterogeneity of environmental disamenities: the impact of crematory operations on adjacent residential values

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A hedonic study of residential house sales in Rawlins, Wyoming, was conducted to estimate the impact of an environmental shock from a new point source upon adjacent residential property values. We use a unique data base of house sale prices and associated house attributes, including structural and neighbourhood characteristics and geographic distances and directions from the source of the shock, atmospheric emissions from a new crematory. Our data spans 27 months of house sales: 7 months before, and 20 months after the startup of crematory operations. Results indicate that proximity, measured both in terms of direction and distance from the crematory, imparts a statistically significant negative impact on average house sale prices – an increase of 0.3 to 3.6% of average sale price for every one-tenth mile increase up to one-half mile in distance away from the crematory, but depending on direction from the crematory. This distance benefit increases somewhat with calendar time only for houses located west of the crematory.

I. Introduction

Residential property values depend both on physical and locational attributes. Attributes include structural, neighbourhood and environmental characteristics, all of which may impact the selling price of a property. Indeed, housing markets are one of the few places where environmental amenities are traded in formal markets along with physical amenities. As such, for decades, economists have used hedonic property value techniques to measure monetary equivalents of a variety of environmental quality changes that affect consumers' welfare via their purchase and consumption of the good 'housing.' Recent examples include air quality (Kiel and McClain, 1995; McMillen and Thorsnes, 2003), aesthetic views (Bourassa *et al.*, 2004) and proximity to other amenities or disamenities such as proximity to natural areas (Thorsnes, 2002) or landfills (Ketkar, 1992).

Hedonic property value studies are useful if they provide empirical evidence that selling prices of a heterogeneous market good reflect alternative levels of amenities (good or bad). Given the sometimes

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elusive nature of environment-related benefits and costs, such information is particularly useful as it provides evidence that people are willing to pay more for higher levels of environmental quality.

When proximity to an environmental externality affects value, both direction and distance may matter. For example, many point sources of pollution produce either noticeable odours or airborne pollutants so that prevailing winds (or lack of air movement) create directional heterogeneity in distance effects. We demonstrate that if directional effects are present but ignored, one might observe no proximity impact on house value even though impacts are indeed present but are not the same in all directions. To date, published hedonic property value studies that employ distance measures pay little attention to direction. While some of these studies account for spatial trends (e.g. Gillen *et al.*, 2001), such as spatial autocorrelation in model error terms, these studies do not specifically address distance profiles as a function of direction. Herriges *et al.* (2005) and Cameron (2006) are the only studies we are aware of which empirically examine direction and distance impacts of an environmental disamenity using a hedonic property value model. But these last two studies disregard the potential impact of spatial autocorrelation and heteroskedasticity upon their reported results. Here we account for direction and distance impacts and test for and make appropriate corrections for spatial autocorrelation and spatial heteroskedasticity.

The following section explains our approach to assessing the impacts on residential property values of proximity to the shock of exposures to atmospheric emissions from a crematory of whose start-up operations adjacent property owners had never been informed.[1] Section III describes our data and model specification, and our results and value estimates are reported in Section IV. Section V concludes.

II. Hedonic Model and Pre-Testing

This section outlines a basic hedonic model to assess the marginal impact on house sale prices of proximity to a point source, environmental disamenity shock, holding constant all other attributes important to these values. The literature has identified several empirical issues that must be addressed in order to optimize both statistical efficiency and precision of estimates using hedonic techniques. The most common and addressable issues include choice of functional form, bias due to omission of relevant explanatory variables and definition of the extent of the market to be examined (sampling).

Following Rosen (1974), this study uses a first-stage hedonic model, in which the hedonic price function is estimated using a sample of prices and characteristics of observed 'transacted' properties,

$$\text{SALEPRICE}_i = \alpha + \sum_j \beta_j D_{ij} + \sum_k \beta_k H_{ik} + e_i \quad (1)$$

where SALEPRICE_i denotes nominal selling price of house i ($i = 1, \ldots, N$), which is a function of two sets of observed variables, D and H. The j variables in D describe the house in terms of its date of sale, and distance and direction from the environmental disamenity. The k variables in H describe the house in terms of its general structure (living area, number of bathrooms, etc) and its accessibility to public facilities. α is a constant term. Expression (1) defines the hedonic price function as a locus of equilibrium points. If the property attributes observed are independent of any not observed, Bajari and Benkard (2005) show this implies the existence of a hedonic price function even if the housing market is imperfectly competitive and lacks a continuum of types.

While choice of functional form for (1) is somewhat arbitrary for the researcher, we choose a double-log specification based upon a number of preliminary regressions (not reported) and statistical testing of goodness-of-fit. The specifications reported in Table 2 emerge as clearly best in terms of statistical fit. These results are consistent with Cropper *et al.* (1988) who show that the double-log form usually performs best relative to linear, semi-log inverse semi-log, and other quadratic forms for first-stage hedonic models, both in terms of model flexibility and ability to measure marginal prices in the presence of misspecifications. Also, functional forms that are too general may not prove robust to small misspecifications (Cassel and Mendelsohn, 1985).

The hedonic technique is especially useful for determining values of general reductions in 'receptor effects,' i.e. a single disamenity 'bundle' comprising several effects such as noise, foul odours, or bothersome visual effects. When these general receptor effects dominate, identification and valuation of specific environmental impacts, which include exposures to specific contaminants, can be problematic unless detailed information is available

[1] Thus the housing market could not anticipate the likely effects of crematory operations.

on all individual effects in the disamenity bundle (see e.g. Palmquist *et al.*, 1997). Since individual effects within the bundle are plausibly correlated, omission of any one or a subset of effects from the hedonic regression will bias the predicted impacts of remaining disamenities accounted for in the regression. However, if assessment of general effects is the focus, windfall losses to receptors will equal to the total decline in predicted property values (Polinsky and Shavell, 1976; Palmquist, 1991). These losses are often expressed in terms of proximity to the disamenity source. Losses due to proximity to an environmental disamenity are larger if the proximity-related decline in property value also includes a slowing of appreciation rates (Mitchell and Carson, 1986). Our goal is to assess the decline in predicted residential property values associated with proximity to a newly installed crematory, of whose planned installation and start-up adjacent property owners were unaware. Proximity (distance and direction) is assumed to capture general receptor effects associated with living near the environmental shock from the atmospheric emissions of the new crematory operation. To assess the proximity-related change in predicted values fully, we also assess the value impact of emitter effects on house price appreciation rates.

While assessment of general proximity effects greatly simplifies model specification and data requirements, other potential estimation problems linger. For instance, if an environmental disamenity affects a large area, and/or there are multiple sources of changed emissions, hedonic price functions can shift, implying that the total predicted change in aggregate property values serves only as an upper bound for the true change in value (Bartik, 1988). That is, marginal changes in property values as measured by the slope of a hedonic price function need not equal that aggregate change in value which is determined by general equilibrium adjustments involving induced relocations and changes in population and housing supply. We limit our analysis to marginal changes since the externality we consider is localized relative to the size of the housing market.

Sample selection bias represents another potential estimation issue because, say, more expensive homes might more likely be offered for sale when confronted by a disamenity shock. We believe this issue to be insignificant for this study since residences in the neighbourhood subjected to the shock are very nearly all middling in their attributes and residents. Also, Jud and Seaks (1994) conclude that ignoring the sample selection issue leads to an average error of only 1% in housing price change estimates.

More importantly, since unobserved or omitted variables in hedonic regressions are often locationally correlated, 'spatial autocorrelation' is frequent in hedonic regressions. Though spatial autocorrelation does not bias ordinary least squares coefficient estimates and thus benefit measures (Leggett and Bockstael, 2000; Kim *et al.*, 2003; Neill *et al.*, 2007), estimates can be inefficient, which leads to biased SEs and inaccurate hypothesis tests.[2] We conducted a series of Kelejian and Robinson (1992) tests to check for any significant presence of spatial autocorrelation in the data of our case study. These tests failed to confirm spatial autocorrelation in all our Table 2 model specifications. However, White (1980) tests failed to reject spatial heteroskedasticity in these specifications. Therefore, the results presented in Table 2 discussed below, use White's (1980) heteroskedasticity consistent covariance matrix to address potentially biased SEs in our ordinary-least-squares (OLS) estimates.

Finally, heterogeneity in distance effects with respect to direction from an environmental disamenity can potentially obscure what might otherwise be a clear price–distance relationship. With directional diffusion of airborne pollutants, one would naturally expect prevailing winds to exacerbate effects for some neighbourhoods while virtually eliminating effects from others, even where distance to the upwind area from the pollution source is considerably less. Also, direction-specific geographic features such as hills and forests can enhance or counter the impact of prevailing winds. If distance and direction are correlated, omission of direction from the hedonic model will result in omitted variable bias of the coefficient estimate for distance. Their direction of drift plausibly affects the impact of mobile pollutants on property values. Surprisingly, almost all published hedonic property value studies that employ distance-to-source as their proximity measure do not include information on orientation of a property to the pollution source. Palmquist *et al.* (1997), Gillen *et al.* (2001), Herriges *et al.* (2005) and Cameron (2006), are the sole exceptions we have been able to identify. But the first two, while acknowledging 'importance' of direction, do not formally consider its effects in

[2] Even if spatial correlation were present, an assumption that any spillovers among neighbouring sites are strictly pecuniary would permit the coefficient on the pollution variable in an OLS hedonic price regression to be interpreted as the complete marginal effect of pollution on house value (Small and Steimetz, 2006). Strictly pecuniary effects imply that the value of neighbouring sites affects the sale price of a particular site but does not affect the amenities of that site.

their empirical framework. This leaves only the latter two studies that explicitly account for distance with directional heterogeneity by combining distance and direction (in the form of upwind and downwind siting for Herriges *et al.*, and of polar coordinates for Cameron) into the hedonic property value model. Our data lack sufficient detail on direction to implement the Cameron (2006) framework. However, we know the location of each sample property within one of eight possible 45° regions (N, NE, E, SE, etc). This enables us to establish a reasonable estimate of the combined influence of distance and direction effects by introducing dummy variables for direction to account for directional interactions in our hedonic OLS regressions.

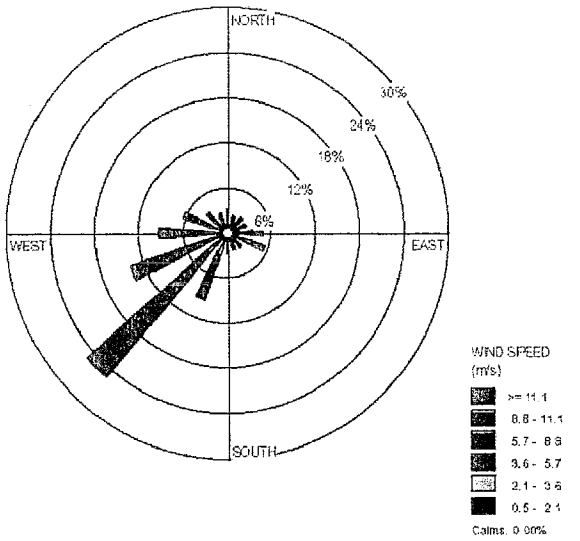

Fig. 1. Rawlins, Wyoming wind rose

III. Data

Our data consists of all 372 single family home transactions in the city of Rawlins, Wyoming, between January 2004 and March 2006. These sales are dispersed throughout the Rawlins city limits. Rawlins, population 8538 in 2000, and 8633 in 2004, is located in Carbon County in South Central Wyoming. Only one settlement with more than 1000 people lies within 100 miles, and that one settlement is nearly 40 miles distant. Rawlins covers approximately 7 square miles and has a population (housing) density of 1153 (521) per square mile. Thus the community's small population and its geographical isolation make treating it as a unified housing market a reasonable assumption. After deletion of 29 properties with missing attribute data, our total sample consists of 343 transactions.

Figure 1 presents a wind rose compiled for the geographical center of Rawlins (NEPA, 2006). The length of each 'spoke' around the circle is the annual frequency the wind blows from a particular direction. These spokes are further broken down into discrete frequency categories indicating the percentage of time the wind blows within a certain speed range from the indicated direction. Each concentric circle represents a different annual frequency, emanating from zero at the center to the highest annual frequency at the outer circle.

Figure 1 shows the Rawlins wind blowing primarily from the southwest; the longest spoke indicates that 25% of all hourly winds emanate from the direct southwest, and roughly 12% of the time from the west and west/southwest. The highest recorded wind velocities are also from the southwest (greater than 11.1 m/s). The upper right-hand quadrant of the rose indicates that wind rarely blows from the northeast or south/southeast, however, roughly 12 % of all hourly winds do blow from the east and east/southeast, albeit at low velocities (0.5 to 2.1 m/s).

The subject crematory is surrounded by residential developments to its north, west and southwest, with commercial development to its southeast. The landscape around the crematory and adjacent residential area has some notable attributes. In particular, a ridge (approximately 200–300 feet in elevation) embraces the residential area to the southwest, west and north of the crematory, forming a continuous, inverted 'J' around this area. The diameter of this area is approximately 0.9 miles. No residential development is located directly west, northwest and north of the J-shaped ridge, nor directly northeast of the crematory.[3]

In March 2004, the Rawlins City Planner issued a building permit to the subject mortuary to install a 40 ton, two-chamber, natural gas-fired Millennium II crematory in a vehicle storage garage adjacent to the mortuary building. Controversy remains as to whether this Planner was authorized to issue a permit for this expanded, nonconforming use of an

[3] This may seem to contradict our data, which indicates (in Table 1) a good deal of housing sales activity in the region northeast of the crematory. However, these homes are located further (about 1 mile on average) northeast of the crematory; open fields, a cemetery and school athletic fields occupy much of the nonresidential area directly northeast of the crematory.

Table 1. Variables, definitions and descriptive Statistics ($N = 343$)

Variable	Definition	Mean	SD
T	Number of months after 31 December 2003 the house was sold.	14.6122	7.0846
AGE	Age of house in years as of 2006.	51.1166	26.3047
SQFT	Square footage of house that is aboveground.	1293.8430	553.4636
SQFTBSMT	Square footage of basement if house has a basement.	666.6531	480.0317
BEDROOMS	Number of bedrooms.	3.2507	1.0123
BATHS	Number of bathrooms.	1.8674	0.6165
FINBSMT	House has a finished basement; 1 = yes; 0 = no.	0.2945	0.4565
TOWNHOUSE	1 if townhouse; 0 otherwise.	0.0583	0.2347
ATTACH2	House has attached 2-car garage; 1 = yes; 0 = no.	0.2653	0.4421
ATTACH3	House has attached 3-car garage; 1 = yes; 0 = no.	0.0058	0.0763
ATTACH4	House has attached 4-car garage; 1 = yes; 0 = no.	0.0058	0.0763
DETACH2	House has detached 2-car garage; 1 = yes; 0 = no.	0.2157	0.4119
DETACH3	House has detached 2-car garage; 1 = yes; 0 = no.	0.0146	0.120
DETACH4	House has detached 2-car garage; 1 = yes; 0 = no.	0.0087	0.0932
DISTANCE	Distance (in tenths of 1 mile) house is located away from crematory.	10.4924	7.8914
DOWNTOWN_MINUTES	Travel distance (in minutes by car) house is located away from the Rawlins downtown area.	2.417	1.763
SALEPRICE	Sale price of house in thousands of nominal dollars.	99.2185	49.8136
North	House is north of the crematory; 1 = yes; 0 = no.	0.0321	0.1764
South	House is south of the crematory; 1 = yes; 0 = no.	0.0262	0.1601
East	House is east of the crematory; 1 = yes; 0 = no.	0.035	0.184
West	House is west of the crematory; 1 = yes; 0 = no.	0.0496	0.2174
Northeast	House is northeast of the crematory; 1 = yes; 0 = no.	0.4227	0.2174
Northwest	House is northwest of the crematory; 1 = yes; 0 = no.	0.1662	0.3728
Southeast	House is southeast of the crematory; 1 = yes; 0 = no.	0.1808	0.3854
Southwest	House is southwest of the crematory; 1 = yes; 0 = no.	0.0875	0.2829

existing funeral home facility in an area zoned for residences since the 1970s. None of the residents in adjacent neighbourhoods were ever notified of plans for the crematory. Cremation operations began in August 2004. Soon after, citizens began complaining to City and State authorities about the crematory with its glaring, all-night illumination, noise and – most notable – noxious odor, which permeated residents' houses, making them feel ill and 'devaluing' (Morton, 2005) their properties. Starting in October 2004, and continuing through the time interval of our data set, the local daily newspaper updated the community on the status of the issue and printed numerous letters from citizens giving their views. In January 2005, the Wyoming Department of Environmental Quality ordered an emissions test and determined that the crematory had emissions comparable to its state permit request with several notable exceptions: annual ambient cadmium and dioxin/furan concentrations at the crematory property boundary exceeded National (and Wyoming) Air Quality Standards, by approximately 205 and 2200%, respectively (URS, 2006). Hydrogen chloride concentrations at this boundary exceeded the one-hour US Environmental Protection Agency's 'remediation goal' by 797%, with sulfur oxide, nitrogen oxide, chromium, and mercury concentrations being from 43 to 74% of the Agency's National Standard or remediation goal. Cadmium, chromium, dioxin/furans, hydrogen chloride and mercury are toxins for which any positive concentration may have human health impacts (Wexler, 2005).

No other new or substantially changed sources of (dis)amenities appeared in Rawlins residential neighbourhoods during our data time interval. Our data includes information on a variety of housing and neighbourhood characteristics typically used in the hedonic property valuation literature to explain variation in single family house selling prices. These data also contain variables describing direction from and distance to the crematory. Our data is deficient in its lack of information on lot size. This omission may detract somewhat from the explained sum of squares of our regressions; however, since our data contains detailed information on the number of attached and detached garages, following Boxall *et al.* (2005), we assume lot size to be captured at least in part by the presence (as well as extent) of transportation-related or other (e.g. maintenance- or recreation-related) vehicle storage structures beyond the livable area of the

Table 2. Parameter estimates with ln(SALEPRICE) as the dependent variable

	Specification			
	1		2	
Variable	Coefficient	*t*-Value	Coefficient	*t*-Value
CONSTANT	0.71441*	1.811	0.67640*	1.698
T	0.01874**	3.999	0.01975**	4.368
Ln(AGE)	−0.16206**	− 7.958	− 0.15841**	− 7.916
Ln(SQFT)	0.46158**	8.337	0.46870**	8.534
Ln(SQFTBSMT)	0.04026**	5.802	0.03971**	5.925
Ln(BEDROOMS)	0.35161**	4.950	0.33811**	4.912
Ln(BATHS)	0.09943	1.482	0.10991*	1.665
Ln(DOWNTOWN MINUTES)	0.11815**	2.278	0.03896	0.666
FINBSMT	0.06881*	1.929	0.06107*	1.759
TOWNHOUSE	−0.21317**	−3.526	−0.18906**	−3.068
ATTACH2	0.26031**	6.394	0.25692**	6.643
ATTACH3	0.31041*	1.658	0.33981**	2.326
ATTACH4	0.24196*	1.734	0.21615**	2.149
DETACH2	0.13376**	2.750	0.14521**	3.124
DETACH3	0.43269**	5.336	0.41962**	4.594
DETACH4	0.35251*	1.654	0.44466**	1.986
ln(DISTANCE)	0.06320**	2.060	0.08960**	2.820
$[\ln(\text{DISTANCE})]^2$	−0.01873**	−2.458	−0.01803**	−1.970
ln(DISTANCE) × *T*	−0.00375*	−1.883	−0.00897**	−3.126
ln(DISTANCE) × North × *T*			0.00818**	3.327
ln(DISTANCE) × South × *T*			0.00403	0.810
ln(DISTANCE) × East × *T*			−0.00345	−0.697
ln(DISTANCE) × West × *T*			0.01480**	3.651
ln(DISTANCE) × Northeast × *T*			0.00582**	2.941
ln(DISTANCE) × Northwest × *T*			0.00289	1.158
ln (DISTANCE) × Southwest × T			0.00771**	3.402
χ^2 (White's homoscedasticity test)	91.13	104.96		
Adjusted R^2	0.7143	0.7326		
F-statistic	48.51	38.48		
Number of observations	343	343		

Notes: * Significant at less than 10%; ** Significant at less than 5%.

house – as indicated by number of attached and/or detached garage spaces.[4]

As for other plausible but unobserved influences upon residential sale prices, we assume them to be independent of the influences we do observe, thus implying the existence of a hedonic price function (Bajari and Benkard, 2005). Distance to schools is a prominent observed influence in numerous hedonic price studies. We lack house-by-house data on it. In the Rawlins case, however, nearly all residences are within walking distance of an elementary school.[5] Variable definitions and descriptive statistics are presented in Table 1.

Variables used to measure D_{ij} include distance in tenths of a mile from the crematory (DISTANCE), and directional dummy variables indicating which of the 45° regions (from the crematory as point of origin), N, S, E, W, NE, SE, SW, NW, contains the sample house. To account for revisions in people's expectations about the Rawlins residential property market, a time trend variable, *T*, measures the number of months after 31 December, 2003 each

[4] Our data indicates a higher correlation between multiple vehicle storage structures and distance away from the downtown area, implying larger lot sizes are most prevalent among residences located at the outer edge of the Rawlins city limits, well beyond the areas plausibly affected by crematory emissions.

[5] Adding covariates to a hedonic price function to avoid omitted variable bias has a cost. If the added covariate is imperfectly measured in the sense that it does not correspond exactly to that feature which the market actually values, measurement error will increase. As more covariates are added, the measurement error bias will increase, thus increasing the noise-to-signal ratio. Atkinson and Crocker (1987) and Graves *et al.* (1988) use the Bayesian diagnostics of Leamer (1978) to demonstrate that measurement error bias appears to be a more serious problem in hedonic price studies than does omitted variable bias.

house was sold. Thus our sample includes properties sold as much as 7 months before and up to 20 months after the environmental shock to the crematory's residential neighbours from its August 2004 start-up. The average T for our sample is 14.61 months; our sample contains a few houses that have sold more than once over our 27-month sampling period. Variables used to measure H_{ik} include house age in years (AGE), square feet of living space both above-ground (SQFT) and below ground (SQFTBSMT), number of bedrooms (BEDROOMS) and bathrooms (BATHS), whether the house has a finished basement (FINBSMT), whether the house is a townhouse (TOWNHOUSE), travel time (by car) in number of minutes from house to downtown Rawlins (DOWNTOWN_MINUTES), and categorical covariates indicating whether or not the house has each of several numbers of attached or detached garage spaces (ATTACHED, DETACHED). ATTACHED_1 and DETACHED_1 are the excluded Table 2 categories, implying that the valuation impacts of the coefficients for the included categories are relative to the valuation impacts of these exclusions.

IV. Results

Table 2 reports OLS estimates of two specifications of the hedonic property value equation. Examination of the covariates in Table 2 indicates that, for both specifications, nearly all estimated coefficients have the correct signs, are statistically significant, and have very similar and plausible magnitudes across specifications when transformed to dollar values. For example, an additional square foot of living space (above ground) is worth roughly \$36 in the average house. An additional bedroom is worth slightly over \$10 300, while a finished basement contributes about \$6250 to the price of an average home.[6] These estimates are very close to the values found in other studies (see e.g. Palmquist *et al.*, 1997; Boxall *et al.*, 2005). Reported at the bottom of the Table 2 are White's (1980) chi-square test statistics of the null hypothesis of homoskedasticity, which clearly reject the null hypothesis at less than the 1% level. Asymptotic SEs used to calculate all Table 2 t-statistics are from White's (1980) heteroskedasticity-consistent covariance matrix. Finally, the reasonably high adjusted R-squared and F-values reported at the bottom of Table 2 indicate that the regressions, as specified, both have adequate fit, and explain a substantial portion of the total variation in observed home sale prices.

Turning to distance effects, specification 1 gives model parameter estimates accounting for time of sale and for distance from the crematory, but with no direction-specific terms. The predicted distance benefit as derived from specification 1 is:

$$\frac{\partial \ln(\text{SALEPRICE})}{\partial \ln(\text{DISTANCE})} = \underset{(2.060)}{0.0632} - \underset{(-1.883)}{0.00375}T - \underset{(-2.458)}{0.0375}\ln(DISTANCE) \quad (2)$$

Accounting for direction-specific heterogeneity, the predicted distance benefit derived from specification 2 is:

$$\frac{\partial \ln(\text{SALEPRICE})}{\partial \ln(\text{DISTANCE})} = \underset{(2.820)}{0.0896} + [\beta_j(\text{direction}_j) - \underset{(-3.126)}{0.00897}]T - \underset{(-1.970)}{0.036}\ln(\text{DISTANCE}) \quad (3)$$

The first term in expression (3) accounts for any nondirection-specific and time-invariant distance benefit. The bracketed terms in (3) account for direction- and nondirection-specific distance benefits, both time varying (in expression (2) all direction-specific benefit terms are assumed zero). The final right-hand-side term in (3) accounts for the distance benefit which is also distance-specific but nondirection-specific and time invariant. A series of F-tests confirms Table 2 specifications 1 and 2 as the clear best-fit benefit hedonic specifications for the Rawlins data. We summarize these tests as follows. First, we introduced and tested for the statistical significance of distance-specific distance coefficients which were time varying and/or direction-specific [we likewise tested in specification 1 for the significance of a time varying, distance-specific coefficient for expression (2)]. All these coefficients were individually and jointly nonsignificant. Second, we introduced and tested for the significance of direction-specific coefficients which were nondistance-specific and time invariant (i.e. direction-specific differences applying to the first term in expression (3)). These coefficients were likewise individually and jointly nonsignificant. Finally, though not applicable to the distance benefit expressions in (2) and (3), we also tested for any direction-specific differences associated with

[6] Interpretation of dummy variable coefficients in Table 2 requires a slight correction. For example, the correct marginal impact on SALEPRICE of the coefficient for FINBSMT is $\exp(\beta_{FB}) - 1$, where β_{FB} is the coefficient estimate for FINBSMT reported in Table 2 (Halvorsen and Palmquist, 1981).

the time coefficient, T; these tests (for specifications 1 and 2) confirmed a single coefficient estimate for T common to all Rawlins regions as most appropriate.[7]

Table 2 specifications 1 and 2 clearly demonstrate that failure to account for directional heterogeneity in Rawlins leads to omission of some important and possibly misleading benefit assessment information. The direction-specific terms in specification 2 are highly significant jointly as well as nearly all individually significant. Table 3 sheds some light on the benefit assessment implications of omission of directional heterogeneity for the Rawlins crematory example. Columns 2–4 of Table 3 provide a breakdown of mean values of DISTANCE, T, and SALEPRICE for all ($N=343$) Rawlins homes sold between 31 December 2003 and 28 March 2006, along with various subsample means of Rawlins homes sold within a specified proximity (distance and direction) to the crematory. As one works down the columns of Table 3, DISTANCE to the crematory declines from a maximum radius of 0.5 to 0.1 miles. Column 5 gives the mean benefit for successive one-tenth mile DISTANCE increases away from the crematory conditional upon direction from the crematory; and column 6 expresses this mean benefit as a percentage of mean SALEPRICE for the particular subsample of homes in question. For example, the subsample of 43 homes located north of and within a distance of 0.2 to 0.3 miles from the crematory would gain an average of $5006.59 if they were to lie within 0.3 to 0.4 miles. The first row of the topmost block in Table 3 provides the mean nondirection-specific DISTANCE benefit for the entire Rawlins sample; the next three rows show the mean distance benefit for all Rawlins homes located North, West and Southwest of the crematory. Each block below this first block presents similar calculations for sample homes within a given distance from the crematory. Benefit expression (2) is used to calculate all nondirection-specific (All Directions) estimates; expression (3) is used to calculate the direction-specific estimates appearing in the last three rows of each block. Absent an accounting of directional heterogeneity in the sample, the average Rawlins home SALEPRICE benefit associated with a 1-tenth mile DISTANCE increase away from the crematory for the period of 31 December 2003 to 28 March 2006, is −$754.08. With directional heterogeneity accounted for in the sample ($N=343$), Rawlins homes located North, West and Southwest of the crematory reveal a mean DISTANCE benefit of $534.51, $3 659.76 and $243.58. Column 6 shows these estimates amount to roughly 0.5, 3.6 and 0.3% of average SALEPRICE for homes in these directions.

As one moves down Table 3, estimates based on benefit expression (2) clearly demonstrate that a 'classical concentric circles' approach to DISTANCE in a hedonic assessment of the Rawlins data–accounting for distance to but not direction from the environmental disamenity–severely understates the assessed benefit associated with home location further away from the disamenity. At the bottom of Table 3, benefit expression (2) finally reveals a positive mean DISTANCE benefit associated for homes lying within a one-tenth mile radius of the crematory. This benefit amounts to $3657.88, or 4.89% of mean SALEPRICE as calculated from the seven sample homes sold in this area. However, expression (2) says that homes located anywhere up to 0.4 miles outside this radius suffer from not being closer to the crematory and its emissions.

Table 3 estimates based on benefit expression (3) reveal a much larger positive and increasing hedonic benefit function with distance for homes North, West, or Southwest of the crematory. Columns 4 and 5 in the table show that homes North and West of the crematory exhibit the highest benefit, ranging from 2% of mean SALEPRICE for homes within the 0.4 to 0.5 mile DISTANCE radius to over 30% of mean SALEPRICE (roughly $19 400 to $27 700) for homes within a 0.1 mile radius. The DISTANCE benefit increases slightly with time (approximately 0.0058% per month) for homes located West of the crematory, but does not appear to increase with time for homes located North or Southwest of the crematory. Homes Southwest of the crematory exhibit more modest benefit increases of 0.5 to 4.7% of mean SALEPRICE (roughly $490 to $4400) as DISTANCE declines from maxima of 0.5 to 0.1 miles. These estimates would be consistent with the Rawlins wind rose data given in Fig. 1 (e.g. prevailing winds sometimes blow from the east), if the 'J-shaped' ridge causes Southwesterly winds to swirl in North and then in West or Southwesterly directions, or if the ridge

[7] Our Table 2 coefficient estimates of 0.018–0.019 for T are not an estimate of the average monthly appreciation rate for Rawlins houses over the time span of our data. This estimate captures an 'embodied' figure, reflecting both Rawlins-specific appreciation and the discount rate; the two cannot be separated (Kiel and McClain, 1995b).

Table 3. Direction- and nondirection-specific benefit estimates for Rawlins, WY

Region	Mean DISTANCE (in tenths of 1 mile) from the crematory	MeanT (number of months after 31.December 2003 house was sold)	Mean nominal SALEPRICE	Mean benefit for one-tenth mile DISTANCE increase away from the crematory	Mean benefit as percent of mean nominal SALEPRICE
Full sample estimates ($N=343$)					
Estimates using benefit expression (2)					
All directions	10.4924	14.6122	99,218	−754.08	−0.76
Estimates using benefit expression (3)					
North	4.5462	15.4615	$104 831	$534.51	0.51
West	3.8667	16.8667	101 627	3 659.76	3,6
Southwest	4.6933	15.9333	83 420	243.58	0.29
Subsample homes located within 0.4 to 0.5 miles of crematory ($N=94$)					
Estimates using benefit expression (2)					
All directions	3.1043	16.2766	93 770	−1 217.83	−1.3
Estimates using benefit expression (3)					
North	2.3444	15.4444	$95 422	$1 914.41	2.0
West	2.1538[a]	18.4615[a]	104 262[a]	8 210.55[a]	7.87[a]
Southwest	3.7526	17.3158	91 758	489.06	0.53
Subsample homes located within 0.3 to 0.4 miles of crematory ($N=72$)					
Estimates using benefit expression (2)					
All directions	2.65	16.431	92 384	−1 218.85	−1.32
Estimates using benefit expression (3)					
North	2.125	14.75	93,600	$2 251.10	2.4
West	2.1538	18.4615	104 262	8 210.55	7.87
Southwest	2.8111	18.2222	108 111	1 124.89	1.04
Subsample homes located within 0.2 to 0.3 miles of crematory ($N=43$)					
Estimates using benefit expression (2)					
All directions	2.0302	16.6512	92 241	−1 172.07	−1.27
Estimates using benefit expression (3)					
North	1.120	13.0	74 260	$5 006.59	6.74
West	1.9364	19.1818	102 491	9 402.24	9.17
Southwest	2.220	18.40	110 200	1 862.57	1.69
Subsample homes located within 0.1 to 0.2 miles of crematory ($N=18$)					
Estimates using benefit expression (2)					
All directions	1.2333	16.6111	93 797	−528.96	−0.56
Estimates using benefit expression (3)					
North	0.675	15.250	57 200	$7 796.74	13.63
West	1.30	19.40	108 180	16 081.95	14.87
Southwest	1.40	9.0	93 000	4 388.07	4.72
Subsample homes located within 0.1 miles of crematory ($N=7$)					
Estimates using benefit expression (2)					
All directions	0.5714	15.0	74 814	3 657.88	4.89
Estimates using benefit expression (3)					
North	0.3333	13.0	54 367	$19 434.39	35.75
West	0.7	24.0	80 000	27 698.32	34.62
Southwest[b]	–	–	–	–	–

Notes: [a]No West-region homes with 0.5 miles > DISTANCE > 0.4 miles.
[b]No Southwest-region homes with DISTANCE < 0.1 miles.

inhibits air movements so as to increase odour for homes located West and Southwest of the crematory. The fact of the matter is that nearly all of the complaints about crematory emissions issue from these three directions.

V. Conclusions

The lack of studies involving direction as well as distance to a pollution source is startling, particularly in light of the widespread application of the

hedonic technique to assessing damages associated with airborne and other mobile pollutants. This article takes advantage of a unique data set to evaluate the impact of a direction-sensitive environmental shock on residential property values in a small, isolated Wyoming community. The regressions included structure, neighbourhood and location variables. Results reveal that control for directional heterogeneity increases the estimated impact of distance from the source of the shock upon residential property values; this impact appears strongest for sample houses North, West and Southwest of the source. Failure to control for directional heterogeneity results in the implausible conclusion that distance undifferentiated by direction from the point emission source has a positive impact on selling price for houses located very close (within 0.1 miles) to the disamenity source, while houses located two to five times farther away experienced reduced sale prices.

Acknowledgement

Helpful comments and suggestions by an anonymous referee are gratefully acknowledged.

References

Atkinson, S. E. and Crocker, T. D. (1987) A Bayesian approach to assessing the robustness of hedonic property value studies, *Journal of Applied Econometrics*, **2**, 27–45.

Bajari, P. and Benkard, C. L. (2005) Demand estimation with heterogeneous consumers and unobserved product characteristics: a hedonic approach, *Journal of Political Economy*, **113**, 1239–74.

Bartik, T. (1988) Measuring the benefits of amenity improvements in hedonic price models, *Land Economics*, **64**, 172–83.

Bourassa, S. C., Hoesli, M. and Sun, J. (2004) What's in a view?, *Environment and Planning A*, **36**, 1427–50.

Boxall, P. C., Chan, W. H. and McMillan, M. L. (2005) The impact of oil and natural gas facilities on rural residential property values: a spatial hedonic analysis, *Resource and Energy Economics*, **27**, 248–69.

Cameron, T. A. (2006) Directional heterogeneity in distance profiles in hedonic property value models, *Journal of Environmental Economics and Management*, **51**, 26–45.

Cassel, E. and Mendelsohn, R. (1985) The choice of functional forms for hedonic price equations: comment, *Journal of Urban Economics*, **18**, 135–42.

Cropper, M. L., Deck, L. B. and McConnell, K. E. (1988) On the choice of functional form for hedonic price functions, *Review of Economics and Statistics*, **70**, 668–75.

Gillen, K., Thibodeau, T. and Wachter, S. (2001) Anisotropic autocorrelation in house prices, *Journal of Real Estate Finance and Economics*, **23**, 5–30.

Graves, P., Murdock, J. C., Thayer, M. A. and Waldman, P. (1988) The robustness of hedonic price estimation: Urban air quality, *Land Economics*, **64**, 220–33.

Halvorsen, R. and Palmquist, R. (1980) The interpretation of dummy variables in semi-logarithmic equations, *American Economic Review*, **70**, 474–5.

Herriges, J. A., Secchi, S. and Babcock, B. (2005) Living with Hogs in Iowa: the impact of livestock facilities on rural residential property values, *Land Economics*, **81**, 530–45.

Jud, G. D. and Seaks, T. G. (1994) Sample selection bias in estimating housing sales prices, *Journal of Real Estate Research*, **9**, 289–97.

Kelejian, H. and Robinson, D. (1992) Spatial autocorrelation: a new computationally simple test with an application to per capita county police expenditures, *Regional Science and Urban Economics*, **22**, 317–31.

Ketkar, K (1992) Hazardous waste sites and property values in the state of new jersey, *Applied Economics*, **24**, 647–59.

Kiel, K. A. and McClain, K. T. (1995a) House prices during siting decision stages: the case of an incinerator from rumor through operation, *Journal of Environmental Economics and Management*, **28**, 221–55.

Kiel, K. A. (1995b) The effect of an incinerator siting on housing appreciation rates, *Journal of Urban Economics*, **37**, 311–23.

Kim, C. W., Phipps, T. T. and Anselin, L. (2003) Measuring the benefits of air quality improvement: a spatial hedonic approach, *Journal of Environmental Economics and Management*, **45**, 24–39.

Leamer, E. E. (1978) *Specification searches: ad hoc inference with nonexperimental data*, John Wiley and Sons, New York, NY.

Leggett, C. G. and Bockstael, N. E. (2000) Evidence of the effects of water quality on residential land prices, *Journal of Environmental Economics and Management*, **39**, 121–44.

McMillen, D. P. and Thorsnes, P. (2003) The Aroma of Tacoma: time varying average derivatives and the effect of a superfund site on house prices, *Journal of Business Economics and Statistics*, **21**, 237–46.

Mitchell, R. C. and Carson, R. T. (1986) Property rights, protest, and the siting of hazardous waste facilities, *American Economic Review*, **76**, 285–90.

Morton, T. (2005) Rawlins residents sue crematory, The Casper Star Tribune, http://www.casperstartribune.net/articles/2005/1 1/13/news/casper/072

Neill, H. R., Hassengahl, D. M. and Assane, D. D. (2007) Estimating the effect of air quality: spatial versus traditional hedonic price models, *Southern Economic Journal*, **73**, 1088–111.

Palmquist, R. B. (1991) Hedonic methods, In *Measuring the Demand for Environmental Quality* (Eds) J. Braden and C. Kolstad, North-Holland, Amsterdam, pp. 77–120.

Palmquist, R. B., Roka, F. M. and Vukina, T. (1997) Hog operations, environmental effects, and residential property, values, *Land Economics*, **73**, 114–24.

Polinsky, A. M. and Shavell, S. (1976) Amenities and property values in a model of an urban area, *Journal of Public Economics*, **5**, 119–29.

Rosen, S. (1974) Hedonic prices and implicit markets: product differentiation in pure competition, *Journal of Political Economy*, **82**, 34–55.

Small, K. A. and Steimetz, S. (2006) Spatial hedonics and the willingness to pay for residential amenities, Working Paper No. 05-06-31, Department of Economics, University of California, Irvine.

Thorsnes, P. (2002) The value of a suburban forest preserve: estimates from sales of vacant residential building lots, *Land Economics*, **78**, 426–41.

URS Corporation (2006) *Rostad Mortuary Crematory Air Quality Impact Analysis*, Colorado, Denver.

Wexler, P. (Ed.) (2005) *Encyclopedia of Toxicology*, 2nd edn, Elsevier, Oxford, UK.

White, H. (1980) A heteroskedasticity-consistent co variance matrix estimator and a direct test for heteroskedasticity, *Econometrica*, **48**, 817–38.

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Environmental mercury release, special education rates, and autism disorder: an ecological study of Texas

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Accepted 1 November 2004

Abstract

The association between environmentally released mercury, special education and autism rates in Texas was investigated using data from the Texas Education Department and the United States Environmental Protection Agency. A Poisson regression analysis adjusted for school district population size, economic and demographic factors was used. There was a significant increase in the rates of special education students and autism rates associated with increases in environmentally released mercury. On average, for each 1000 lb of environmentally released mercury, there was a 43% increase in the rate of special education services and a 61% increase in the rate of autism. The association between environmentally released mercury and special education rates were fully mediated by increased autism rates. This ecological study suggests the need for further research regarding the association between environmentally released mercury and developmental disorders such as autism. These results have implications for policy planning and cost analysis.

Keywords: Mercury; Special education; Autism; Environmental toxins; Ecological

Introduction

Exposure to a variety of environmental neurotoxicants is known to affect normal child development, resulting in a spectrum of adverse outcomes, ranging from severe mental retardation and developmental disability to more subtle changes in functioning, depending in part on the timing and dose of the chemical agent (Landrigan and Garg, 2002; Mendola et al., 2002; Rice and Barone, 2000).

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) section 104 (i), as amended by the Superfund Amendments and Reauthorization Act (SARA), requires the Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Protection Agency (EPA) to prepare a list, in order of priority, of substances that are most commonly found at waste facilities on the National Priorities List (NPL) and which are determined to pose the most significant potential threat to human health due to their known or suspected toxicity and potential for human exposure. Accordingly, mercury is listed as the third-most frequently found (arsenic and lead are

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1353-8292/$ - see front matter © 2005 Published by Elsevier Ltd.
doi:10.1016/j.healthplace.2004.11.005

first and second) toxic substance in the United States (ATSDR, 2001).

Symptoms of nervous system disruption associated with chronic exposure to mercury has been known since the 19th century, when mercury was widely used in the felt industry which led to the expression of "hatter's disease" (Hu, 1998). Further epidemiological evidence of the neurotoxicity of mercury dates back to the 1950s, when it was ascertained that thousands of people in Minamata and Niigata Japan suffered various neurological impairments caused by consumption of mercury contaminated fish (Harada, 1978). However, the neurotoxicity of low-level mercury exposure has only recently been documented (NAS, 2000; EPA, 1997) and recent reports implicate mercury in the etiology of various developmental and learning disabilities (Ramirez et al., 2003; Grandjean et al., 2003) including autism (Bernard et al., 2001, 2002).

Recent evidence for mercury toxicity relevant to the biology of autism is compelling (Palomo et al., 2003; Aschner and Walker, 2002; Bernard et al., 2002; Vojdani et al., 2003) and Bradstreet et al. (2003) report that levels of urinary mercury after a 3-day treatment with an oral chelating agent, meso-2,3-dimercaptosuccinic acid (DMSA), in children with autistic spectrum disorders were three times those in a matched normal control sample.

Environmentally released mercury is a major source of mercury exposure. Mercury is released into the environment largely from fossil fuel (mainly coal) combustion by electrical utilities and from municipal and medical waste incinerators. This inorganic mercury becomes airborne and may be carried for miles before being deposited on soil or water. This inorganic form of mercury is then converted to a toxic form (methylmercury) by chemical reactions or by bacteria, which is absorbed by aquatic microorganisms that are eaten by fish, and in this manner accumulates up the aquatic food chain. Humans are primarily exposed through fish consumption (Myers et al., 2000) and transmission from mothers to infants is well documented in animal models (Newland et al., 1994) and human studies (Ramirez et al., 2000; Grandjean et al., 1995). Results from several studies show that maternal mercury exposure during pregnancy is associated with neuropsychological deficits in children and that this association is most evident in women with stable exposures throughout pregnancy (Ramirez et al., 2003; Grandjean et al., 2003).

Other than accidental poisoning at the population level, where developmental disabilities have been reported as the result of large mercury spills (Racz and Vandewater, 1982), there have been no published studies examining the risk of disability associated with mercury released into the environment within the current legal limits. The available information regarding exposure to toxic agents associated with developmental disorders is suggestive but inconclusive (Ostrowski et al., 2003). In a prior study, we report evidence for an association between environmentally released mercury and various developmental disorders, including autism, at the state level ($n = 50$) (unpublished manuscript). We considered the positive association between developmental disabilities and environmentally released mercury in that investigation as preliminary due to the relatively small number of large geological regions. In this study, we investigate the association between environmentally released mercury pollution and autism rates at the county ($n = 254$) and school district level ($n = 1184$) in Texas. The advantage of using county level data in this study allows an investigation using greater numbers of smaller geographic units in the analysis—this can potentially increase our power to detect an effect if in fact it present. Since Texas ranks 4th among states with the highest reported mercury releases (next to California, Oregon, and West Virginia) (USEPA-TRI, 2004), analysis of data from this state can be useful for further investigation of the association between environmental mercury release and developmental disorders. In this study, we investigate the association between total special education rates, autism, and environmental mercury release.

Methods

Data source and sample data regarding environmentally released mercury for each county were obtained from the United State Environmental Protection Agency Toxics Release Inventory (TRI) (USEPA-TRI, 2004). TRI collects information about chemical releases and waste management reported by major industrial facilities in the US. The TRI database was established by Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (EPCRA). Under EPCRA, industrial facilities in specific sectors are required to report their environmental releases and waste management practices annually to the EPA. Facilities covered by this act must disclose their releases to air, water, and land of approximately 650 toxic chemicals, as well as the quantities of chemicals they recycle, treat, burn, or otherwise dispose of on-site and off-site. The current analysis uses reports of pollution that industrial facilities provided to TRI for the calendar year 2001. The total number of pounds of environmentally released mercury was obtained for each county.

Administrative data from the Texas Education Agency (TEA) from school years 2000–2001 were analyzed. Data and data description are available at the TEA website at http://198.214.99.202. In compliance with the Texas Education Code, the Public Education Information Management System (PEIMS) contains

data necessary for the legislature and the TEA to perform their legally authorized functions in overseeing public education. The database consists of student demographic, personnel, financial, and organizational information. Autism counts per school district were obtained by special request from the TEA. Data were from 1184 school districts in 254 counties in Texas. These districts represented approximately 4 million children enrolled in grades K through 12.

Diagnosis of autistic disorder was abstracted from the school record for each year of the study period. Diagnoses were made by qualified special education psychologists employed by the TEA or from psychologists or medical doctors outside the TEA system. While diagnoses were not standardized, there is considerable evidence that diagnoses of autistic disorder are made with good reliability and specificity in the field (Eisenmajer et al., 1996; Hill et al., 2001, Mahoney et al., 1998).

District population wealth was calculated as a school district's total taxable property value in 2001 as determined by the Comptroller's Property Tax Division (CPTD), divided by the total number of students in the district in 2000–2001. Property value was determined by the CPTD as part of its annual study, which attempts to present uniformly appraised property valuations statewide. The CPTD value is calculated by applying ratios created from uniform independent appraisals to the district's assessed valuations.

Racial composition was accounted for by the proportion of European-American children enrolled in schools within each district.

Total number of students was calculated as all enrolled students as of October 28, 2000 in grades kindergarten through twelve, who attended at least 1 day of school for that school year. Statewide, 6975 students, or 0.2% of all students, were enrolled but did not attend school.

Proportion of economically disadvantaged students was calculated as the percentage of students who were eligible for free meals under the National School Lunch and Child Nutrition Program, reduced-price meals under the National School Lunch and Child Nutrition Program, or other public assistance.

Total number of students enrolled in special education was calculated as the number of students receiving special education in each district.

Urbanicity. Eight separate demographic district regions were utilized in the analysis: (1) *Major urban* districts are the districts with the greatest membership in counties with populations of 650,000 or more, and more than 35% of the students are identified as economically disadvantaged. (2) *Other central city*—The major school districts in other large, but not major, Texas cities. Other central city districts are the largest districts in counties with populations between 100,000 and 650,000 and are not contiguous to any major urban districts. (3) *Major suburban* districts are contiguous to major urban districts. If the suburban district is not contiguous, it must have a student population that is at least 15% of the size of the district designated as major urban. (4) *Other central city suburban*—Other school districts in and around the other large, but not major, Texas cities. They are contiguous to other central city districts. If the suburban district is not contiguous, it must have a student population that is at least 15% of the size of the district designated as central city. (5) *Independent town*—The largest school districts in counties with populations of 25,000–100,000. (6) *Non-metro: fast growing* school districts that are not in any of the above categories and that exhibit a 5-year growth rate of at least 20%. These districts must have at least 300 students in membership. (7) *Non-metro: stable* school districts that are not in any of the above categories, yet have a number of students in membership that exceeds the state median. (8) *Rural* school districts that do not meet the criteria for placement into any of the above categories. These districts either have a growth rate less than 20% and the number of students in membership is between 300 and the state median, or the number of students in membership is less than 300.

In the analysis, the first two categories above were combined to form an "urban" dummy variable, categories three and four were combined to form a "suburban" dummy variable and categories five through seven formed an "other" category, with rural districts as the reference group.

Statistical methods. Since the 1184 school districts were nested within 254 counties, we modeled the data using a multilevel Poisson regression model to adjust estimates due to a potential county level clustering effect—which can bias estimated standard errors downward, thus leading to type I errors if not properly addressed (Barcikowski, 1981).

A multilevel Poisson regression model allowing for over-dispersion of the dependent variable was used in which the total number of children with autism and the number of special education students (excluding autism) was modeled separately as a function of the total pounds of environmentally released mercury. The model was adjusted for percent of the population of European-American descent, district population wealth, percent economically disadvantaged and urbanicity. Rates were offset by the total number of children served in a school district. For the model predicting autism rates, special education counts were included as a covariate in a subsequent model. For the model predicting special education rates, autism counts were also included as a covariate in a separate model. All models were estimated using MLwiN software with a log link function specified (Goldstein et al., 1998). The analysis yields adjusted relative rate estimates as a function of pounds of environmentally released mercury.

Results

Table 1 shows the descriptive statistics of the study variables. The standard deviation and the maximum and minimum values indicate considerable variation for all study variables. Table 2 shows the results of the regression model where autism rates were modeled as a function of pounds of mercury and sociodemographic covariates (model 1), plus adjustment for the number of special education students (excluding autism) (model 2).

Model 1 shows that for each 1000 lb of environmentally released mercury, the rate of autism increases by 61%. A small but significant rate increase is noted for districts with higher wealth, and a small but significant inverse association is observed for percentage of European American and economically disadvantaged students. A large effect is observed for community type. The highest rate increase is observed when comparing urban to rural school districts—relative to rural districts there is a 473% higher rate of autism. There is a 255%

Table 1
Descriptive statistics for study variables ($n = 1184$ school districts in 254 counties)

	Mean	SD	Minimum	Maximum
Autism count total	5.11	21.39	0	416
Total special education population count	414.12	1205.21	0	21,900
Pounds of environmental mercury release	203.99	522.84	0	2059
Total student population	3382.30	10908.99	6	209,916
Percent economically disadvantaged	47.28	21.70	0	100
Percent European American	58.33	29.71	0	100
District wealth	$189,080	$262,290	0	$4,276,736
Community type				
% Urban	4.1	—	—	—
% Suburban	13.2	—	—	—
% Rural	34.9	—	—	—
% Other	47.8	—	—	—

Table 2
Poisson regression estimates predicting relative rate of autism prevalence

	Estimate (SE)	Relative rate	Lower 95% CI	Upper 95% CI
Model 1: Predicting autism prevalence rates as a function of mercury release with demographic covariate adjustments				
Mercury (per 1000 pounds)	0.479 (0.041)	1.614	1.487	1.752
Percent European American	−0.023 (.001)	0.977	0.975	0.979
District wealth (per 100,000 dollars)	0.060 (0.010)	1.062	1.041	1.083
Percent economically disadvantaged	−0.029 (0.001)	0.971	0.969	0.973
Urban versus rural	1.553 (0.109)	4.726	3.800	5.877
Suburban versus rural	0.935 (0.108)	2.547	2.052	3.161
Other versus rural	0.027 (0.112)	1.027	0.821	1.285
Model 2: Predicting autism prevalence rates as a function of mercury with demographic and special education count adjustment				
Mercury (per 1000 pounds)	0.160 (0.031)	1.174	1.103	1.249
Percent European American	−0.019 (0.001)	0.981	0.979	0.983
District wealth (per 100,000 dollars)	0.010 (0.010)	1.010	0.990	1.030
Percent economically disadvantaged	−0.034 (0.001)	0.967	0.965	0.969
Urban versus rural	0.953 (0.078)	2.593	2.219	3.031
Suburban versus rural	0.808 (0.074)	2.243	1.935	2.601
Other versus rural	−0.356 (0.087)	0.700	0.589	0.834
Special education count (per 1000)	0.172 (0.005)	1.188	1.176	1.200

higher rate of autism in suburban relative to rural districts.

In model 2, after adjustment for the number of special education students, mercury remained a significant predictor of autism rates, indicating a 17% increase in autism rates for every 1000 lb of mercury released in the environment. The number of special education students was a significant predictor of autism rates as well. Wealth was no longer a significant predictor and the other covariates showed decreases relative to model 1, but remained significant.

Table 3 shows the regression estimates where special education rates (excluding autism counts) were modeled as a function of pounds of mercury and sociodemographic covariates (model 3), plus adjustment for the number of autistic students (model 4).

Model 3 shows that each 1000 lb of reported mercury release is associated with a 43% increase in the rate of special education students. Small but significant increases were associated with the percentage of European Americans, economically disadvantaged and district wealth. Community type was strongly associated with special education rates. All community-type categories show a much higher percentage of special education students relative to rural communities.

In model 4, after adjusting for total autism counts, the association between pounds of mercury and special education rates was no longer statistically significant—with the other covariates in the model remaining significant. This indicates that increased rates in autism account for the association between environmentally released mercury and the rate of special education students.

Discussion

To the best of our knowledge, this is one of the first investigations to report an ecological association between developmental disorders and environmentally released mercury.

The results of this study demonstrate that school district autism and special education rates are significantly associated with environmentally released mercury. This association was independent of the number of children served in the educational system for that district, district wealth, ethnic make-up, and community type. Further, these results indicate that the association between mercury release and school district special education rates was completely accounted for by increased rates of autism. This indicates that, in Texas, the increase in special education rates attributable to environmental mercury can be explained by increases in autism. The results of this study are consistent with our prior nation-wide study where an association between various developmental disabilities and environmentally released mercury was observed at the state level

Table 3
Poisson regression estimates predicting relative rate of special education prevalence

	Estimate (SE)	Relative rate	Lower 95% CI	Upper 95% CI
Model 3: Predicting special education prevalence rates as a function of mercury with demographic adjustments				
Mercury (per 1000 pounds)	0.360 (0.030)	1.433	1.350	1.522
Percent white	0.004 (0.001)	1.004	1.002	1.006
District wealth (per $100,000)	0.050 (0.010)	1.051	1.030	1.073
Percent economically disadvantaged	0.012 (0.001)	1.012	1.010	1.014
Urban versus rural	2.741 (0.104)	15.502	12.591	19.087
Suburban versus rural	2.110 (0.103)	8.248	6.713	10.135
Other versus rural	1.550 (0.110)	4.711	3.781	5.871
Model 4 Predicting special education prevalence rates as a function of mercury with demographic and autism count adjustments				
Mercury (per 1000 pounds)	−0.062 (0.032)	0.940	0.882	1.002
Percent white	0.008 (0.001)	1.008	1.006	1.010
District wealth (per $100,000)	0.030 (0.010)	1.030	1.010	1.051
Percent economically disadvantaged	0.014 (0.001)	1.014	1.012	1.016
Urban versus rural	2.240 (0.068)	9.393	8.199	10.762
Suburban versus rural	1.902 (0.066)	6.699	5.871	7.645
Other versus rural	1.174 (0.073)	3.235	2.795	3.743
Autism count (per 100)	0.689 (0.022)	1.992	1.906	2.081

(unpublished manuscript). However, the results of this report should be interpreted with caution for a number of reasons.

First, this is an ecological study that precludes interpretation at the individual level. We have used aggregate units in this analysis to investigate differential rates of autism as a function of pounds of mercury at the county level. While we properly addressed the potentially biasing effects of clustering (school districts nested within counties) by utilizing appropriate analytic methods (e.g. multilevel-analysis), individual data are required to make a better case for the observed associations and their interpretations. Nevertheless, ecological studies of this type are often an important first step in identifying subsequent areas of investigation.

Second, a causal association between environmentally released mercury and developmental disorders cannot be determined from this cross-sectional data. Data availability permitting, future studies could investigate this association by using longitudinal data where changes in mercury levels over time may be used as a predictor of the rate of change in developmental disorders over time.

Third, we should consider that school-based administrative autism data, such as these, are only a proxy for true community prevalence. However, these autism rates are most likely biased downward. For example, Yeargin-Allsopp et al. (2003) found that, in one metropolitan area, 18% of children who qualified for a diagnosis of autism according to their study criteria were receiving special education services but had not been categorized as having autism. The critical unknown issue is whether identification of children in the special education system is systematically biased in the same direction as reporting of environmental mercury release. For example, counties in which administrations are more aggressive regarding penalties for underreporting toxic release may also have educational policies that result in a greater number of children identified for special education services. Despite the limitations of these administrative data, as demonstrated, these data can be a useful component to preliminary epidemiological studies (Dales et al., 2001). By demonstrating an association between environmentally released mercury and developmental disorders, the results of this study provide a necessary first step in identifying plausible contributing factors of risk for developmental disabilities.

This line of research has implications for toxic substance regulation and prevention policies. The effects of differing state policies regarding toxic release of mercury on the incidence of developmental disorders should be investigated. For example, policies that have successfully limited exposures to lead have had direct effects on morbidity and have demonstrated reductions in health care costs related to lead exposure (Sargent et al., 1999, Galke et al., 2001; Brown, 2002). However, while federal efforts toward reducing mercury exposure through policy have been successful to some extent by signing bills into law, proportionally few have been enacted (Mercury Policy Project (MMP), 2004). Despite existing policy recommendations, debate concerning acceptable levels of safety still remains (Dourson et al., 2001; Kaiser, 2000), thus, limiting progress toward evaluating policies related to reducing exposure to mercury.

Conclusions

What is currently known about the low-level toxicity of mercury from behavioral toxicology and behavioral teratology studies are convincing enough to warrant further study. This study is among the first to demonstrate an association between environmentally released mercury at the county level and the rate of developmental disability. Given the limitations of this ecological association, future studies should investigate this association using other methodologies and samples. This line of research has important implications for public health policy and supports prior recommendations for reducing environmentally released mercury (Needleman, 1995; Landrigan et al., 1994).

References

Agency for Toxic Substances and Disease Registry (ATSDR), 2001. CERCLA Priority List of Hazardous Substances. US Department of Health and Human Services, Public Health Service, Atlanta, GA. www.atsdr.cdc.gov/clist.html.

Aschner, M., Walker, S.J., 2002. The neuropathogenesis of mercury toxicity. Molecular Psychiatry 7 (Suppl. 2), S40–S41.

Barcikowski, R., 1981. Statistical power with group mean as the unit of analysis. Journal of Educational Statistics 6, 267–285.

Bernard, S., Enayati, A., Redwood, L., Roger, H., Binstock, T., 2001. Autism: a novel form of mercury poisoning. Medical Hypotheses 56, 462–471.

Bernard, S., Enayati, A., Roger, H., Binstock, T., Redwood, L., 2002. The role of mercury in the pathogenesis of autism. Molecular Psychiatry 7, S42–S43.

Bradstreet, J., Geier, D., Kartzinel, J., Adams, J., Geier, M., 2003. A case-control study of mercury burden in children with autistic spectrum disorders. Journal of American Physicians and Surgeons 8 (3), 76–79.

Brown, M.J., 2002. Costs and benefits of enforcing housing policies to prevent childhood lead poisoning. Medical Decision Making 22 (6), 482–492.

Dales, L., Hammer, S., Smith, N., 2001. Time trends in autism and in MMR immunization coverage in California. Journal of the American Medical Association 285 (9), 1183–1185.

Dourson, M.L., Wullenweber, A.E., Poirier, K.A., 2001. Uncertainties in the reference dose for methylmercury. Neurotoxicology 22 (5), 677–689.

Eisenmajer, R., Prior, M., Leekam, S., Wing, L., Gould, J., Welham, M., 1996. Comparison of clinical symptoms in autism and Asperger's disorder. Journal of the American Academy of Child & Adolescent Psychiatry 35 (11), 1523–1531.

Environmental Protection Agency, 1997. Mercury Study Report to congress, vol 1. Available at: http://www.epa.gov/ttnatw01/112nmerc/volume1.pdf. Accessed February 22, 2004.

Galke, W., Clark, S., Wilson, J., et al., 2001. Evaluation of the HUD lead hazard control grant program: early overall findings. Environmental Research 86 (2), 149–156.

Goldstein, H., Rasbash, J., Plewis, I., Draper, D., Browne, W., Yang, M., Woodhouse, G., Healy, M.A., 1998. User's guide to MLwiN, Version 1.0, January. Institute of Education. ISBN 085473 547X.

Grandjean, P., Weihe, P., White, R.F., 1995. Milestone development in infants exposed to methylmercury from human milk. Neurotoxicology 16, 27–33.

Grandjean, P., White, R.F., Weihe, P., Jorgensen, P.J., 2003. Neurotoxic risk caused by stable and variable exposure to methylmercury from seafood. Ambulatory Pediatrics 3 (1), 18–23.

Harada, M., 1978. Congenital Minamata disease: intrauterine methylmercury poisoning. Teratology 18, 285–288.

Hill, A., Bolte, S., Petrova, G., Beltcheva, D., Tacheva, S., Poustka, F., 2001. Stability and interpersonal agreement of the interview-based diagnosis of autism. Psychopathology 34 (4), 187–191.

Hu, H., 1998. Heavy metal poisoning. In: Fauci, A.S., Braunwald, E., Isselbacher, K.J., Wilson, J.D., Martin, J.B., Kasper, D.L., Hauser, S.L., Longo, D.L. (Eds.), Harrison's Principles of Internal Medicine, 14th ed. McGraw-Hill, New York, pp. 2564–2569 (Chapter 397).

Kaiser, J., 2000. Mercury report backs strict rules. Science 289, 371–372.

Landrigan, P.J., Garg, A., 2002. Chronic effects of toxic environmental exposures on children's health. Journal of Toxicology—Clinical Toxicology 40 (4), 449–456.

Landrigan, P.J., Graham, D.G., Thomas, R.D., 1994. Environmental neurotoxic illness: research for prevention. Environmental Health Perspectives 102 (Suppl. 2), 117–120.

Mahoney, W., Szatmari, P., MacLean, J., Bryson, S., Bartolucci, G., Walter, S., 1998. Reliability and accuracy of differentiating pervasive developmental disorder subtypes. Journal of the American Academy of Child & Adolescent Psychiatry 37 (3), 278–285.

Mendola, P., Selevan, S.G., Gutter, S., Rice, D., 2002. Environmental factors associated with a spectrum of neurodevelopmental deficits. Mental Retardation Developmental Disabilities Research Reviews 8 (3), 188–197.

Mercury Policy Project (MMP), 2004. Web site. Available at http://www.mercurypolicy.org. Accessed March 1.

Myers, G.J., Davidson, P.W., Cox, C., Shamlaye, C., Cernichiari, E., Clarkson, T.W., 2000. Twenty-seven years studying the human neurotoxicity of methylmercury exposure. Environmental Research 83 (3), 275–285.

National Academy of Sciences, 2000. Toxicological Effects of Methylmercury. National Academy Press, Washington, DC.

Needleman, H.L., 1995. Behavioral toxicology. Environmental Health Perspectives 103 (Suppl. 6), 77–79.

Newland, M.C., Yezhou, S., Logdberg, B., Berlin, M., 1994. Prolonged behavioral effects of in utero exposure to lead or methyl mercury: reduced sensitivity to changes in reinforcement contingencies during behavioral transitions and in steady state. Toxicology and Applied Pharmacology 126, 6–15.

Ostrowski, S., Wilbur, S., Chou, C., Pohl, H., Stevens, Y., Allred, P., Roney, N., Fay, M., Tylenda, C., 2003. Agency for Toxic Substances and Disease Registry's 1997 priority list of hazardous substances. Latent effects—carcinogenesis, neurotoxicology, and developmental deficits in humans and animals. Toxicology & Industrial Health 15 (7), 602–644.

Palomo, T., Beninger, R.J., Kostrzewa, R.M., Archer, T., 2003. Brain sites of movement disorder: genetic and environmental agents in neurodevelopmental perturbations. Neurotoxological Research 5 (1–2), 1–26.

Racz, W., Vandewater, L., 1982. Perspectives on the central nervous system toxicity of methylmercury. Canadian Journal of Physiology and Pharmacology 60, 1037–1045.

Ramirez, G., Vince Cruz, C., Pagulayan, O., Ostrea, E., Dalisay, C., 2000. The Tagum Study I: analysis and clinical correlates of mercury in maternal and cord blood, breast milk, meconium, and infants' hair. Pediatrics 106 (4), 774–781.

Ramirez, G., Pagulayan, O., Akagi, H., et al., 2003. Tagum study II: follow-up study at two years of age after prenatal exposure to mercury. Pediatrics 111 (3), e289–e295.

Rice, D., Barone, S., 2000. Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models. Environmental Health Perspectives 108 (Suppl 3), 511–533.

Sargent, J.D., Dalton, M., Demidenko, E., Simon, P., Klein, R.Z., 1999. The association between state housing policy and lead poisoning in children. American Journal of Public Health 89 (11), 1690–1965.

United States Environmental Protection Agency Toxics Release Inventory, 2004. http://www.epa.gov/tri/. Accessed May.

USEPA-TRI, 2004.

Vojdani, A., Pangborn, J.B., Vojdani, E., Cooper, E.L., 2003. Infections, toxic chemicals and dietary peptides binding to lymphocyte receptors and tissue enzymes are major instigators of autoimmunity in autism. International Journal of Immunopathology and Pharmacology 16 (3), 189–199.

Yeargin-Allsopp, M., Rice, C., Karapurkar, T., Doernberg, N., Boyle, C., Murphy, C., 2003. Prevalence of autism in a US metropolitan area. Journal of the American Medical Association 289, 49–55.

Environ. Sci. Technol. **2003**, *37*, 62−67

Characterizing the Emissions of Polychlorinated Dibenzo-*p*-dioxins and Dibenzofurans from Crematories and Their Impacts to the Surrounding Environment

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This study was set out to characterize PCDD/F emissions from crematories and assess their impacts on the surrounding environment. Two crematories located in southern Taiwan were investigated, including the one (C1) with no air pollution control device installed and the other (C2) installed with a bag filter. Results show the mean PCDD/F emissions (11% oxygen) from the stacks of C1 and C2 were 2.36 and 0.322 ng I-TEQ Nm^{-3}, respectively. The mean emission factors for C1 and C2 were 13.6 and 6.11 μg I-TEQ $body^{-1}$, respectively. The removal efficiency of the bag filter on PCDD/Fs was 55.1%. The estimated PCDD/F emission rate for all crematories in Taiwan was 0.838 g I-TEQ yr^{-1} accounting for 227% and 112% of the annual emissions from all medical waste incinerators and municipal waste incinerators, respectively. The above results indicate that PCDD/F emissions from crematories were quite significant. To assess the impact of PCDD/F emissions from a crematory to the surrounding environment, ambient air samples were collected from the downwind site of C1 with the maximum ground concentration. We found the estimated maximum ground concentration at the downwind site of C1 (= 0.521 pg I-TEQ Nm^{-3}) was much higher than that found at the background, rural area, residential area, urban area, and industrial area (= 0.006, 0.023, 0.052, 0.093, and 0.190 pg I-TEQ Nm^{-3}, respectively). The above results suggest that PCDD/F emissions from a crematory did significantly affect its surrounding environment. In conclusion, a proper control strategy should be taken immediately in order to eliminate PCDD/F emissions from crematories.

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Introduction

After polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were discovered in the flue gases and fly ash of municipal waste incinerators in 1977 (*1*), PCDD/F emissions from various sources have become a serious issue in many countries, because of their toxicological effects and associated adverse health implications. PCDD/Fs are mainly formed during anthropogenic activities and are usually referred to as dioxins. Intensive studies have been conducted on various PCDD/F emission sources, including the waste combustion sources, chemical-industrial sources, and other thermal sources. Nevertheless, only a few studies were carried out on crematories (*2*−*7*).

In a study conducted by Fiedler in Germany, PCDD/F toxic equivalent (i.e., TEQ) concentrations of ~8 ng TEQ Nm^{-3} were measured in the stack flue gases of crematories (*2*). Takeda et al. measured PCDD/F emissions from 17 crematories in Japan found PCDD/F concentrations and their corresponding TEQ concentrations in the stack flue gases were 4.9−1200 ng Nm^{-3} (12% oxygen) and 0.064−24 ng TEQ Nm^{-3}, respectively (*5*). In the UK, a laboratory study conducted by the Warren Spring Laboratory found the mean PCDD/F TEQ concentration of 46 ng TEQ Nm^{-3} (11% oxygen) for the cremation process (*7*). The wide range of PCDD/F concentrations arising from various crematories are believed to be due to their intrinsic differences in operation conditions, air pollution control devices, and involved incinerating materials (*5*).

In the U.S. (*8*), UK (*7*), and Japan (*5*), PCDD/F emission rates for the crematory source were found as ~9.1, 1−35, and 1.3−3.8 g TEQ yr^{-1}, respectively. In principle, the total PCDD/F emission from the crematory was relatively small as compared with that from the municipal waste incinerator. For example, a recent study conducted in Japan has indicated that the crematory emission accounted for only 0.13−0.29% of that emitted from municipal waste incinerators (*5*). But it should be noted that most crematories are equipped with a low stack and are situated in the proximity of the residential area. In particular, most of them do not adopt any air pollution control device to eliminate PCDD/F emissions from stacks. Based on these, it can be expected that PCDD/F emissions from a crematory might significantly affect its surrounding environment. Moreover, it should be noted that recently the cremation ratio has increased dramatically in Taiwan and many other countries. In Taiwan, the cremation ratio is expected to increase from 66.9% in 2000 to 85.0% in 2005. In the U.S., the cremation ratio has increased significantly from 15.2% in 1987 to 25.0% in 2000 and is expected to reach 37.0% in 2010 (*8*). In Japan, because of the encouragement of the governmental policy its current cremation ratio is as high as 99% (*4*). Based on these data, it is expected that crematories will play an important role on PCDD/F emissions not only in Taiwan area but also in many other countries.

Indeed, in addition to PCDD/Fs, PCBs, and PAHs, total suspended particles (TSP) and odor released from crematories might also cause serious problems to human health. However, the U.S. EPA has reported that there appears to be no "safe" level for dioxin exposure, and the levels of dioxin and dioxin-like chemicals found in the general U.S. population were "at or near levels associated with adverse health effects" (*9*). Subjected to both cost and manpower, only PCDD/F emissions from crematories were studied in this work. In this study, two crematories located in southern Taiwan with similar operation conditions were investigated. The congener

10.1021/es0208714 CCC: $25.00
Published on Web 11/22/2002

TABLE 1. Basic Information for the Two Investigated Crematories of C1 and C2

crematory	C1	C2
operational temperature of the primary combustor	730 °C	750 °C
operational temperature of the secondary combustor	620 °C	650 °C
capacity	0.5 body h^{-1}	0.5 body h^{-1}
auxiliary fuel	diesel (40 L h^{-1})	diesel (40 L h^{-1})
air pollution control devices		bag filter
temperature of the stack flue gas	300 °C	200 °C
height of the stack	5 m	6 m

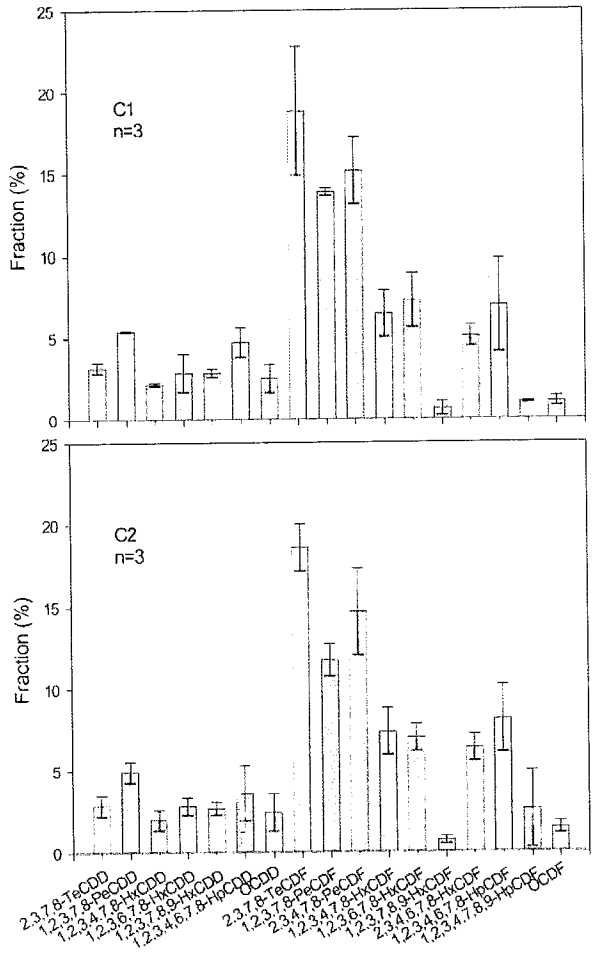

FIGURE 1. Congener profiles of seventeen 2,3,7,8 chlorinated substituted PCDD/Fs containing in the stack flue gases of C1 and C2.

profiles of PCDD/Fs in the stack flue gases of these two crematories were presented and compared. PCDD/F emission factors and emission rates for both crematories were determined. Furthermore, to assess the influence of PCDD/F emissions from a crematory process to the surrounding environment, the PCDD/F concentrations in the atmosphere of the background area, rural area, residential area, urban area, and industrial sites were measured and were compared with the results that were obtained from the vicinity of a crematory.

TABLE 2. Mean PCDD/Fs Emission Factors for the Two Investigated Crematories of C1 and C2

	C1 ($n = 3$)		C2 ($n = 3$)	
PCDD/Fs	mean g body^{-1}	RSD %	mean g body^{-1}	RSD %
2,3,7,8-TeCDD	2.26	74	0.969	61
1,2,3,7,8-PeCDD	4.01	80	1.70	46
1,2,3,4,7,8-HxCDD	1.59	78	0.738	31
1,2,3,6,7,8-HxCDD	1.76	48	0.894	53
1,2,3,7,8,9-HxCDD	2.19	87	0.964	52
1,2,3,4,6,7,8-HpCDD	3.78	93	0.977	82
OCDD	2.12	101	0.552	43
2,3,7,8-TeCDF	12.9	66	6.39	48
1,2,3,7,8-PeCDF	10.3	80	3.71	46
2,3,4,7,8-PeCDF	10.7	71	4.82	45
1,2,3,4,7,8-HxCDF	5.24	94	2.73	49
1,2,3,6,7,8-HxCDF	5.90	95	2.34	42
1,2,3,7,8,9-HxCDF	0.358	19	0.242	66
2,3,4,6,7,8-HxCDF	4.00	89	2.19	44
1,2,3,4,6,7,8-HpCDF	6.05	104	3.06	55
1,2,3,4,7,8,9-HpCDF	0.766	77	0.490	65
OCDF	0.698	58	0.495	60
total PCDD/Fs (μg body^{-1})	74.6	81	33.3	43
total I-TEQ (μg I-TEQ body^{-1})	13.6	75	6.11	45

Material and Methods

Investigating PCDD/F Emissions from the Cremation Process. Two crematories (denoted as C1 and C2) located in southern Taiwan were selected in this study. Both crematories had the same capacity (= 0.5 body h^{-1}) and were equipped with two combustion chambers (i.e., a primary and a secondary combustion chamber) operated under very similar combustion conditions (= 730 °C and 620 °C and 750 °C and 650 °C in the primary and secondary combustion chambers for C1 and C2, respectively). Both crematories used diesel as their auxiliary fuel with the same feeding rate specified at 40 L h^{-1}. C1 was not equipped with any air pollution control device, but C2 was facilitated with one bag filter with an automatic shaking control unit. Both crematories were equipped with a low stack (stack height = 5 and 6 m for C1 and C2, respectively). Basic information for these two crematories is described in more detail in Table 1.

Three PCDD/F samples were collected from the stack flue gas for each of the two selected crematories according to the U.S. EPA modified Method 23. The sampling train adopted in this study is comparable with that specified by the U.S. EPA Modified Method 5. Prior to sampling, XAD-2 resin was spiked with PCDD/F surrogate standards prelabeled with isotopes. The sampling time for each stack flue gas sample was ~2.5 h. To ensure the free contamination of the collected samples, one trip blank and one field blank were also taken when the field sampling was conducted.

Assessing PCDD/F Emissions from the Crematory to the Surrounding Environment. To assess the influence of PCDD/F emissions from a crematory on the surrounding environment, four ambient air samples were collected from two sampling sites at the vicinity of C1. The above two sampling sites were known with the maximum ground concentrations of C1 determined by using the Industrial Source Complex Short-Term Model (ISCST3). Yet, it is true that the accuracies regarding the use of ISCST3 on estimating maximum ground PCDD/F concentrations might be affected by the deposition of particle-phase PCDD/Fs and the decay of PCDD/Fs in the air due to photolysis (*10*). In this study, because C1 was known with a low stack and hence the duration of emitted PCDD/Fs transported from the stack to the ground level could be quite short. Based on this, we assumed both the deposition of particle-phase PCDD/Fs and photolysis of PCDD/Fs during the transportation period were

TABLE 3. PCDD/F Emission Factors for the Crematory Obtained from Different Studies

emission factors	reference	annotation
13.6 μg I-TEQ body^{-1}	this study	none of APCD
6.11 μg I-TEQ body^{-1}	this study	bag filter as its APCD
2.4−80 μg I-TEQ body^{-1}	(*7*)	
6 μg I-TEQ body^{-1}	(*3*)	
28 μg I-TEQ body^{-1}	(*10*)	derived from one crematory in Germany
70−80 μg I-TEQ body^{-1}	(*10*)	derived from two crematories in UK
0.5 μg I-TEQ body^{-1}	(*10*)	derived from one crematory in U.S.
9.2 μg I-TEQ body^{-1} (regarding ND as 0)		
11 μg I-TEQ body^{-1} (regarding ND as the half value of the detection limit)	(*4*)	derived from 10 crematories in Japan
3.97 μg I-TEQ body^{-1} (arithmetical mean)	(*5*)	derived from 17 crematories in Japan
1.83 μg I-TEQ body^{-1} (geometric mean)		

negligible. In this study, the dispersion parameters (such as atmospheric stability and mixing height) adopted in ISCST3 were determined based on the hourly meteorological data. According to the data obtained from the local weather bureau, we found that the prevailing winds were NW and N with their average wind speeds of 4.2 m s^{-1} and 2.4 m s^{-1}, respectively. Based on this, two sampling sites situated at the downwind sites of C1 with distances 80 m (SE) and 65 m (E) away from the stack were then determined in this study. For comparisons, five sampling sites were also selected for collecting ambient air samples during the same time. The first sampling site, the Keng-Ting National Park (n = 2), was situated at the southern end of Taiwan. This site was selected because it was far away from all possible pollution sources and hence its PCDD/F concentration could be regarded as the background level. The second sampling site was located at the Taitung county (n = 4), the least industrialized area in Taiwan, and hence was thought to be representative for the rural area. The other thee sampling sites were selected from the residential area (n = 2), urban area (n = 4), and industrial area (n = 4) of the same city as where C1 was located (i.e., the Kauhsiung city, the most industrialized area in Taiwan).

Each ambient air sample was collected using a PS-1 sampler (Graseby Andersen, GA) according to the revised EPA Reference Method T09A. The sampling flow rate was specified at ~0.225 m^3 min^{-1}. Each sample was collected continuously on three consecutive days (sampling volume = ~972 m^3). The PS-1 sampler was equipped with a quartz-fiber filter for sampling particle-phase PCDD/Fs and followed by a glass cartridge for sampling gas-phase PCDD/Fs, respectively. A known amount of surrogate standard was spiked to the glass cartridge in the laboratory prior to the field sampling being conducted.

Sample Analysis. Analyses of stack flue gas and ambient air samples followed the U.S. EPA modified method 23 and EPA Reference Method T09A, respectively. All chemical analyses were carried out by the Super Micro Mass Research and Technology Center in Cheng Shiu Institute of Technology—the only accredited laboratory in Taiwan for PCDD/F analyses. Each collected sample was spiked with a known amount of the internal standard. After being extracted for 24 h, the extract was concentrated, treated with concentrated sulfuric acid, and then followed by a series of sample cleanup and fractionation procedures. The eluate was concentrated to ~1 mL, then transferred to a vial, and then further concentrated to nearly dryness by using a nitrogen stream. Prior to PCDD/F analysis, the standard solution was added to the sample to ensure the recovery during the analysis process.

Two high-resolution gas chomatographs/high-resolution mass spectrometers (HGC/HMS) were used for PCDD/Fs analyses (one for analyzing stack flue gas samples and the other for ambient air samples). The HGC (Hewlett-Packard 6970 Series gas, CA) was equipped with a DB-5 fused silica capillary column (L = 60 m, ID = 0.25 mm, film thickness = 0.25 μm) (J&W Scientific, CA) and with a splitless injection. The oven temperature program was set according to the following: begin at 150 °C (held for 1 min), then increase at 30 °C min^{-1} to 220 °C (held for 12 min), then increase at 1.5 °C min^{-1} to 240 °C (held for 5 min), and finally increase at 1.5 °C min^{-1} to 310 °C (held for 20 min). Helium was used as the carrier gas. The HMS (Micromass Autospec Ultima, Manchester, UK) mass spectrometer was equipped with a positive electron impact (EI+) source. The analyzer mode of the selected ion monitoring (SIM) was used with resolving power at 10 000. The electron energy and source temperature were specified at 35 eV and 250 °C, respectively.

Results and Discussion

Characteristics of PCDD/F Emissions from Crematories. The congener profiles of the 2,3,7,8-substituted PCDD/Fs were selected as the signatures of the crematory emissions. Each selected congener was normalized by reference to the total weight of all 2,3,7,8-congeners. Figure 1 shows the congener profiles of the seventeen 2,3,7,8 chlorinated substituted PCDD/Fs (mean±SD) detected from the stack flue gases of C1 and C2. The top three congeners for both crematories were 2,3,7,8-TeCDF, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDF. The above results were quite similar to the congener profiles obtained from 10 crematories in Japan (*4*). Indeed, the involved incinerating materials (such as the weight of the dead body, sex, type of coffin, and other accompanied funeral materials, etc.) in crematories of the above-mentioned study might be different for us. However, the above-mentioned study has concluded that the incinerating materials might have a very limited effect on the congener profiles (*4*). The results obtained from this study further support the plausibility of the above inference.

PCDD/F Emissions from Crematories. Table 2 shows the mean emission factors for C1 (no air pollution control device was installed) and C2 (equipped with a bag filter) were 74.6 and 33.3 μg body^{-1} (in terms of total PCDD/F emissions) and 13.6 and 6.11 μg I-TEQ body^{-1} (in terms of total I-TEQ emissions), respectively. It is known that both C1 and C2 had quite comparable operation conditions (see Table 1). Therefore, it was assumed that both crematories might result in similar PCDD/F emissions during the cremation process. Based on this, the removal efficiency of the bag filter could be determined according to the following equation

$$\text{removal efficiency } (\eta;\ \%) = (A - B)/A \times 100\%$$

where A and B were the mean emission factors of C1 and C2, respectively. Based on this, it can be found that the removal efficiencies of the bag filter on the total PCDD/F emission and the total PCDD/F I-TEQ emission were 55.4% (= (74.6−33.3)/74.6) and 55.1% (= (13.6−6.11)/13.6), respectively. The

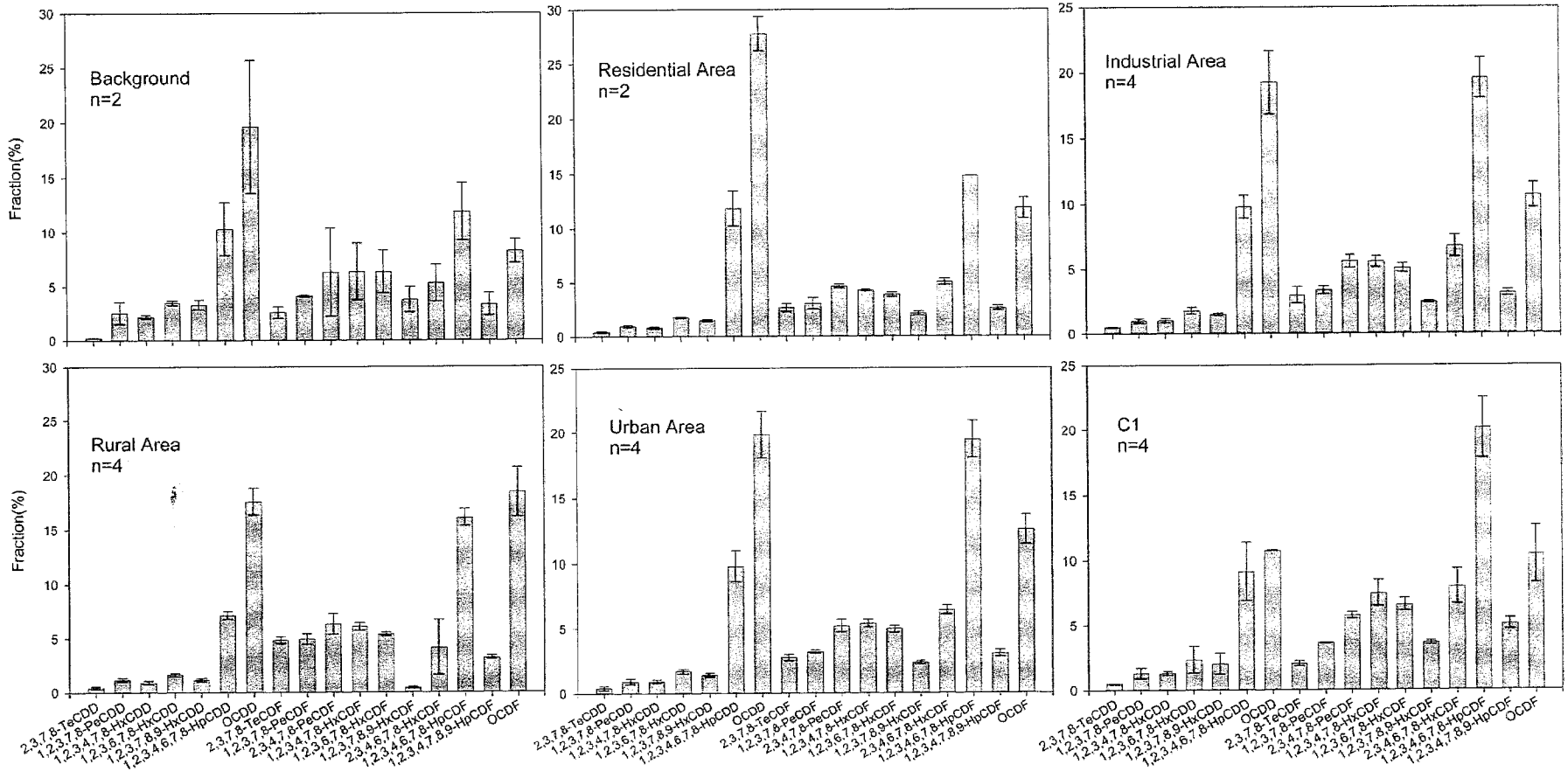

FIGURE 2. Congener profiles of seventeen 2,3,7,8 chlorinated substituted PCDD/Fs in ambient air.

TABLE 4. Mean PCDD/F Concentrations Found in Ambient Air of the Background, Rural Area, Residential Area, Urban Area, Industrial Area, and the Vicinity of C1

	background ($n = 2$)		rural area ($n = 4$)		residential area ($n = 2$)		urban area ($n = 4$)		industrial area ($n = 4$)		C1 ($n = 4$)	
PCDD/Fs	mean pg Nm^{-3}	RSD %	mean pg Nm^{-3}	RSD %	mean pg Nm^{-3}	RSD %	mean pg Nm^{-3}	RSD %	mean pg Nm^{-3}	RSD %	mean pg Nm^{-3}	RSD %
2,3,7,8-TeCDD	0.000	47	0.002	38	0.004	11	0.005	20	0.013	36	0.029	26
1,2,3,7,8-PeCDD	0.002	4	0.004	13	0.008	3	0.013	24	0.027	40	0.088	62
1,2,3,4,7,8-HxCDD	0.002	29	0.003	27	0.007	2	0.013	30	0.027	42	0.085	46
1,2,3,6,7,8-HxCDD	0.002	31	0.005	24	0.015	4	0.024	28	0.049	43	0.166	75
1,2,3,7,8,9-HxCDD	0.002	24	0.004	26	0.012	3	0.020	27	0.041	41	0.142	71
1,2,3,4,6,7,8-HpCDD	0.007	14	0.023	19	0.101	23	0.142	29	0.269	45	0.626	58
OCDD	0.013	7	0.057	19	0.237	16	0.283	18	0.516	41	0.708	36
2,3,7,8-TeCDF	0.002	56	0.016	17	0.022	4	0.039	10	0.076	18	0.136	45
1,2,3,7,8-PeCDF	0.003	39	0.016	16	0.026	8	0.045	16	0.088	31	0.237	35
2,3,4,7,8-PeCDF	0.005	91	0.020	20	0.040	6	0.074	18	0.150	36	0.381	40
1,2,3,4,7,8-HxCDF	0.005	73	0.020	13	0.036	7	0.077	19	0.151	40	0.480	23
1,2,3,6,7,8-HxCDF	0.005	65	0.017	14	0.033	5	0.070	18	0.138	41	0.428	29
1,2,3,7,8,9-HxCDF	0.003	6	0.001	35	0.018	2	0.033	14	0.067	45	0.241	39
2,3,4,6,7,8-HxCDF	0.004	66	0.014	67	0.043	4	0.092	20	0.188	48	0.540	51
1,2,3,4,6,7,8-HpCDF	0.009	57	0.051	11	0.126	10	0.279	20	0.538	45	1.30	25
1,2,3,4,7,8,9-HpCDF	0.002	5	0.010	12	0.022	18	0.043	21	0.085	43	0.330	27
OCDF	0.006	24	0.058	5	0.100	2	0.178	12	0.288	41	0.660	15
total PCDD/Fs	0.070	37	0.320	14	0.849	10	1.43	17	2.71	41	6.57	36
PCDDs	0.028	13	0.097	19	0.383	16	0.500	21	0.941	41	1.84	51
PCDFs	0.042	53	0.223	13	0.466	5	0.930	16	1.77	41	4.73	30
PCDDs/PCDFs ratio	0.742	42	0.432	10	0.819	11	0.536	9	0.535	8	0.377	23
total I-TEQ (pg I-TEQ/ Nm^3)	0.006	58	0.023	17	0.050	4	0.093	16	0.190	38	0.521	41

above results were similar to the results that obtained by Giugliano et al. (*11*). In their study, they measured PCDD/F concentrations at both inlet and outlet of the fabric filter of a municipal solid waste incinerator. Although the removal efficiency on total particulates was as high as >99.9%, removal efficiencies on total PCDD/F emissions and total PCDD/F I-TEQ emissions were ~45% and ~64%, respectively. Based on this, it is concluded that the removal efficiency of the bag filter on PCDD/F emissions was inadequate.

Table 3 shows total PCDD/F I-TEQ emission factors of crematories reported by other research. It can be found that the emission factors found in this study were quite comparable with that found by Takeda et al. (*4*). However, the wide range of PCDD/F emission factors found in other studies indicating that to generalize a universal emission factor for the cremation process might be not possible at this stage. Obviously, this could be due to the intrinsic differences in the types of combustion chamber, the operating conditions, and the types of air pollution control devices among various crematories.

Currently, a total of 32 crematories have been established in the Taiwan area. All crematories are facilitated with a low stack. Half of them were equipped with no air pollution control device, and the rest of them were only equipped with either a bag filter or a cyclone. According to statistical data provided by the Ministry of the Interior, there were ~85 000 cremations (cremation ratio = 66.9%) in 2000. By directly adopting the emission factors of C1 and C2 (assuming C1 and C2 are representative to those crematories installed without and with air pollution control devices, respectively), this study yielded the total PCDD/F I-TEQ emission rate for all crematories was ~0.838 g I-TEQ yr^{-1}. Comparing the above results with other emission sources, we found the total emission from crematories accounted for ~227% and 112% of the emissions from medical waste incinerators (= 0.369 g I-TEQ yr^{-1}) (*12*) and municipal waste incinerators (= 0.750 g I-TEQ yr^{-1}) (*13*), respectively. Unlike what was found in Japan (i.e., crematory emissions accounted for only 0.13–0.29% of I-TEQ yr^{-1} of that emitted from municipal waste incinerators) (*5*), crematories in Taiwan did play a much more important role in PCDD/F emissions.

Significance of PCDD/F Emissions from Crematories on the Surrounding Environment. Figure 2 shows the congener profiles of PCDD/Fs of the background, rural area, residential area, urban area, industrial area, and the vicinity of C1, respectively. All six categories show that the most abundant congeners in the atmosphere were 1,2,3,4,-6,7,8- HpCDD, OCDD, 1,2,3,4,6,7,8- HpCDF, and OCDF, which were consistent with those found in other studies (*14–17*). Table 4 lists the mean PCDD/F concentrations for the above six categories as 0.070, 0.320, 0.849, 1.43, 2.71, and 6.57 pg Nm^{-3}, respectively, and the corresponding I-TEQ concentrations were 0.006, 0.023, 0.052, 0.093, 0.190, and 0.521 pg I-TEQ Nm^{-3}, respectively. In principle, the results obtained from this study (except for the concentration of the vicinity of C1) are similar to that found in Germany (e.g., rural area = 0.025–0.070 pg I-TEQ Nm^{-3}; urban area = 0.070–0.350 pg I-TEQ Nm^{-3}) (*18*). In this study, the mean I-TEQ concentration in the vicinity of C1 was ~86.8, 22.6, 10.0, 5.6, and 2.7 times higher than that of the background, rural area, residential area, urban area, and industrial area, respectively. The high I-TEG concentration found in the vicinity of C1 might be because the involved crematory (i.e., C1) had a low stack and was installed with no air pollution control devices.

Yet, it is true that PCDD/F emissions obtained from this study were on a time-weighted-average basis. It did not provide real-time variations on PCDD/F emissions. However, in this study we did find the contents of N_2, O_2, and CO_2 in stack flue gases of C1 and C2 during the sampling period were quite stable (N_2, O_2, and CO_2 concentrations = ~80.6%, 14.6%, 4.80% for C1 and = ~80.2%, 15.8%, and 3.90% for C2, respectively). At this stage, whether PCDD/F emissions were also as stable as the above compounds warrants the need for further investigation. Nevertheless, the results obtained from this study do indicate that the impact of PCDD/F emissions from crematories to the surrounding environment was quite significant. Therefore, it is concluded that a proper control strategy should be taken immediately in order to eliminate PCDD/F emissions from crematory sources.

Literature Cited

(1) Olie, K.; Vermeulen, P. L.; Hutzinger, O. *Chemosphere* 1977, *6*, 455.
(2) Fiedler, H. *Organohalogen Compd.* 1993, *11*, 221–228.
(3) Wevers, M.; De Fré, R. *Organohalogen Compd.* 1995, *24*, 105.
(4) Takeda, N.; Takaoka, M.; Fujiwara, T.; Takeyama, H.; Eguchi, S. *Chemosphere* 2000, *40*, 575.
(5) Takeda, N.; Takaoka, M.; Fujiwara, T.; Takeyama, H.; Eguchi, S. *Chemosphere* 2001, *43*, 763.
(6) Luthardt, P.; Mayer, J.; Fuchs, J. *Chemosphere* 2002, *46*, 1303.
(7) Eduljee, G. H.; Dyke, P. *Sci. Total Environ.* 1996, *177*, 303.
(8) U.S. EPA *Database of Sources of Environmental Releases of Dioxin like Compounds in the United States*; EPA/600/C-01/012; 2001.
(9) U.S. EPA *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds*; EPA/600/P-00/001Bb; 2000.
(10) Lorber, M.; Eschenroeder, A.; Robinson, R. *Atmos. Environ.* 2000, *34*, 3995.
(11) Giugliano, M.; Cernuschi, S.; Grosso, M.; Miglio, R.; Aloigi, E. *Chemosphere* 2002, *46*, 1321.
(12) Wang, L.-C.; Lee, W.-S.; Lee, W.-J.; Hung, C.-H.; Chang-Chien, G.-P.; Chen, S.-J.; Tsai, P.-J. *Atmos. Environ.* 2002, revised.
(13) Wang, L. C.; Lee, W. J.; Tsai, P. J.; Lee, W. S.; Chang-Chien, G. P.; Wu, J. D. *Chemosphere* 2002, revised.
(14) Coleman, P. J.; Lee, R. G.; Alcock, R. E.; Jones, K. C. *Environ. Sci. Technol.* 1997, *31*, 2120.
(15) Abad, E.; Caixach, J.; Rivera, J. *Chemospere* 1997, *35*, 453.
(16) Lee, R. G. M.; Green, N. J. L.; Lohmann, R.; Jones, K. C. *Environ. Sci. Technol.* 1999, *33*, 2864.
(17) Sin, D. W.; Choi, J. Y. Y.; Louie, P. K. K. *Environ. Sci. Technol.* 2002, *47*, 647.
(18) Fiedler, H. *Chemosphere* 1996, *32*, 55.

Received for review August 7, 2002. Revised manuscript received October 25, 2002. Accepted October 30, 2002.

ES0208714

Golden Gate University Environmental Law Journal

Volume 2
Issue 1 *Symposium Edition - the West's Aging Dams: Retain or Remove?*

Article 7

8-11-2010

Dust in the Wind? The Bell Tolls for Crematory Mercury

Philip Donald Batchelder

COMMENT

DUST IN THE WIND? THE BELL TOLLS FOR CREMATORY MERCURY

TABLE OF CONTENTS

I. INTRODUCTION

Cremation is becoming the method of choice for dealing with the deceased in the United States. Although environmental concerns often motivate this choice, cremations are not ecologically benign. Most significantly, the global environment is suffering from crematory emissions of mercury due to incineration of dental amalgam fillings. Until now, these emissions have been considered too low to merit regulation in the United States. Because cremation is becoming more widespread, some state governments have begun to craft policies targeting crematory mercury in the context of broader efforts to eliminate mercury pollution.

There are two basic choices for eliminating crematory mercury: installing filtration technologies to capture the toxin, or mandating that all dental amalgam fillings be removed from a body prior to cremation. Given the costliness of the first option and the practical and socio-cultural challenges of the second, governments should adopt a comprehensive approach that educates the public about this issue, encourages voluntary removal of fillings at death, fosters existing ecological alternatives to cremation and develops new alternatives, and uses market incentives and targeted legislation to help the cremation industry reduce its harmful impacts.[1]

Part II of this Comment outlines the toxicity and behavior of mercury. Part III asserts that cremation is a significant and growing source of mercury pollution. Part IV describes the current regulatory atmosphere for crematory mercury vapor: the federal government's decision to leave it largely unregulated and the efforts of a few states, including Maine, Minnesota, and Colorado, to begin tackling this problem. Part IV also contains a case study discussing whether agencies in the San Francisco Bay Area of California are effectively addressing crematory mercury. Part V explores the options of either capturing mercury emitted from crematories or pulling teeth containing dental amalgam fillings prior to cremation. It also includes an assessment of our collective capacity to change cultural death practices in order to address this threat. Part V concludes with a mention of two alternatives to cremation: green burial and promession.

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[1] "Cremation industry," as used in this Comment, refers to businesses involved in—but not necessarily limited to—cremation. Crematory operators may also be in the mortuary services industry and/or the cemetery services industry. *See* CREMATION ASS'N OF N. AM., 2006 CANA CREMATION CONTAINER, DISPOSITION AND SERVICE SURVEY FINAL RESULTS 9 (2006), http://www.cremationassociation.org/docs/06disposition.pdf.

II. MERCURY IS TOXIC AND PREVALENT

The modern scientific consensus is that mercury, even in minute amounts, is extremely toxic. A recent article in the Journal of Law and Health states, "Arguably, mercury ranks as the second most poisonous compound on earth, and no agency or health organization would dispute that mercury is toxic."[2] It is the most toxic substance on the U.S. Department of Health and Human Services' Priority List of Hazardous Substances, and it trails only arsenic and lead in frequency of occurrence in this country.[3] In its various forms,[4] mercury is "permanently recycled in the physical, chemical and biological processes in the environment"[5] and cannot be broken down or processed into different constituents.[6] As a result, it accumulates as it passes through the food chain.[7]

Humans are most often exposed to a particularly potent form called methylmercury, which can severely impair biological functions.[8] Chronic, low-level exposure to methylmercury is toxic to the kidneys, while high-dosage exposure can cause permanent damage.[9] Although such intense exposure is rare for the general population, "[t]he problem of methylation of past and present . . . mercury discharges continues, and the long retention time of mercury by [aquatic] sediments delays the elimination of contamination for many years."[10]

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[2] Kimberly M. Baga, *Taking a Bite Out of the Harmful Effects of Mercury in Dental Fillings: Advocating for National Legislation for Mercury Amalgams*, 20 J.L. & HEALTH 169, 179 (2007) ("Many healthcare organizations, including the American Public Health Association, the California Medical Association, and Health Care Without Harm, support a ban on any mercury-containing product used by humans.").

[3] Lyn Patrick, *Mercury Toxicity and Antioxidants*, 7(6) ALT. MED. REV. 456, 456 (2002), *available at* http://findarticles.com/p/articles/mi_m0FDN/is_6_7/ai_96416600 ("Mercury toxicity is also considered the second-most common cause of acute heavy metal poisoning . . . .").

[4] For a complete description of mercury's chemical behavior, see LOUIS M. SCARMOUTZOS & OWEN E. BOYD, ENVIRONMENTAL AND TOXICOLOGICAL CONCERNS OF DENTAL AMALGAM AND MERCURY 9-17 (2003), http://www.mvssolutions.com/mercury.pdf.

[5] OSPAR Comm'n, 2000, *Background Document on Mercury and Organic Mercury Compounds* 3 (2004 update), http://www.ospar.org/documents/dbase/publications/p00100_Mercury%20and%20Organic%20Mercury%20Compounds.pdf.

[6] SCARMOUTZOS & BOYD, *supra* note 4, at 3.

[7] MICHELLE ALLSOPP ET AL., UNIV. OF EXETER, U.K., INCINERATION AND HUMAN HEALTH 76, http://www.inceneritori.org/incin.pdf (last visited Mar. 7, 2008) [hereinafter INCINERATION AND HUMAN HEALTH] (citing a 1989 World Health Org. study). "Bioaccumulation" refers to the pooling, over time, of a substance in the tissues of an organism. SCARMOUTZOS & BOYD, *supra* note 4, at 3.

[8] U.S. EPA, EPA'S ROADMAP FOR MERCURY 3 (2006), http://www.epa.gov/mercury/pdfs/FINAL-Mercury-Roadmap-6-29.pdf [hereinafter ROADMAP FOR MERCURY]; *see also* INCINERATION AND HUMAN HEALTH, *supra* note 7, at 76.

[9] INCINERATION AND HUMAN HEALTH, *supra* note 7, at 76 (citing "damage to the [central nervous system], the kidneys, and the developing foetus").

[10] INCINERATION AND HUMAN HEALTH, *supra* note 7, at 76; *see also* Dan Krotz, *Gold Rush*

Moreover, methylmercury seriously threatens other species, especially those whose consumption of fish (or of fish-eating prey) makes exposure more likely.[11] Methylmercury has been detected in fish, eagles, otters, and endangered Florida panthers.[12] Depending on the exposure level, the effects can include mortality, reduced fertility, slower growth, and abnormal behavior that adversely affects survival.[13]

Factories, power plants, incinerators, hospitals, and other industries release mercury pollution into the atmosphere.[14] Natural sources of mercury vapor include forest fires and volcanic eruptions.[15] Once airborne, mercury vapor may drift over vast distances,[16] so pinpointing a source of particular mercury pollution can be very difficult.[17] In 1996, the Massachusetts Department of Environmental Protection estimated that of the 1800 to 3700 pounds of mercury deposited yearly onto the state's land and water, as much as 59% may have come from out of state.[18] Elemental mercury may reside in the atmosphere for up to a year,[19] so emissions from one continent are likely to contribute to deposition on other continents.[20] A study by the United Nations Environment Programme suggests that "up to 50% of anthropogenic[21]

Still Haunts San Francisco Bay, SCIENCE@BERKELEY LAB (Nov. 29, 2005), http://www.lbl.gov/Science-Articles/Archive/sabl/2005/November/01-gold-rush.html. "Methylation" refers to the process by which elemental mercury becomes methylmercury. *See* SCARMOUTZOS & BOYD, *supra* note 4, at 9-17.

[11] ROADMAP FOR MERCURY, *supra* note 8, at 7.

[12] *Id.*

[13] *Id.*

[14] *See* BARRY R. LEOPOLD, USE AND RELEASE OF MERCURY IN THE UNITED STATES 6 (2002), http://www.epa.gov/nrmrl/pubs/600r02104/600r02104prel.pdf.

[15] OSPAR Comm'n, 2000, *supra* note 5, at 4.

[16] *Id.* at 5.

[17] It is not impossible, however. Researchers are now able to use isotope analysis to identify some emission sources. Telephone Interview with Sarah Rothenberg, Postdoctoral Fellow, San Francisco Estuary Inst. (Mar. 4, 2008) [hereinafter Rothenberg].

[18] MASS. DEP'T OF ENVTL. PROT., TOXICS AND HAZARDS: MERCURY IN MASSACHUSETTS (1996), http://www.mass.gov/dep/toxics/stypes/hgexsum.htm. Drift and deposition of airborne pollutants is difficult to characterize; Massachusetts' estimate is based on "preliminary data." *Id.*; *see also* ROADMAP FOR MERCURY, *supra* note 8, at 53 (estimating that the nationwide deposition from other parts of the world equals 83%, with the United States and Canada sharing responsibility for the other 17%).

[19] U.N. Env't Programme, *Global Mercury Assessment* § 83 (2002), http://www.chem.unep.ch/mercury/Report/GMA-report-TOC.htm.

[20] *See, e.g.*, Matt Pottinger et al., *Invisible Export – A Hidden Cost of China's Growth: Mercury Migration*, WALL ST. J., Dec. 20, 2004, *available at* http://yaleglobal.yale.edu/display.article?id=5058.'

[21] "Anthropogenic" means originating from human activities. MERRIAM-WEBSTER ONLINE DICTIONARY, ANTHROPOGENIC, http://www.merriam-webster.com/dictionary/anthropogenic (last visited Feb. 10, 2008).

mercury deposited to North America is from external sources."[22] Further, the study notes that such deposition may be temporary because mercury can be released again to the air from water and soil surfaces.[23]

Global atmospheric "background" mercury significantly increases the mercury burden at most locations.[24] Small amounts of mercury are continually settling into watersheds from the air;[25] cumulatively, the mercury concentration in lakes and streams may reach threatening levels. "Approximately one gram of mercury, the amount in a single fever thermometer, is deposited to a 20-acre lake each year from the atmosphere. This small amount, over time, [if totally infused into the food chain,] can contaminate the fish in that lake, making them unfit" for regular consumption.[26] Thus, the estimated forty-three pounds per year of crematory mercury produced in Oregon alone[27] is enough—conceptually—to contaminate 19,500 lakes and to poison the food chains

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[22] U.N. Env't Programme, *supra* note 19, at § 83.

[23] *Id.* at § 84; *see also* ALAN C. HEYVAERT ET AL., DEP'T OF ENVTL. SCI. & POLICY, UNIV. OF CAL. AT DAVIS, ATMOSPHERIC LEAD AND MERCURY DEPOSITION AT LAKE TAHOE, http://trg.ucdavis.edu/research/annualreport/contents/lake/ article11.html (last visited Mar. 7, 2008) ("[I]t is possible that air parcels traveling toward Tahoe could entrain [mercury] volatilized from the waste of historical gold and silver mining.").

[24] U.N. Env't Programme, *supra* note 19, at § 81 ("Similarly, virtually any local source contributes to the background concentration—the global mercury pool in the biosphere—much of which represents anthropogenic releases accumulated over the decades.").

[25] *See, e.g.*, HEYVAERT ET AL., *supra* note 23 (describing atmospheric mercury deposition into Lake Tahoe, "a relatively pristine, non-industrialized subalpine basin").

[26] Edward B. Swain, Minn. Pollution Control Agency, One Gram of Mercury in a Twenty Acre Lake: Origin of the Phrase (Oct. 2007) (unpublished manuscript, on file with author). This statement is often cited to describe mercury's potent toxicity. Telephone Interview with Ned Brooks, Mercury Reduction Coordinator, Minn. Pollution Control Agency (Oct. 29, 2007). For it to be true, the annual gram must be effectively and entirely absorbed into the food chain. *Id.* This, in turn, would depend on a multitude of factors, including lake depth, sediment composition, and the presence of sufficient bacteria or other microorganisms. *See, e.g.*, ROADMAP FOR MERCURY, *supra* note 8, at 4 ("Aquatic ecosystems respond to changes in mercury deposition in a highly variable manner as a function of differences in their chemical, biological, and physical properties. Depending on the characteristics of a given ecosystem, methylating microbes convert a small but variable fraction of the inorganic mercury in the sediments and water derived from human activities and natural sources into methylmercury.").

[27] OR. DEP'T OF ENVTL. QUALITY, MERCURY REDUCTION STRATEGY 15 (2002), http://www.deq.state.or.us/about/eqc/agendas/attachments/2006aug/D-AttBMercuryReduction Strategy.pdf. While the Oregon D.E.Q. recorded its estimates with "low" confidence, *id.* at 5, this 2001 estimate is based on assumed emissions of one gram of mercury per cremation, *id.* at 15, which is lower than other, well-founded estimates. *Cf.* PETER MAXSON, CONCORDE EAST/WEST SPRL, MERCURY IN DENTAL USE: ENVIRONMENTAL IMPLICATIONS FOR THE EUROPEAN UNION 9-10 (2007), http://www.zeromercury.org/EU_developments/Maxson%20Dental%2014May2007%20-%20A5colour.pdf (reprinting the results of several studies and concluding that, "[w]hile the range of estimates is large, they converge at approximately 3 g mercury per person cremated.").

within.[28] Forty-three pounds is only roughly 3% of Oregon's total emissions; this indicates the heavy overall burden of mercury pollution.[29] Nationally, forty-four states, one territory, and two Indian tribes have issued fish consumption advisories warning some people to limit their consumption of fish from certain water bodies because of methylmercury contamination.[30]

Because the dangerous effects of mercury pollution are so well established, many governments and non-governmental organizations are coordinating efforts to eliminate it.[31] However, while the U.S. Environmental Protection Agency (EPA) has identified cremation as a source of mercury,[32] the agency has thus far excluded crematory emissions from any explicit regulation.[33] Meanwhile, some state governments are exploring ways to reduce crematory mercury[34] ("cremercury"[35]), and EPA has stated its intent to address specific point sources of mercury emissions in conjunction with broader regional efforts.[36]

III. CREMATION IS A SIGNIFICANT SOURCE OF MERCURY EMISSIONS

The cremation of human bodies with mercury dental fillings[37] is

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[28] Forty-three pounds equals 19,504 grams; at one gram per lake, this roughly equals 19,500 lakes. Importantly, this is a conceptual—not actual—scenario. *See supra* note 26.

[29] *See* OR. DEP'T OF ENVTL. QUALITY, *supra* note 27, at 5.

[30] ROADMAP FOR MERCURY, *supra* note 8, at 16.

[31] EPA is involved with several such efforts, including the following: U.S./Canada Great Lakes Binational Toxics Strategy, the New England Governors/Eastern Canadian Premiers Regional Mercury Action Plan, the Commission for Environmental Cooperation North American Regional Action Plan for Mercury, the U.N. Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution Protocol on Heavy Metals, the U.N. Environment Programme Mercury Program, the U.N. Industrial Development Organization Global Mercury Project, and the Arctic Mercury Project. ROADMAP FOR MERCURY, *supra* note 8, at 55-57.

[32] U.S. EPA, MERCURY STUDY REPORT TO CONGRESS VOLUME II: AN INVENTORY OF ANTHROPOGENIC MERCURY EMISSIONS IN THE UNITED STATES ES-5 (1997), http://www.epa.gov/ttncaaa1/t3/reports/volume2.pdf.

[33] E-mail from Marsha Marsh, Health Scientist, U.S. EPA, to author (Oct. 13, 2007) (on file with author). The Agency does not address crematory mercury at all in its recent ROADMAP FOR MERCURY. *See generally* ROADMAP FOR MERCURY, *supra* note 8. However, the U.N. Environment Programme, with whom EPA is involved in broad mercury reduction efforts, explicitly discusses methods to reduce crematory mercury emissions. U.N. Env't Programme, *supra* note 19, at § 124.

[34] Telephone Interview with Mark McMillan, Mgr., Mercury Program, Colo. Dep't of Public Health & Env't (Nov. 1, 2007) [hereinafter Mark McMillan].

[35] The cremation industry coined the term "cremains" from "cremated ashes." JESSICA MITFORD, THE AMERICAN WAY OF DEATH REVISITED 17 (Vintage 1996) (1963). This Comment follows suit with "cremercury."

[36] ROADMAP FOR MERCURY, *supra* note 8, at 59.

[37] "For over 150 years, mercury-containing fillings (often called 'silver' or 'amalgam') have

increasingly figuring into local, regional, and international pollution-reduction efforts as a significant and reducible source of airborne mercury.[38] While almost all other domestic anthropogenic mercury sources, like cement kilns, waste incinerators, and other industries, are reducing mercury output because of targeted legislation and improved technology,[39] cremation stands alone in the United States as a mercury source that is projected to rise sharply.[40] This is due to the convergence of two trends: first, for several more decades people are going to be dying with more mercury amalgam dental fillings than previously; second, the dramatic, ongoing increase in cremation rates means that a great number of these fillings appear destined for incineration.[41]

The average cremation emits two to three grams of mercury,[42] almost exclusively from the volatilization of dental amalgam fillings.[43] EPA estimates that the U.S. population constitutes a reservoir of as much as 1000 tons of mercury in fillings.[44] As of 2000, 175,000 U.S. dentists were installing roughly 100 million amalgams in patients' teeth each year.[45] Even if dental mercury amalgam fillings are phased out,[46] the

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been used extensively to fill dental cavities. Four metals—mercury, silver, copper and tin—primarily comprise amalgam, with mercury being approximately 50% by weight. While use of mercury-free dental fillings is becoming more prevalent, most dentists in the United States still use mercury-containing amalgam." MERCURY POLICY PROJECT, DON'T LET IT GO TO YOUR HEAD: PHASING OUT MERCURY TOOTH FILLINGS 3 (2007), http://www.mercurypolicy.org/new/documents/DentalHgReportFinalnew0107.pdf. By one estimate, each amalgam filling contains from .37 to .74 gram of mercury. John Reindl, Summary of References on Mercury Emissions from Crematoria 3 (Aug. 27, 2007) (unpublished study, on file with author).

[38] John Reindl, Summary of References on Mercury Emissions from Crematoria 18 (Aug. 27, 2007) (unpublished study, on file with author).

[39] *See, e.g.*, ROADMAP FOR MERCURY, *supra* note 8, at 22 ("Medical waste incinerators and municipal solid waste combustors are now subject to stringent control standards that require facilities to reduce mercury emissions by over 90% from 1990 levels. These efforts have contributed to reducing overall mercury emissions to the air by about 45% (from 220 tons in 1990 to 113 tons in 1999).").

[40] Telephone Interview with Ned Brooks, Mercury Reduction Coordinator, Minn. Pollution Control Agency (Oct. 29, 2007) [hereinafter Ned Brooks].

[41] MERCURY POLICY PROJECT, *supra* note 37, at 5.

[42] *See, e.g.*, PETER MAXSON, CONCORDE E./W. SPRL, MERCURY IN DENTAL USE: ENVIRONMENTAL IMPLICATIONS FOR THE EUROPEAN UNION 9-10 (2007), http://www.zeromercury.org/EU_developments/Maxson%20Dental%2014May2007%20-%20A5colour.pdf.

[43] *See* LEOPOLD, *supra* note 14, at 64.

[44] MERCURY POLICY PROJECT, *supra* note 37, at 4. Fillings constantly emit mercury vapor. "However, since the average daily intake for a person with fillings is 1.24 micrograms of mercury (USDHHS 1993), the amount of mercury 'lost' before cremation is minuscule." LEOPOLD, *supra* note 14, at 65-66.

[45] MERCURY POLICY PROJECT, *supra* note 37, at 4 ("In 2004, [EPA] estimated that dental clinics use[d] 34 tons of mercury annually, 14% of the total annual mercury consumption in the U.S.") (citing KING COUNTY DEP'T OF NATURAL RES., MANAGEMENT OF HAZARDOUS DENTAL WASTES IN KING COUNTY, 1991-2000 (2000); WATER ENV'T FED'N, CONTROLLING DENTAL

large baby-boomer population[47] is aging, and—given the rising trend toward cremation—a great proportion of their fillings is on the way to crematories.[48]

Until recently, most people died toothless—or nearly so.[49] Modern dentistry enables more and more people to die with their own teeth; the downside is that these teeth often contain mercury fillings.[50] As cremation rates increase, so does the number of amalgam fillings incinerated in crematories. This is true in the United Kingdom, where the British Dental Association divides the population into three groups: the very old, who generally die with no teeth; those with heavily restored teeth, including amalgam fillings; and "the fluoride toothpaste generation."[51] Experts have predicted that without intervention, cremercury emissions in the United Kingdom would increase by two thirds from 2000 to 2020, before "decreas[ing] back to back to 2000 emission levels around 2055."[52] The United States faces a similar quandary.[53]

The continuing, dramatic expansion of cremation practices in the United States is a major compounding factor in rising cremercury emissions.[54] Cremation is a fast-growing, billion-dollar industry.[55] From 1975 to 2005, the number of crematories increased by more than 450%.[56]

FACILITY DISCHARGES IN WASTEWATER, ALEXANDRIA, VA (1999)).

[46] MERCURY POLICY PROJECT, *supra* note 37, at 3.

[47] The boomer population is approximately seventy-seven million. U.S. CENSUS BUREAU, POPULATION AND HOUSING CHARACTERISTICS OF BABY BOOMERS 26 TO 44 YEARS OLD: 1990 (1996), http://www.census.gov/population/censusdata/cph-l-160h.txt.

[48] *See, e.g.*, JOHN REINDL, MERCURY EMISSIONS FROM CREMATORIA, GREAT LAKES BINATIONAL TOXIC STRATEGY at slide 14 (2005), http://www.epa.gov/bns/reports/stakesdec2005/mercury/Reindl.pdf.

[49] STEPHEN MOORE & JULIAN SIMON, IT'S GETTING BETTER ALL THE TIME: 100 GREATEST TRENDS OF THE LAST 100 YEARS 42 (2001).

[50] *See, e.g.*, Reindl, *supra* note 38, at 5.

[51] U.K. Dep't of Env't, Food, & Rural Affairs, *Mercury Emissions from Crematoria* 8 (2003), http://www.defra.gov.uk/environment/ppc/old-consultations/crematoria/consultation.pdf [hereinafter DEFRA First Consultation].

[52] *Id.*

[53] MERCURY POLICY PROJECT, *supra* note 37, at 5.

[54] *Id.*

[55] MARK HARRIS, GRAVE MATTERS: A JOURNEY THROUGH THE MODERN FUNERAL INDUSTRY TO A NATURAL WAY OF BURIAL 55 (2007) [hereinafter GRAVE MATTERS].

[56] *See* Cremation Ass'n of N. Am., History of Cremation, http://www.cremationassociation.org/html/history.html (last visited Mar. 7, 2008) (stating that there were 425 crematories in 1975); *see also* CREMATION ASS'N OF N. AM., UPDATED 2004 AND 2005 CASES PER CREMATORY BY STATE, http://www.cremationassociation.org/docs/per-crematory.pdf (indicating that there were 1971 crematories in 2005).

In 2004, about 740,695 people, or 31% of the deceased, were cremated.[57] Meanwhile, the rate in Marin County, California, had already reached 80%.[58] By 2030, it is anticipated that more than half of all U.S. residents will be choosing cremation,[59] and this trend is unlikely to reverse course.[60]

Mercury is one component of a complex array of pollutants that may emanate from a particular cremation,[61] and it is a challenging one to quantify.[62] Attempts to measure mercury emissions from cremations have yielded a wide range of results, and disagreement remains as to crematories' share of the global mercury pollution inventory.[63] While consistent crematory mercury emissions measures are scarce, the range has been narrowed using two basic methods.[64] The first is to measure actual emissions from test cremations.[65] The second is a "mass balance" approach that gauges pertinent factors (such as average number of

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[57] CREMATION ASS'N OF N. AM., PROJECTED VS. ACTUAL DEATH AND CREMATION NUMBERS, http://www.cremationassociation.org/docs/crem-data-predict.pdf (last visited Mar. 7, 2007). At an average of $1800 per cremation, GRAVE MATTERS, *supra* note 55, at 67, that would total $1,333,251,000.

[58] Peter Fimrite, *Marin Cemetery: Ashes to Ashes, Dust to Mulch*, S.F. CHRON., Aug. 22, 2004, *available at* http://sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2004/08/22/MNGEV8CIGT1.DTL. As of 2005, California's overall percentage was 52%—the tenth-highest rate in the nation—and the state ranked highest nationally in the number of cremations (120,883). CREMATION ASS'N OF N. AM., FINAL 2005 STATISTICS & PROJECTIONS TO THE YEAR 2025, 2006 PRELIMINARY DATA 4 (2007), http://www.cremationassociation.org/docs/CANA-Final06Prelim.pdf.

[59] Cremation Ass'n of N. Am., Deaths & Cremations, United States, 2002-2040, http://www.cremationassociation.org/html/photo-deaths-cremation.html (last visited Mar. 7, 2008).

[60] *See* GRAVE MATTERS, *supra* note 55, at 55 (observing that in countries where cremation has "taken hold," the rate has not diminished).

[61] *See* TERESE GREGG ET AL., UNIV. OF FLA. CREMATION PROJECT, POLLUTANTS, http://www.ees.ufl.edu/homepp/cywu/ENV4121/Project2001/Crematory/Pollutants.htm (last visited Feb. 10, 2008) [hereinafter POLLUTANTS] (listing pollutants such as carbon monoxide, sulphur dioxide, hydrogen chloride, nitrogen oxides, dioxins, mercury, cadmium, lead, and particulate matter).

[62] *See* Chang-Yu Wu, Univ. of Fla., Air Pollution Control, http://www.ees.ufl.edu/homepp/cywu/AirPollutionControl.html (last visited Mar. 7, 2008) ("Mercury is a unique metal in combustion systems. . . ."). However, through the Environmental Technology Verification Program, EPA Region 9 offers qualified agencies the use of a sophisticated device that would enable accurate testing of cremercury emissions. Rothenberg, *supra* note 17; *see generally* U.S. EPA, ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM (2007), http://epa.gov/etv/pubs/600etv07009s.pdf.

[63] SCARMOUTZOS & BOYD, *supra* note 4, at 35 ("The amount of mercury released into the environment from dental amalgams has historically been the most unreliable and underestimated amount included in mercury emissions reports.").

[64] TETRA TECH, POLLUTION PREVENTION CREMATORIA PROJECT FINAL REPORT 5 (2007) (on file with author).

[65] *E.g.*, CAL. AIR RES. BD., EVALUATION TEST ON TWO PROPANE FIRED CREMATORIES AT CAMELLIA MEMORIAL LAWN CEMETERY (1992) (on file with author).

fillings per person, age ranges, and composition of average amalgam fillings) to estimate likely emissions.[66]

Given the difficulty in accounting for numerous, complex variables, the inconsistency of test results is not surprising.[67] Slight variations in the composition of amalgam fillings in different "test corpses" can significantly affect measurements at the top of a chimney.[68] Moreover, depending on the incinerator design, mercury can attach to brick, mortar, or soot on the interior, and thus remain unmeasured.[69] Cremations typically last for several hours, yet some test designs have failed to account for the behavior of the metal at different stages of the process.[70] Other variables that can affect the consistency of measurements include the composition of any containers or vestments accompanying the body into the furnace[71]; the presence of implanted medical devices[72]; the age, weight, and number of amalgam fillings of the test corpse; and—particularly important—the operating temperature of the crematory itself.[73]

These factors demonstrate the inadvisability of holding out the results of any particular test as representative. Yet, EPA appears to have done just that. In 1999, the Cremation Association of North America (CANA) and EPA jointly conducted a test at New York's Woodlawn Crematory ("Woodlawn study").[74] At the time, the facility was the only one in the country fitted with a scrubber filter,[75] and the test aimed, in

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[66] *See, e.g.*, JANE H. LUNDQUIST, BAY AREA AIR QUALITY MGMT. DIST., ESTIMATE OF MERCURY EMISSIONS FROM CREMATORIA IN THE BAY AREA 1 (2000) (on file with author); *see also* TETRA TECH, *supra* note 64, at 5.

[67] LUNDQUIST, *supra* note 66, at 1.

[68] *See, e.g.*, Reindl, *supra* note 38, at 10.

[69] *See, e.g.*, MAXSON, *supra* note 42, at 8.

[70] *See* Reindl, *supra* note 38, at 10 (critiquing the EPA/CANA Woodlawn study).

[71] Roughly 80% of cremated bodies are cremated in special "cremation caskets." CREMATION ASS'N OF N. AM., *supra* note 1, at 17. These are made of materials such as corrugated cardboard to burn readily and with minimal pollution. Otherwise, casket handles, trim, paneling, and padding, which could be made of zinc, plastics, styrofoam, or fiberglass, could cause toxic emissions. *See* GRAVE MATTERS, *supra* note 55, at 57-58.

[72] These may include a "cardiac pacemaker, prostheses, silicon[e] implants, or . . . radioactive seeds used in some cancer therapies." GRAVE MATTERS, *supra* note 55, at 53. Incineration of such items can produce dangerous pollution and can damage cremation units. *Id.*

[73] Reindl, *supra* note 38, at 5-6, 7; *see also* Rothenberg, *supra* note 17.

[74] U.S. EPA, EMISSION TEST EVALUATION OF A CREMATORY AT WOODLAWN CEMETERY BRONX, NY, EPA/R-99-0491999 (1999).

[75] A scrubber filter is a device through which gases exiting the cremation unit are blown. TERESE GREGG ET AL., UNIV. OF FLA., DEVICES (2001), http://www.ees.ufl.edu/homepp/cywu/ENV4121/Project2001/Crematory/Devices.htm#wet [hereinafter DEVICES] ("In the wet scrubber the air is sprayed with water to remove as much air pollutants [sic] as possible from the stream. The droplets containing the pollutants gather at the bottom . . . and are drained out. The water stream is

part, to measure the efficacy of this filtration system.[76] Because the mercury emission results were interpreted as being very low (equivalent to 238 pounds per year nationally,[77] or approximately 0.2g per cremation[78]), the study might be crucial to the industry's continuing avoidance of regulation for controlling mercury.[79]

However, concerns have been raised about the study's accuracy and reliability.[80] John Reindl, who has studied the cremercury issue in depth, writes that

> the lead [consultant who] performed the work notes that the data are subject to interpretation. He goes on to note that the data are averages and recommends that they be multiplied by the total time of the cremation. He also notes that they do not include measurements from the time break during which the measuring instruments were switched from one access port to another, nor any releases from the warm-up

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then taken to a holding tank where the heavy particles settle out. The water can then be reused in the wet scrubber or can be disposed of after referring to the local or state regulations. [These devices] are seldom used in crematoriums because the pollutant removal benefit does not outweigh the cost of the equipment.").

[76] Reindl, *supra* note 38, at 9. *Contra* Paul Rahill, *An Environmental Journey of Ten Years*, MORTUARY SCIENCE, May 2006, *available at* http://www.cremationassociation.org/docs/EnvironmentalJourney.pdf ("One of the reasons Woodlawn was selected was because their cremation equipment was typical to what could be routinely found operating throughout North America."). *But see* Wu, *supra* note 62 (asserting that mercury "is insoluble, making [a] scrubber useless in removing it from flue gas.").

[77] CREMATION ASS'N OF N. AM., MERCURY UPDATE, http://www.cremationassociation.org/docs/mercury-update.pdf (last visited Mar. 7, 2008).

[78] In 1999, 598,721 people were cremated in the United States. CREMATION ASS'N OF N. AM., HISTORICAL CREMATION DATA, http://www.cremationassociation.org/docs/WebHistData.pdf (last visited Mar. 7, 2008). The calculation for the average mercury emission per cremation is the following: 238 pounds divided by 598,721 cremated people equals .00039 pound, or approximately .2 gram per cremation.

[79] *See* e-mail from Mark Harris, to author (Aug. 27, 2007) (on file with author) [hereinafter Mark Harris]. Mr. Harris is the author of GRAVE MATTERS, cited *supra* note 55. *See generally* ROADMAP FOR MERCURY (containing no mention of cremation).

[80] Reindl, *supra* note 38, at 9 (quoting the study's disclaimer: "This report presents the results of a single test program at a single cremation facility. It should not be assumed that these results would characterize emissions at other cremation facilities without further study."). Reindl identifies further reasons for doubting the study's utility. For example: "[Only n]ine cremations were done. . . . [CANA] says that mercury averaged 0.23 grams/hour of operation, but there are no data on mercury emissions varying with temperatures, since, according to the article, it was assumed that mercury emissions would not change with temperature. . . . However, the actual study . . . shows somewhat different data. . . . The report gives no data on the number of teeth nor the number of restorations present. In addition, although it is clear that some mercury was removed by the wet scrubber system, no data are provided on the analysis of the mercury in the water from the scrubber. The ash also does not appear to have been tested for mercury. The report also does not indicate how the cadavers for analysis were selected and whether they are representative of the population being cremated." *Id.* at 9-10.

> and cooldown periods. . . . Thus, there is a significant difference of opinion among two of the principals in the Woodlawn study on how to interpret the data from this study. In addition, the EPA project manager of the study . . . questions the validity of the testing, and notes that mercury levels were sometimes higher after pollution control equipment than before it . . . .[81]

Nonetheless, the Woodlawn study is likely to impede any person, agency, or organization contending that crematory mercury is a concern in the United States.[82] CANA touts the results on its website: "A joint effort by CANA and EPA produced evidence that crematories are capable of low emission[s] without the addition of pollution equipment . . . ."[83]

Other studies show more mercury output from cremation, ranging from 1.6 to 8.5 grams per cremation, with two to four grams as an average.[84] In crafting protocols to reduce cremercury, the United Kingdom's Department for Environment, Food, and Rural Affairs (DEFRA) settled on a three-gram average,[85] and Colorado's Department of Public Health and Environment commissioned a study concluding that the average is 3.2 grams.[86] At this rate, a busy crematory could release as much as twenty-four pounds of mercury vapor annually.[87] EPA itself

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[81] *Id.* at 9.

[82] *See, e.g.*, Mark Harris, *supra* note 79 ("Yes, the EPA ruling was based on studies the Agency did in conjunction with the cremation industry, and, yes, other groups—including the New England Zero Mercury Campaign—say actual mercury emissions are much higher and thus worthy of regulation. . . . But, still, you'll have to deal with the fact of EPA's numbers, which the cremation industry quotes to vouch for the safety of current emissions.").

[83] Cremation Ass'n of N. Am., Emissions Tests Provide Positive Results for Cremation Industry (1999), http://www.cremationassociation.org/html/environment.html (conceding—here, at least—that Woodlawn was "one of the only crematories in North America with additional pollution control equipment"). In terms of avoiding mercury emission controls, the industry could be considered to have an unfair advantage because three quarters of North Americans are unaware that amalgam fillings contain mercury to begin with, and are thus unaware of the impact these fillings may have upon being incinerated. *See* MERCURY POLICY PROJECT, *supra* note 37, at 7. EPA's study, despite the disclaimers, simply provides further cover for the industry. However, the industry faces a different problem of public perception: a significant number of people mistakenly believe that cremation is either forbidden by their religion or cannot be done in conjunction with a traditional funeral or other memorial service. CREMATION ASS'N OF N. AM., CREMATION DATA AND PREDICTIONS: DATA TRENDS (2005), http://www.cremationassociation.org/docs/wirthlin-excerpt.pdf.

[84] Reindl, *supra* note 38, at 1; *see also* OSPAR Comm'n, 2000, *supra* note 5, at 6 (assuming that three grams of mercury are emitted per cremation).

[85] DEFRA First Consultation, *supra* note 51, at 7.

[86] TETRA TECH, *supra* note 64, at ES-1.

[87] Alan Mills, *Cremation Pollution*, N.Y. TIMES, Aug. 21, 1990, *available at* http://query.nytimes.com/gst/fullpage.html?res=9C0CEED8163FF932A1575BC0A966958260.

cites estimates of 130 pounds of cremercury for Wisconsin, Minnesota, and Michigan alone in 1994-95.[88] In 1997, prior to the Woodlawn study, EPA estimated that the nation's crematories emitted 1600 pounds of mercury annually,[89] and a report prepared for EPA in 2006 puts this number at 6528 pounds.[90]

Another impediment arose in 2005, following the low test results from the Woodlawn study (and despite the prior indications of higher actual emissions), when EPA determined that the Clean Air Act rules governing solid waste combustion did not apply to crematories, thereby declining to promulgate any regulations for the time being.[91] However, cremercury has remained on EPA's radar,[92] and some state environmental protection agencies began looking more closely at the issue. Colorado, for instance, received EPA funding to do so.[93]

EPA's *Roadmap for Mercury* ("Roadmap") expresses the agency's intent to collaborate with state, tribal, local, and international governments to reduce mercury pollution:

> As co-regulators with EPA, states have been actively engaged in a range of programs and partnerships to reduce mercury uses, releases, and exposure and to conduct mercury monitoring activities. . . . [S]tates and local governments have been leaders in mercury reduction efforts. EPA will build on these efforts and, where appropriate, help state and local governments replicate successful efforts.[94]

Hence, while current action to curtail cremercury is now occurring only at the state level, EPA has not necessarily closed the door to taking action of its own.

Mills based his calculation on an average of three grams of mercury emitted per cremation. Reindl, *supra* note 38, at 8.

[88] Wisconsin, Minnesota, and Michigan's respective totals were nineteen, seventy-one, and forty pounds. U.S. EPA, Great Lakes Binational Toxics Strategy, http://www.epa.gov/glnpo/bnsdocs/milwaukeehg/appendixa.html (last visited Mar. 7, 2008).

[89] U.S. EPA, LOCATING AND ESTIMATING AIR EMISSIONS FROM SOURCES OF MERCURY AND MERCURY COMPOUNDS § 8.4 (1997), *available at* http://www.epa.gov/ttnchie1/le/mercury.pdf (giving an estimate of 0.80 tons, which is equal to 1600 pounds).

[90] Barr Eng'g & Alexis Cain, Envtl. Scientist, U.S. EPA, Mercury Flow Worksheet (June 2006) (unpublished study, on file with author).

[91] Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Other Solid Waste Incineration Units, 70 Fed. Reg. 74,881 (proposed Dec. 16, 2005) (codified at 70 C.F.R. pt. 60).

[92] Mark McMillan, *supra* note 34.

[93] *Id.*

[94] ROADMAP FOR MERCURY, *supra* note 8, at 18-19.

IV. CREMERCURY: ADRIFT IN A SEA OF REGULATION

A. RULING OUT FEDERAL REGULATION (FOR NOW)

The federal government heavily regulates mercury as a major criteria pollutant,[95] yet it has no policy addressing cremercury.[96] One reason is that the major industrial emitters, such as petroleum refineries and power plants, emit significantly more mercury pollution than crematories and are simply higher priorities for regulation.[97] However, to the extent that crematories continue to escape regulation, and especially as the cremation industry continues its growth, cremercury will become an ever-greater slice of the emissions pie,[98] potentially triggering new federal or state regulatory imperatives.[99]

The Clean Air Act (CAA)[100] does not currently target cremercury. In 2005, EPA, which is under no explicit mandate to issue standards for every type of incinerator, ruled against regulating crematories as solid waste incinerators under CAA § 129:

> [I]n considering the nature of human crematories, EPA has determined that the human body should not be labeled or considered "solid waste." Therefore, human crematories are not solid waste combustion units, and are not a subcategory of [Other Solid Waste Incineration units] for regulation.[101] [Further, the] CAA is ambiguous regarding

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[95] *See generally* U.S. EPA, Mercury: Laws and Regulations, http://www.epa.gov/mercury/regs.htm (last visited Mar. 7, 2008).

[96] E-mail from Marsha Marsh, Health Scientist, U.S. EPA, to author (Oct. 13, 2007) (on file with author).

[97] *See generally* U.S. EPA, Clean Air Mercury Rule, http://www.epa.gov/air/mercuryrule/ (last visited Mar. 7, 2008).

[98] *See* N.M. ENV'T DEP'T & N.M. DEP'T OF HEALTH, NEW MEXICO MERCURY REDUCTION ACTION PLAN 4 (2006), http://www.nmenv.state.nm.us/Special/MercuryTF-ReportFinal_11_27_06.pdf [hereinafter NEW MEXICO MERCURY REDUCTION ACTION PLAN]; Alexis Cain et al., *Substance Flow Analysis of Mercury Intentionally Used in Products in the United States*, 11 J. INDUS. ECOLOGY 61, 70-71 (2007).

[99] *See, e.g.*, Mark Harris, *supra* note 79.

[100] *See generally* Clean Air Act, 42 U.S.C.A. § 7401 et seq. (Westlaw 2008).

[101] Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Other Solid Waste Incineration Units, 70 Fed. Reg. 74,881 (proposed Dec. 16, 2005) (codified at 70 C.F.R. pt. 60). Of course, cremation is an ancient practice. While categorizing human remains as "solid waste" might provide for sensible control over disposition (given the ecological needs of modern societies, e.g., to control pollution), to consider cremation as merely a way to deal with waste would be to dramatically rob the practice of its broad cultural values. *Cf.* DAVID ABRAM, THE SPELL OF THE SENSUOUS 15 (1996) ("Some cultures may burn . . . the body in order to more completely return the person, as smoke, to the swirling air, while that which departs as flame is offered to the sun and stars, and that which lingers as ash is fed to the dense earth."); *see*

> what categories of solid waste incineration units must be regulated under section 129(a)(1)(E). After discussing timelines for very specific categories of solid waste incinerators (e.g., large and small municipal waste combustors, commercial and industrial waste incinerators, and hospital and medical waste incinerators), the CAA states only that EPA must publish a schedule for promulgating standards for "other categories of solid waste incineration units."[102]

The regulatory status of crematories under the CAA might change when EPA updates the CAA's Area Source program, by which the agency will address "certain smaller point sources that emit mercury."[103] Cremercury may also become a focus of the Integrated Urban Air Toxics Strategy, which is part of EPA's national air toxics program under the CAA.[104] The strategy offers ways to assess the risks of urban air pollution and to reduce toxic emissions from area sources.[105] It also targets mercury as one of thirty-three hazardous air pollutants (HAPs) "pos[ing] the greatest threat to public health in the largest number of urban areas."[106] EPA has set forth standards for some industrial sources of HAPs while continuing to analyze others.[107]

Ironically, the shrinking contributions of major anthropogenic mercury sources may catalyze cremercury regulation. As New Mexico notes in its 2006 Mercury Reduction Action Plan, "after the full implementation of [EPA's Clean Air Mercury Rule[108]], the relative contribution of mercury from other sources [such as cremation] will increase."[109] Still, cremation's growing share of the national mercury

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also MARY ROACH, STIFF: THE CURIOUS LIVES OF HUMAN CADAVERS 275 (2004) ("The line between solid waste disposal and funerary rituals must be well maintained.").

[102] Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Other Solid Waste Incineration Units, 70 Fed. Reg. 74,874-75 (proposed Dec. 16, 2005) (codified at 70 C.F.R. pt. 60).

[103] ROADMAP FOR MERCURY, *supra* note 8, at 8 (citation omitted).

[104] *Id.* at 25.

[105] *Id.* Area sources "emit less than 10 tons annually of a single HAP or less than 25 tons annually of a combination of HAP." *Id.* at 31.

[106] *Id.* at 31.

[107] *Id.*

[108] According to EPA, the goal of the Clean Air Mercury Rule is to complement the Clean Air Interstate Rule's significant reductions in mercury emissions from coal-fired power plants, "the largest remaining sources of mercury emissions in the country. When fully implemented, these rules will reduce utility emissions of mercury from 48 tons a year to 15 tons, a reduction of nearly 70 percent." U.S. EPA, *supra* note 97.

[109] NEW MEXICO MERCURY REDUCTION ACTION PLAN, *supra* note 98, at 2. New Mexico estimates that the state's twenty crematories emit forty pounds of mercury annually and notes that Colorado's cremercury reduction initiative may serve as a model for addressing the source. *Id.* at 4. *See also* Alexis Cain et al., *Substance Flow Analysis of Mercury Intentionally Used in Products in*

emissions inventory is not solely attributable to the reduction of other sources.[110] The cremation industry is booming; therefore, actual amounts of cremercury will also continue to rise.[111]

EPA's Toxics Release Inventory (TRI) offers yet another possible route for bringing cremercury under federal or state regulation.[112] The TRI program tracks "disposal or other releases and other waste management activities" for mercury and hundreds of other hazardous substances.[113] In 2000, the TRI dramatically lowered the reporting threshold from 10,000 pounds to ten pounds; consequently, smaller users must now report.[114]

Massachusetts adopted the new reporting threshold in its 2006 revisions to the state's Toxics Use Reduction Act (TURA), targeting mercury as a persistent bioaccumulative toxin.[115] However, the new ten-pound reporting limit applies only to "Large Quantity Toxics Users" who 1) exceed the threshold, 2) are classified in certain industries according to the North American Industrial Classification System (NAICS), and 3) employ ten or more fulltime employees.[116] The NAICS classification for crematories makes them subject to TURA.[117] However, since most crematories are smaller operations,[118] they may remain exempt from reporting requirements in Massachusetts—even though they could be expected to release more than double the threshold amount.[119]

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the United States, 11 J. INDUS. ECOLOGY 61, 71 (2007) ("Atmospheric releases associated with dental amalgam use have remained relatively stable, with reduced releases caused by controls on incineration of infectious waste partially offset by increased releases from cremation of corpses.").

[110] *See, e.g.*, CREMATION ASS'N OF N. AM., *supra* note 57 (demonstrating that cremation rates are likely to keep rising).

[111] Ned Brooks, *supra* note 40.

[112] *See generally* U.S. EPA, Toxics Release Inventory Program, http://www.epa.gov/tri/ (last visited Mar. 3, 2008).

[113] U.S. EPA, 2003 TRI PUBLIC DATA RELEASE EREPORT 1 (2005), http://www.epa.gov/tri/tridata/tri03/pdr/2003eReport.pdf.

[114] ROADMAP FOR MERCURY, *supra* note 8, at 27; *see also* LEOPOLD, *supra* note 14, at 4.

[115] *See* Mass. Dep't of Envtl. Prot., About TURA Reporting & Fees, http://www.mass.gov/dep/toxics/tura/reportsum.htm (last visited Mar. 8, 2008).

[116] *Id.*

[117] N. Am. Indus. Classification Sys., http://www.census.gov/eos/www/naics/htmls/8/812220.htm (listing crematories under Classification 812220).

[118] E-mail from Paul Rahill, Pres., Matthews Cremation (Feb. 7, 2008) (on file with author) (estimating two to five employees each).

[119] *See supra* text accompanying note 87.

B. FIRST NIBBLES AT THE STATE LEVEL

A handful of states have taken a more direct pollution prevention approach. Two legislatures have considered, and rejected, measures directly targeting cremercury, but the issue is not going away.

i. Minnesota

The Minnesota House Finance and Health Policy Committee considered and rejected a measure in 2005 that called for the removal of dental amalgam prior to cremation.[120] The proposal reappeared in 2007 drafts of the Mercury Products Bill.[121] The initial House version called for amalgam removal,[122] but a subsequent revision replaced the removal requirement with a call for the University of Minnesota Mortuary Science Program to conduct a feasibility study of amalgam removal.[123] The final version passed by the legislature and signed by the governor contained neither provision.[124]

Nonetheless, the issue soon resurfaced when Minnesota's Pollution Control Agency set a goal to reduce overall mercury pollution from the currently estimated 3600 pounds annually to 800 pounds annually by 2025.[125] The Agency now estimates that the state's crematories contribute eighty pounds annually, but that this could rise to 120 pounds in ten years if not addressed.[126] Ironically, if the state's overall reduction target is met without cremercury abatement, cremercury's share will have increased from a mere 2.2 % of the emissions inventory to 15%.[127] This is roughly the same level as in the United Kingdom, where the amount is considered high enough that major initiatives are already

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[120] H.F. 661, 84th Leg. Sess. (Minn. 2005) (as introduced), https://www.revisor.leg.state.mn.us/bin/bldbill.php?bill=H0661.0&session=ls84.

[121] H.F. 1316, 85th Leg., Reg. Sess. (Minn. 2007) (first engrossment), http://wdoc.house.leg.state.mn.us/leg/LS85/HF1316.1.pdf.

[122] H.F. 1316, 85th Leg., Reg. Sess. (Minn. 2007) (as introduced), http://wdoc.house.leg.state.mn.us/leg/LS85/HF1316.0.pdf.

[123] H.F. 1316, 85th Leg., Reg. Sess. (Minn. 2007) (first engrossment), http://wdoc.house.leg.state.mn.us/leg/LS85/HF1316.1.pdf.

[124] E-mail from Kate Perushek, Legislative Assistant, Minn. House of Representatives, to author (Oct. 1, 2007) (on file with author).

[125] Ned Brooks, *supra* note 40. The Agency has set an interim reduction goal of 50% by 2018. "How [these goals] will be accomplished is yet to be determined but could include amalgam or tooth removal, chemical cremation or emission controls." E-mail from Ned Brooks, Mercury Reduction Coordinator, Minn. Pollution Control Agency, to author (Mar. 10, 2008) (on file with author).

[126] Ned Brooks, *supra* note 40.

[127] 120 pounds is 15% of the 800 pound target.

underway to tackle cremation-based mercury pollution.[128]

ii. Maine

Maine has also considered targeted cremercury legislation.[129] In 2005, State Senator Scott Cowger introduced a bill that would have given cremators the option of either installing mercury filtration equipment or removing amalgam fillings.[130] Some industry representatives actively opposed both options, and the Maine Senate Natural Resources Committee rejected the bill.[131] No similar measure has resurfaced in the state. Cowger believes that the bill raised awareness of the cremercury problem, and that a bill promoting a voluntary filling-extraction scheme would have gotten more traction.[132] He also believes that a bill delegating filling removal to funeral home operators, instead of to crematory operators who are more constrained in how they can legally "impact" a body, would have faced less opposition.[133]

iii. Colorado

In 2006, the Colorado Department of Public Health and Environment (CDPHE) obtained a $50,000 grant from EPA to launch a "Crematoria Pollution Prevention Initiative" ("Colorado initiative").[134] After reviewing available literature on cremercury, CDPHE's consultant used a mass balance measure to determine with a high level of confidence that the state's crematories were emitting approximately 110 pounds of mercury annually and represented the largest uncontrolled

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[128] BBC News, *Crematoria Warned Over Mercury* (Jan. 10, 2005), http://news.bbc.co.uk/1/hi/health/4160895.stm ("[C]rematoria are responsible for 16% of the UK's mercury pollution.").

[129] Telephone Interview with Matthew Prindiville, Natural Res. Council of Me. (Oct. 14, 2007).

[130] Paul Carrier, *Panel Kills Mercury Bill Aimed at Crematoriums*, PORTLAND PRESS HERALD, May 25, 2005.

[131] *Id.*

[132] E-mail from Scott Cowger, former Me. State Senator, to author (Nov. 17, 2007) (on file with author). *But see infra* text accompanying note 147 ("[A]mong the main objections behind the funeral industry's refusal to continue was that the voluntary approach would be ineffective.").

[133] Carrier, *supra* note 130. Of course, this distinction would be moot when the crematory is operated as part of a funeral home, the essential functions of which involve invasive treatment of bodies. *See, e.g., infra* note 262 (describing embalming).

[134] Mark McMillan, *supra* note 34; *see generally* Mark McMillan, Mgr. Mercury Program, Colo. Dep't of Public Health & Env't, *Mercury Reduction From Crematoria Through Collaboration & the Dev. of Best Mgmt. Practices*, http://www.ecos.org/files/2746_file_Session_2_Mark_McMillan.ppt (last visited Mar. 8, 2008) [hereinafter CDPHE].

source of airborne mercury in the state.[135] CDPHE also estimated that national cremercury emissions totaled roughly thirty times the figure derived from the Woodlawn study.[136]

To guide the initiative, CDPHE convened a group of stakeholders, including regulators, pollution prevention engineers, mercury specialists, dentists, and representatives of the religious community and of the funeral services industry.[137] The team considered three basic options: no action, pollution control, and pollution prevention.[138] Inaction was ruled out because CDPHE had already established that cremations were emitting significant amounts of mercury, and end-of-pipe filtration was rejected as too costly (estimates range from $175,000 to more than $700,000 per crematorium[139]). The team chose instead to study the feasibility of pre-combustion extraction of fillings.[140] However, at least partly because legislatures in Maine and Minnesota had failed to pass regulatory mandates,[141] Colorado decided to investigate a voluntary approach based on an organ donation model, extensive public outreach, and the development of best practices for the parties who would perform the extractions.[142] The stakeholders aimed "to develop . . . voluntary mercury pollution prevention strategies that could be tested and disseminated throughout the state."[143] This goal was based on the belief that informed citizens would agree to pre-cremation extraction of amalgam fillings.[144]

The Colorado stakeholders began a thorough investigation of how fillings could be practically removed in the challenging context of social conventions and mainstream funeral practices. The focal questions included when the fillings should be removed, how the jaw should be opened, how the teeth should be removed, and what should happen after

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[135] TETRA TECH, *supra* note 64, at 5-7.

[136] Mark McMillan, *supra* note 34; *see also* SCARMOUTZOS & BOYD, *supra* note 4, at 35 (estimating that U.S. crematory mercury emissions total three tons annually).

[137] Mark McMillan, *supra* note 34. Colorado's process was similar to "consultations" carried out by the United Kingdom's Department for Environment, Food and Rural Affairs. *See, e.g.*, U.K. Dep't of Env't, Food, & Rural Affairs, *Mercury Emissions from Crematoria, Second Consultation* (2004), www.defra.gov.uk/environment/ppc/old-consultations/crematoria-two/consultation.pdf [hereinafter DEFRA Second Consultation].

[138] CDPHE, *supra* note 134, at slide 9.

[139] *Id.*; *see also* Douglas Crowl, *Funeral-Home Owner Battles Larimer County Over Crematorium*, THE COLORADOAN, Mar. 3, 2008 (citing a potential $500,000 cost for one Colorado crematory operator).

[140] CDPHE, *supra* note 134, at slide 15-17.

[141] TETRA TECH, *supra* note 64, at 12.

[142] Mark McMillan, *supra* note 34.

[143] TETRA TECH, *supra* note 64, at 1.

[144] *Id.*

the amalgam-containing teeth are removed.[145] While the project's final report includes valuable information regarding these challenges—some actual tooth-extraction experiments were conducted—the whole investigation ended prematurely when the industry representatives withdrew and refused to participate further.[146]

Perhaps surprisingly, among the main objections behind the industry representatives' refusal to continue was that the voluntary approach would be ineffective and that "[w]ithout formal regulation or law, tooth extraction will result in little to no participation by Funeral Service Professionals in Colorado."[147] The spokesperson for the industry participants also referred to a cremation industry article that focused on EPA's decision that corpses are not to be regulated under solid waste rules and on the low results of the Woodlawn study.[148]

While it is unclear how Colorado intends to proceed,[149] the state's Crematoria Pollution Prevention Initiative was a bold attempt to tackle the economic, social, and practical hurdles facing the pre-cremation extraction proposal.

iv. Case Study: Cremercury and the San Francisco Bay Area

The cremation rate in the nine counties comprising the Bay Area is well above the national average.[150] Marin County's 80% cremation rate may rank as the nation's highest.[151] In 1997, Bay Area crematories together incinerated as many as 23,662 bodies,[152] and in 2007, there were

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[145] TETRA TECH, *supra* note 64, at 9-11. This study was probably much like the one the University of Minnesota's Mortuary Science Program would have conducted had the Minnesota Legislature enacted its proposed cremercury legislation. *See supra* text accompanying note 123.

[146] TETRA TECH, *supra* note 64, at 12.

[147] TETRA TECH, *supra* note 64, at App. C (reprinting correspondence from Martha Thayer, Dir., Arapahoe Cmty. College Sch. of Mortuary Science, to John Reindl, Recycling Mgr., Dane County, Wis., & Caitlin Rood, Tetra Tech (June 9, 2006)).

[148] *Id.* (reprinting correspondence from Martha Thayer, Dir., Arapahoe Cmty. College Sch. of Mortuary Science, to John Reindl, Recycling Mgr., Dane County, Wis., & Caitlin Rood, Tetra Tech (June 1, 2006)).

[149] *See* DeeDee Correll, *Cremation a Hazard to the Living?*, L.A. TIMES, Dec. 26, 2007 (describing the "stalemate" over cremercury between Colorado state health officials and a crematory operator who wants to relocate his facility).

[150] The rate was roughly 52% as of 1997. LUNDQUIST, *supra* note 66, at 3. As of 2005, California's overall percentage was also 52%—the tenth-highest rate in the nation—and the state ranked highest nationally in the number of cremations (120,883). CREMATION ASSOCIATION OF N. AM., FINAL 2005 STATISTICS AND PROJECTIONS TO THE YEAR 2025, 2006 PRELIMINARY DATA (2007), http://www.cremationassociation.org/docs/CANA-Final06Prelim.pdf.

[151] Fimrite, *supra* note 58.

[152] LUNDQUIST, *supra* note 66, at 3.

approximately fifty Bay Area crematories.[153] Cremation might be the region's third largest source of airborne mercury.[154]

California, and the San Francisco Bay Area in particular, is often seen as a leader in environmental protection.[155] Both the San Francisco Bay Regional Water Quality Control Board and the Bay Area Air Quality Management District (BAAQMD) have regulatory roles in managing mercury pollution, whether by monitoring toxicity levels, regulating existing emitters, or by administering the permits for proposed new sources.[156] While cremercury is getting more attention from some local agencies and nongovernmental organizations,[157] these emissions are too low, by BAAQMD's calculations, to trigger the relevant local regulations.[158] These regulations include a California law, the Air Toxics "Hot Spots" program, as well as BAAQMD's "New Source Review" rules.[159] However, if any official entities are going to act, it will likely be the region's storm water management agencies under mandates from the Clean Water Act.[160]

a. CARB & BAAQMD

The Air Toxics "Hot Spots" Information and Assessment Act ("Hot Spots") was adopted in 1987 to address rising public health concerns about airborne toxics.[161] Through the Hot Spots program, the California

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[153] E-mail from Alicia Gilbreath, Envtl. Analyst, San Francisco Estuary Inst. (Nov. 12, 2007) (on file with author) [hereinafter Alicia Gilbreath].

[154] *Id.* (citing estimates by Sarah Rothenberg, Postdoctoral Fellow, San Francisco Estuary Inst., derived from 2007 Cal. Air Res. Bd. statistics). No one has accurately measured the actual mercury emissions of Bay Area crematories. Rothenberg, *supra* note 17.

[155] OMB Watch, *California Moves to Reinstate Reporting Standards Weakened by Federal EPA* (2007), http://www.ombwatch.org/article/articleview/3810/1/241?TopicID=1; *see also* David R. Baker, *California Fighting Global Warming with Technology, Greenbacks*, S.F. CHRON., Nov. 14, 2007.

[156] *See, e.g.*, San Francisco Bay Reg'l Water Qual. Control Bd., San Francisco Bay Mercury TMDL, http://www.waterboards.ca.gov/sanfranciscobay/TMDL/sfbaymercurytmdl.htm (last visited Mar. 8, 2008); *see also* SAN FRANCISCO BAY AREA AIR QUALITY MGMT. DIST., CREMATORIES: PROCESS DESCRIPTION, PERMIT REQUIREMENTS, SAMPLE EVALUATION, http://www.baaqmd.gov/pmt/handbook/s11c05hd.htm (last visited Mar. 8, 2008).

[157] *See, e.g.*, Mary Spicuzza, *Pulling Teeth*, METRO, June 8, 2000, http://www.metroactive.com/papers/metro/06.08.00/cremations-0023.html.

[158] E-mail from Brian Bateman, Dir. of Eng'g, Bay Area Air Quality Mgmt. Dist., to author (Nov. 16, 2007) (on file with author).

[159] *Id.*

[160] Telephone Interview with Richard Looker, Water Quality Eng'r, San Francisco Bay Reg'l Water Quality Control Bd. (Nov. 5, 2007) [hereinafter Richard Looker].

[161] Cal. Air Res. Bd., Overview of the Air Toxics "Hot Spots" Information and Assessment Act (2005), http://www.arb.ca.gov/ab2588/overview.htm. When the Hot Spots program was enacted,

Air Resources Board (CARB) requires emissions inventories and health risk assessments for designated pollutant sources, including crematories.[162] CARB delegates administration of Hot Spots to the state's air quality management districts, including BAAQMD.[163] Qualifying businesses must quantify emissions, including emissions of mercury.[164] A business that emits high levels of potent chemicals must conduct a risk assessment to gauge the number of people in the vicinity of their facility that may get cancer or other acute or chronic disorders from the emissions.[165] No crematory has yet reported mercury emissions high enough (by BAAQMD's rubric) to trigger a risk assessment under the Hot Spots program.[166]

BAAQMD also keeps tabs on cremercury through its permitting rules for new facilities.[167] An applicant for a new crematory must submit an estimate of the number of cremations it intends to conduct and a projection of pollutant emissions, along with information regarding abatement equipment.[168] The agency then gauges whether the facility will exceed established "toxic risk screen trigger levels."[169] As with the Hot Spots program, no crematory has exceeded the agency's threshold to merit more than the reporting requirements.[170]

For both the Hot Spots program and new source permitting, BAAQMD provides crematory operators the data with which to calculate their projected emissions;[171] therefore, if BAAQMD's number is

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the BAAQMD already had a similar risk management policy in place. Enactment of the state rule required many existing facilities to conduct new emissions inventories and, in some cases, comprehensive risk assessments. Telephone Interview with Jane Lundquist, Eng'r, Bay Area Air Quality Mgmt. Dist. (Nov. 21, 2007).

[162] Telephone Interview with Chris Halm, Air Pollution Specialist, Cal. Air Res. Bd. (Nov. 21, 2007) [hereinafter Halm]; *see also* Cal. Air Res. Bd., *supra* note 161.

[163] Halm, *supra* note 162.

[164] *See* Cal. Air Res. Bd., *supra* note 161; *see also* BAY AREA AIR QUALITY MGMT. DIST., RULES & REGULATIONS, http://www.baaqmd.gov/dst/regulations/index.htm (last visited Mar. 8, 2008).

[165] *See* Cal. Air Res. Bd., *supra* note 161; *see also* BAY AREA AIR QUALITY MGMT. DIST., *supra* note 164.

[166] Telephone Interview with Jane Lundquist, Eng'r, Bay Area Air Quality Mgmt. Dist. (Nov. 21, 2007) [hereinafter Lundquist].

[167] *Id.*; *see also* BAY AREA AIR QUALITY MGMT. DIST., TABLE 2-5-1: TOXIC AIR CONTAMINANT TRIGGER LEVELS, http://www.baaqmd.gov/dst/regulations/rg0205.pdf (last visited Mar. 8, 2008).

[168] *See* SAN FRANCISCO BAY AREA AIR QUALITY MGMT. DIST., CREMATORIES: PROCESS DESCRIPTION, PERMIT REQUIREMENTS, SAMPLE EVALUATION, http://www.baaqmd.gov/pmt/handbook/s11c05hd.htm (last visited Mar. 8, 2008).

[169] Halm, *supra* note 162.

[170] Lundquist, *supra* note 166.

[171] *Id.*

inaccurate, the applicant's calculations will be skewed. In a 2000 report, *Estimate of Mercury Emissions From Crematoria in the Bay Area*, BAAQMD calculated that each cremation produces 1.1 grams of vaporized mercury,[172] a fraction of the more common estimate of two to three grams.[173] Even CARB's emissions factor, based on results from a 1992 cremation test, is higher, at 1.5 grams.[174] BAAQMD's report cites, as a "worst case" scenario (according to figures at the time), regional crematory mercury emissions of 104.3 pounds per year, or 1.9 grams per body.[175] BAAQMD's "most plausible" estimate is 26.8 pounds per year, or .51 gram of mercury per body.[176] Using three grams per body—a figure closer to that used by DEFRA, Colorado, the OSPAR Commission, and others—the emissions of Bay Area crematories would total 156.5 pounds per year. Given that this figure is significantly higher than BAAQMD's "worst case" estimate, and given the apparent inconsistencies within BAAQMD's modeling, the agency should reconsider its baseline calculations.[177]

Projections using estimates of two to three grams per cremation may still be insufficient to exceed the agency's trigger levels, but the gap would close significantly. For example, if a crematory processed 3605 bodies in one year, as did one Bay Area facility,[178] the mercury emissions could be as high as twenty-four pounds.[179] BAAQMD mandates a risk assessment if a facility exceeds the mercury "chronic trigger level" of thirty-nine pounds per year.[180] This Comment does not consider whether the Agency's threshold is appropriate, but this too is an issue warranting further consideration.

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[172] LUNDQUIST, *supra* note 66, at 3.

[173] *See supra* text accompanying note 84.

[174] *See, e.g.*, Reindl, *supra* note 38, at 9 (citing CAL. AIR RES. BD., EVALUATION TEST ON TWO PROPANE-FIRED CREMATORIES AT CAMELLIA MEMORIAL LAWN CEMETERY, TEST REPORT NO. C-90-004. (1992) (on file with author)).

[175] LUNDQUIST, *supra* note 66, at 1.

[176] *Id.*

[177] Through the Environmental Technology Verification Program, EPA Region 9 offers qualified agencies the use of a sophisticated device that would enable accurate testing of cremercury emissions. Rothenberg, *supra* note 17; *see generally* U.S. EPA, ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM (2007), http://epa.gov/etv/pubs/600etv07009s.pdf.

[178] Alicia Gilbreath, *supra* note 153.

[179] At three grams each, 3605 cremations would produce 23.84 pounds of mercury. *See also* Mills, supra note 87 (calculating the annual cremercury output of a busy crematory to be as high as twenty-four pounds). Mills calculated an average of 3 grams of mercury emitted per cremation. Reindl, *supra* note 38, at 8.

[180] BAY AREA AIR QUALITY MGMT. DIST., TABLE 2-5-1: TOXIC AIR CONTAMINANT TRIGGER LEVELS, http://www.baaqmd.gov/dst/regulations/rg0205.pdf (last visited Nov. 24, 2007) (referring to organic mercury and mercury compounds, e.g., methylmercury).

b. Cremercury in the Water

The biologically rich San Francisco Bay receives extensive surface water runoff, including that of two major river systems, laden with sediments and nutrients drawn from vast watersheds.[181] The Bay also collects a dangerous amount of mercury because these watersheds were subject to many decades of mercury-intensive gold mining.[182] This mercury alone profoundly affects the health of the environment, and it is projected to take many decades, if not a century or more, for the gold-mining mercury burden to abate somehow.[183] As part of a general effort to restore and protect the Bay, local agencies have focused on reducing additional new sources of mercury.[184] With roughly fifty crematories in the Bay Area,[185] cremercury is gradually getting more attention, including that of several non-governmental organizations and at least one agency, as a source that can and should be reduced.[186]

The Total Maximum Daily Load (TMDL) Program,[187] which EPA administers pursuant to the federal Clean Water Act, sets "the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards."[188] Because EPA lists the San Francisco Bay as "impaired" by mercury,[189] there is a TMDL capping the amount of mercury permissibly emitted to air, land, and water from all sources

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[181] NASA Visible Earth, Sacramento River Delta (2006), http://visibleearth.nasa.gov/view_rec.php?id=17383 ("Between the two of them, the Sacramento and the San Joaquin Rivers drain most of the state of California, collecting and concentrating rainfall and snowmelt [from] the Sierra Nevada and funneling it toward San Francisco Bay.").

[182] Krotz, *supra* note 10.

[183] *See, e.g., id.* ("[I]t takes as long as 50 years for the Bay's mercury concentrations to respond to changes in input.").

[184] Telephone Interview with Geoff Brosseau, Exec. Dir., Bay Area Stormwater Mgmt. Agencies Ass'n (BASMAA) (Nov. 5, 2007) [hereinafter Geoff Brosseau].

[185] Alicia Gilbreath, *supra* note 153. By contrast, there are only six crematoria in the entire state of Maine. Telephone Interview with Scott Cowger, former Me. State Senator, (Oct. 8, 2007).

[186] *See, e.g.*, Spicuzza, *supra* note 157 (quoting a Clean Water Action member as calling cremercury "low hanging fruit").

[187] *See generally* U.S. EPA, National Pollutant Discharge Elimination System (NPDES), http://cfpub.epa.gov/npdes/ (last visited Mar. 8, 2008).

[188] U.S. EPA, Impaired Waters and Total Maximum Daily Loads, http://www.epa.gov/OWOW/tmdl/ (last visited June 28, 2008). A TMDL determination operates in conjunction with the National Pollutant Discharge Elimination System Permit Program regulating point source discharges to surface waters. Geoff Brosseau, *supra* note 184.

[189] U.S. EPA, Section 303(d) List Fact Sheet for Watershed: San Francisco Bay, http://iaspub.epa.gov/tmdl_waters10/huc_rept.control?p_huc=18050004&p_huc_desc=SAN%20FRANCISCO%20BAY&p_cycle=2006 (last visited June 28, 2008).

combined.[190] The Bay Area agencies responsible for controlling surface water discharges (e.g., urban runoff) have set a twenty-year goal of cutting approximately in half the amount of mercury that enters the Bay in this manner annually, from 353 pounds to 181 pounds.[191] In light of ongoing research and pending negotiations with private parties, this goal may yet be revised.[192]

The Bay Area Stormwater Management Agencies Association (BASMAA) is the umbrella organization of the San Francisco Bay's eight municipal storm water programs, which together must meet these reduction targets.[193] BASMAA has considered that crematories may be a significant and potentially abatable source occupying the stormwater agencies' waste load allocation.[194] The Association also needs to consider that the number of crematories in its territory is likely to grow as more people choose cremation over other disposition methods.[195]

Although airborne mercury can drift and may reside for extended periods in the atmosphere,[196] BASMAA considers it prudent to assume that some cremercury deposits locally and is then carried to the Bay in run-off.[197] Supporting this assumption is the fact that crematories have shorter stacks than other emitters such as petroleum refineries.[198] Tests show that mercury levels in the topsoil surrounding a crematory are often elevated.[199] Further, mercury-contaminated surface water presents a

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[190] If a water body is listed as "impaired" by pollution under the Clean Water Act, EPA (or the state in which the body is located) establishes TMDLs, or "waste load allocations," for the pollutants-of-concern for that water body. Local agencies are then responsible for ensuring that discharges of the pollutants do not exceed the TMDL. Geoff Brosseau, *supra* note 184.

[191] Geoff Brosseau, *supra* note 184.

[192] *Id.* In addition, EPA and the states "are modifying surface water discharge permits to incorporate more stringent requirements in mercury discharges, where appropriate." ROADMAP FOR MERCURY, *supra* note 8, at 8-9.

[193] *See* Bay Area Stormwater Mgmt. Agencies Ass'n, About BASMAA, http://basmaa.org/about/ (last visited Mar. 8, 2008).

[194] Geoff Brosseau, *supra* note 184.

[195] *Cf.* CREMATION ASS'N OF N. AM., CREMATION DATA & PREDICTIONS: DATA TRENDS, http://www.cremationassociation.org/docs/crem-data-predict.pdf (last visited Mar. 7, 2008).

[196] *See supra* text accompanying note 19.

[197] Geoff Brosseau, *supra* note 184.

[198] Richard Looker, *supra* note 160.

[199] Reindl, *supra* note 38, at 14-17 (summarizing research on mercury in soils surrounding crematoria). This may be true even though the vast majority of mercury emitted from a crematory is in an inert gaseous form that is unlikely to deposit locally. Rothenberg, *supra* note 17. The remainder is composed of reactive, oxidized mercury and mercury bound to particulate matter. The ratio of these various forms depends on factors such as the operating temperature of the crematory retort. While the inert gaseous mercury takes up what might be a long residence in the atmosphere, the other forms are more readily deposited, although actual figures are elusive. *Id.*

localized threat,[200] and crematories may be located near residences.[201] For these reasons, BASMAA may be the first official entity looking at ways to reduce cremercury in the Bay Area.

Efforts to control mercury air pollution in the San Francisco Bay Area illustrate the myriad complexities of similar efforts elsewhere. Those in charge must make regulatory decisions based on substantial uncertainties due to the variable nature of this particular pollutant. What is certain at this time is that mercury is a potent and persistent toxin that must be effectively controlled. Bay Area agencies should reevaluate baseline assumptions about cremercury to address current emissions and to prepare for the cremation industry's apparently inevitable rise.

V. TOLLING THE BELL FOR CREMERCURY

To the extent that state and local governments are merely following EPA's lead when it comes to cremercury, these governments are missing an important opportunity to reduce a known source of highly toxic pollution. As states like Minnesota, Maine, and Colorado struggle to develop appropriate policies, however, the cremation industry knows that the cremercury issue is not going away.[202] Following the Woodlawn study, an article in *Mortuary Science Magazine* warned the industry to consider next steps to address the problems that "still exist for current and future crematory operations."[203] Sensing that the regulatory climate may change for cremercury, the industry might attempt to head off direct regulation through voluntary measures.[204] Once a feasible regulation has been enacted by some state or region in the U.S., others may follow suit. For example, New Mexico's mercury reduction plan plainly states that it will consider "adoption or adaptation of the best management practices being developed by Colorado."[205]

The question remains: what socially and economically palatable regulation would effectively reduce cremercury emissions? Colorado's study highlighted the two basic options—collecting the fillings or

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[200] Geoff Brosseau, *supra* note 184.

[201] *See* Justin Berton, *Burning Issues: Vocal Sunnyvale Residents Say New Crematorium will be Responsible for the Stink in their City*, METRO, Aug. 30, 2001, *available at* http://www.metroactive.com/papers/metro/08.30.01/crematorium-0135.html.

[202] *See* Rahill, *supra* note 76.

[203] *Id.* (noting that states had begun crafting regulations "without the benefit" of data from the Woodlawn study, and focusing on the (alleged) environmental benefit of operating crematories at lower temperatures).

[204] Mark Harris, *supra* note 79. Such "voluntary" action is not likely to occur unless the regulations are clearly being developed. *See, e.g., supra* text accompanying note 147.

[205] NEW MEXICO MERCURY REDUCTION ACTION PLAN, *supra* note 98, at iii.

capturing the vapors.[206] As that study indicated, filtration technology is so expensive that governments seeking to curb cremercury emissions should instead develop effective pollution prevention protocols for removing the amalgam fillings prior to combustion.[207] Focusing entirely on end-of-pipe solutions to avoid the uncomfortable subject of how cadavers should be treated would be misguided—especially as some within the death services industry allow that a tooth removal system *might* just work.[208]

The development of mandatory cremercury reduction goals might best be achieved by developing best practices for both options and letting market forces drive the decisions. In short: fix the goal, then let the industry choose its path to get there.

A. CREMATION FILTRATION: A COSTLY OPTION OF QUESTIONABLE EFFICIENCY

Several techniques exist to capture mercury from flue gases,[209] but EPA has not yet adopted an official standard, or Maximum Available Control Technology.[210] All of the available techniques are costly. For each crematory furnace in its European member states, the OSPAR Commission cited an annual estimated cost range of to $31,161 to $82,217.[211] A survey conducted for the Colorado Department of Public

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[206] TETRA TECH, *supra* note 64, at ES-1. Other options were considered, including the placement of an as-yet-unknown mercury-stabilizing substance in the mouth of a cadaver prior to sewing it shut; the goal was to avoid problems of disfigurement and timing. *See id.* at app. C (reprinting correspondence from Mark McMillan, Mgr., Mercury Program, Colo. Dep't of Pub. Health & Env't, to Martha Thayer, Dir., Arapahoe Cmty. College Sch. of Mortuary Science, et al. (July 18, 2006)).

[207] *See* TETRA TECH, *supra* note 64, at 8.

[208] TETRA TECH, *supra* note 64, at 11 ("[O]ne funeral professional indicated that he had removed teeth from time to time in response to family requests. This funeral professional indicated that in his experience, tooth removal before cremation, while not standard, was also not an uncommon activity."); telephone Interview with Michael P. LuBrant, Dir., Univ. of Minn. Program of Mortuary Science (Nov. 5, 2007). Mr. LuBrant, however, raised many substantial practical obstacles to such tooth collection. *See infra* text accompanying notes 243-67.

[209] OSPAR Comm'n, *Mercury Emissions from Crematoria and Their Control in the OSPAR Convention Area* 9-11 (2003), http://www.ospar.org/documents/dbase/publications/p00179_Mercury%20emissions%20from%20crematoria.pdf (discussing the following technologies and their respective mercury removal efficiencies: co-flow filters, > 98%; solid bed filters, > 90%; gas scrubbing, which reduces the mercury concentration in the flue gases to approximately 0.1-0.2 mg/m^3; ceramic reactor, efficiency unknown; gold filter, efficiency unknown; honeycomb catalytic adsorber, > 99.9%.). *But see* Wu, *supra* note 62 (calling scrubbers "useless" for this application).

[210] E-mail from Chang-Yu Wu, Professor, Univ. of Fla. (Nov. 12, 2007) (on file with author).

[211] OSPAR Comm'n, *supra* note 209, at 12. These figures represent the lowest estimate (27,270 eruros) for a "cold start" furnace to the highest estimate (75,450 euros) for a "warm start" furnace. *Id.* ("These costs involve technical installation, which includes the cost of additional

Health and Environment found that filtration equipment could cost as much as $690,000.[212] Additionally, there could be ongoing costs associated with transporting, treating, and—depending on the filter type—storing the mercury-laden filter media.[213] Importantly, because mercury will likely be phased out of dentistry altogether,[214] and because the population with amalgam fillings will eventually expire, abatement equipment could be superfluous in a matter of decades. The economic impact of the European Union's cremercury mandate[215] will be instructive, but the United States should meanwhile explore all options.

The expense of effective filtration systems indicates, in part, that the science of mercury vapor capture is highly complex.[216] Except for mercury, "the heavy metals released from waste incinerators have decreased considerably due to improvements in pollution abatement technologies."[217] Temperature controls, wet scrubbers, bag houses, and ambient dust collectors are all useful to control other pollutants[218] but may have only collateral benefits in reducing mercury emissions.[219] Mercury is elusive:

> Mercury is a unique metal in combustion systems. While most other metals are emitted as particulate matters, mercury is mainly emitted as elemental mercury vapor. . . . Therefore, particle control devices are not capable of capturing it. Meanwhile, it is insoluble, making scrubber[s] useless in removing it from flue gas. . . . EPA [once suggested that]

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emission monitors, transport, assembly and civil engineering costs (for renovations)."). In 2003, when the OSPAR Commission report was released, 27,270 euros to 75,450 euros was the rough equivalent of $31,161 to $82,217. European Cent. Bank, Statistical Data Warehouse (2008), http://sdw.ecb.int/ quickview.do?SERIES_KEY=120.EXR.D.USD.EUR.SP00.A. *See also* AEA TECHNOLOGY / NILU-POLSKA, COSTS AND ENVIRONMENTAL EFFECTIVENESS OF OPTIONS FOR REDUCING MERCURY EMISSIONS TO AIR FROM SMALL-SCALE COMBUSTION INSTALLATIONS 49 (2005), http://ec.europa.eu/environment/chemicals/mercury/pdf/sci_final_report.pdf (describing a "nominal additional cost of mercury abatement . . . per cremation . . . .").

[212] Tetra Tech, Control Technologies for Crematoria Hg Emissions 3 (July 18, 2007) (unpublished study, on file with author). It is not clear whether the $690,000 figure includes expenses in addition to procurement and installation.

[213] Telephone Interview with Jim Berlow, Dir., Hazardous Waste Minimization and Mgmt. Div., U.S. EPA Office of Solid Waste (Nov. 5, 2007).

[214] *See generally* MERCURY POLICY PROJECT, *supra* note 37, at 2 (describing results of national survey of dentists, which indicated that "a majority will eventually stop using mercury tooth fillings for 'environmental / waste disposal' reasons . . . .").

[215] BBC News, *supra* note 128 ("The industry has been told mercury filtering equipment must be fitted at crematoria by 2012 to halve emissions.").

[216] *See* Wu, *supra* note 62.

[217] INCINERATION AND HUMAN HEALTH, *supra* note 7, at 11.

[218] DEVICES, *supra* note 75.

[219] *See* Reindl, *supra* note 38, at 10 ("[I]t is clear that some mercury was removed by the wet scrubber system.").

> Activated Carbon [would be] the Maximum Available Control Technology [for major, regulated emitters]. However, it's not an ideal material (e.g., it requires 3 kg of the best carbon to remove 1g of [mercury, the equivalent of only two fillings]).[220]

In addition to activated carbon, sorbant materials such as bauxite or kaolinite may effectively remove heavy metals; but "their effective area is on the surface and hence a high quantity is required to control the heavy metal emission."[221] Further, inconsistencies between crematory facilities (e.g., because of relative age, upkeep, and technique)[222] make elusive the hard data that regulators would need to devise an ideal filtration scheme properly based on reduction targets and fiscal considerations.

Another problem with collecting mercury through the use of filtration technology is that this process results in a much larger bulk of contaminated waste—as much as 3.3 pounds of filter media per filling[223]—to be handled, treated, and/or stored properly.[224] Thus, while control technologies may curtail immediate releases to the air, they "still result in mercury wastes that are potential sources of future emissions . . . ."[225] Collected fillings of a much smaller volume than the filter media would pose a smaller lasting danger.[226]

A thoroughly conceived regulatory policy accounts for not only the economic feasibility of solutions, but the costs of nonregulation as well.[227] With potential cremercury regulations, the equation contains a

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[220] Wu, *supra* note 62. *But see* OSPAR Comm'n, *Recommendation on Controlling the Dispersal of Mercury from Crematoria* 3 (2003) (on file with author) (calling scrubbers effective for reducing mercury concentration in flue gases).

[221] Wu, *supra* note 62.

[222] In the United Kingdom, such inconsistencies led to the conclusion that "to install abatement at all crematoria could lead to significant numbers of crematoria closures." U.K. Dep't of Env't, Food, & Rural Affairs, *Summary of the Responses to the Consultation Paper in July 2004* 3 (2004), http://www.defra.gov.uk/environment/ppc/old-consultations/crematoria-two/responses.pdf.); *see also* DEFRA Second Consultation, *supra* note 137, at 7 ("[R]educing emissions of mercury from crematoria should aim to be achieved without forcing any crematoria closures due to physical constraints such as insufficiency of space or heritage considerations.").

[223] Wu, *supra* note 62 (referring to activated carbon, bauxite, and kaolinite). Accordingly, as much as 16.5 pounds (7500 grams) of media would be required to capture 2.5 grams of mercury from the teeth of a corpse cremated with five fillings.

[224] Disposal of this mercury-contaminated media would then be governed under the Resource Conservation and Recovery Act (RCRA). *See generally* EPA Land Disposal Restrictions Program, 40 C.F.R. § 268 (2005).

[225] U.N. Env't Programme, *supra* note 19, at § 121.

[226] For cost reasons alone, this should be true, since lower expenses for collection, transport, treatment, and/or storage of hazardous materials (because of the lower volume) would encourage proper disposal.

[227] *See* Frank Ackerman & Lisa Heinzerling, *Pricing the Priceless: Cost-Benefit Analysis of*

substantial variable: what is the economic burden of cremercury pollution? The same question arose in the United Kingdom when cremercury controls were first suggested, and DEFRA, the agency in charge, responded, "It is often necessary to take environmental decisions without certain knowledge."[228]

The European Union's proposed mandate raised a number of concerns with a filtration approach: the difficulty of retrofitting some existing facilities, especially those in historic buildings; the possibility that some facilities would have to close because of the great cost; architectural aesthetic impacts; and the unfairness that smaller facilities might have to bear the same burden as large ones.[229] In response to these and other concerns, DEFRA created a "burden sharing" program called the Crematoria Abatement of Mercury Emissions Organisation (CAMEO).[230] In 2006, DEFRA stated that the system was working well:

> Under burden-sharing, crematoria operators can choose whether to fit

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Environmental Protection, 150 U. PA. L. REV. 1553 (2002).

[228] DEFRA Second Consultation, *supra* note 137, at 6. The United Kingdom implemented its cremercury abatement policy under obligations including the OSPAR Recommendation on Mercury from Crematoria, European Union 4th Air Quality Daughter Directive, and the United Nations Protocol on Heavy Metals. *Id.* at 7. As of 2004, cremation rates topped 40% in nine E.U. member states, with four countries exceeding 70%: MAXSON, *supra* note 42, at 17. Other E.U. countries, including Cyprus, Estonia, Greece, Lithuania, and Malta, have no appreciable cremation rate. Overall, the average for the twenty-seven E.U. countries is roughly 33%, or about the same as the U.S. average. *Id.* The European Union has taken bold steps to curtail crematoria mercury emissions. BBC News, *supra* note 128 ("The industry has been told mercury filtering equipment must be fitted at crematoria by 2012 to halve emissions."). *See* Comm'n of the Eur. Communities, *Development of an EU Mercury Strategy, Invitation to Comment* 31 (2004), http://ec.europa.eu/environment/chemicals/mercury/pdf/consultation.pdf (highlighting "the possibility of significant [cremercury] emissions for many years to come in the absence of abatement") (citation omitted). *See also* Doug Hernan, *What Will it Take to Get U.S. Deathcare Professionals to TRULY Adopt a Global View?*, FUNERALWIRE.COM (Apr. 26, 2007), http://www.funeralwire.com/article.php?id=20401 ("European nations are clamping down heavily on air . . . pollution—and those environmental-protection measures 'will have a serious impact' on deathcare professionals in this country . . . perhaps even affecting emission standards for crematories."). Filling-extraction was ruled out as socially unacceptable. OSPAR Comm'n, *OSPAR Recommendation 2003/4 on Controlling the Dispersal of Mercury from Crematoria* 3 (2003); DEFRA Second Consultation, *supra* note 137, at 10. *But see* Mark Macaskill and Toby Macdonald, *Corpses' Teeth May Have to be Pulled*, TIMES ONLINE, Dec. 12, 2004, http://www.timesonline.co.uk/tol/news/uk/scotland/article402237.ece ("'Removing teeth with fillings would be the easiest solution,' said Bill Stanley, a spokesman for the Institute of Cemetery and Crematorium Management in Scotland. 'Pacemakers are routinely removed before a body is cremated as they explode when subjected to high temperatures. The concerns are that the public wouldn't wear it but they don't know about the issue and it needs to be raised. We need to discuss it more fully but it's feasible and members of our organisation wouldn't have any problems carrying out the work.'").

[229] DEFRA Second Consultation, *supra* note 137, at 7-8.

[230] News Release, U.K. Dep't of Env't, Food, & Rural Affairs, Halving Mercury Emissions from Crematoria - Novel "Burden Sharing" Approach to Continue 448/06 (Oct. 19, 2006).

> mercury abatement equipment or contribute to the costs of others doing so. Many operators have joined the CAMEO scheme, which is arranging burden sharing at the national level and provides an umbrella organisation for both running the system and reporting to [DEFRA]. CAMEO will register all burden sharing arrangements, with CAMEO members being free to choose their burden sharing partners. . . . Other operators are making their own arrangements, either by fitting equipment to part of their crematorium, or coming to a private agreement with other crematoria.[231]

One of CAMEO's key functions is enabling the United Kingdom's cremation industry to meet concrete cremercury reduction goals.[232] The U.S. cremation industry consists of small operators, some of which are nonprofits, and corporate chains like the Neptune Society.[233] If concrete goals like those in the European Union are set in the United States, a system akin to CAMEO might be necessary to avoid facility closures and unfair burdens. Large or small, the cost of abatement equipment would likely be passed on to the consumer. According to the OSPAR Commission, this could increase the cost of a cremation in its member countries by 15-20%, depending on the furnace type.[234] Given the average cremation cost in the United States of $1800, this might correspond to an increase of $270 to $360.

Another option would be for federal or state governments to establish a dedicated pollution prevention fund to partially offset the cost; this fund could be funded through assessments on polluters. Even if the extra cost fell entirely on consumers, it could be offset by as-yet-unquantified environmental health benefits, and the total price would still be far less than the average $10,000 tab for a standard funeral.[235] Removing teeth, however, would be even less expensive.

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[231] *Id.*

[232] *Id.*

[233] Telephone Interview with Joe Sehee, Founder, Green Burial Council (Nov. 20, 2007).

[234] OSPAR Comm'n, *Mercury Emissions from Crematoria and Their Control in the OSPAR Convention Area* 12 (2003), http://www.ospar.org/documents/dbase/publications/p00179_Mercury%20emissions%20from%20crematoria.pdf.

[235] GRAVE MATTERS, *supra* note 55, at 56.

B. TOOTH EXTRACTION

i. The Focus on Fillings: Solutions Begin in the Dentist's Office

Thus far, this Comment has focused on one end of one particular mercury waste stream; that is, what happens to mercury in fillings at the end of a person's life. The discussion is not neatly separated from what happens at the initial source of that waste stream: the dentist's office. The dental care industry is a major mercury consumer. According to EPA, in 2001, 14% of the mercury produced for industry in the United States went for use in dental amalgam fillings,[236] which are the primary source of cremercury emissions.[237] One recent study suggests that "the most amenable sources for mercury remediation include the dental office and the crematory."[238]

According to EPA, "[m]any state, tribal, and local governments have been leaders in addressing mercury releases. States have developed innovative mercury release and use reduction laws and regulations that supplement, and in some cases provide a model for, national efforts."[239] One increasingly common trend is to control or ban mercury fillings.[240] EPA's Roadmap notes, "Many states have initiated efforts to reduce mercury in wastewater by focusing on the dental sector. Mercury in dental wastewater [which may result from amalgam installation or removal] can be removed by relatively inexpensive amalgam separators and/or by using other pollution prevention practices."[241] Another increasing trend, albeit wholly based on personal choices and not on any

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[236] ROADMAP FOR MERCURY, *supra* note 8, at 36.

[237] REINDL, *supra* note 48, at slide 2.

[238] SCARMOUTZOS & BOYD, *supra* note 4, at 35 ("Mercury releases from dental amalgam may enter into the environment from three major sources: (1) Interment and cremation (2) Household sewage waste (3) Evacuation and discharge systems at dental offices.").

[239] ROADMAP FOR MERCURY, *supra* note 8, at 29-30 (citing several efforts to reduce the discharge of mercury into the waste stream from such sources as automotive switches and dental offices, but not mentioning any attempts to control cremercury).

[240] *See* Baga, *supra* note 2, at 179 (describing impacts from the use mercury amalgam fillings, including crematory mercury emissions).

[241] ROADMAP FOR MERCURY, *supra* note 8, at 28 ("Amalgam separators currently on the market can capture more than 95 percent of the mercury particles in wastewater."). *Contra* Telephone Interview with Seymour Kurtz, DDS (Oct. 29, 2007) (asserting that the mercury separators required by California regulations to be installed and maintained in dental offices are unduly expensive; that dental offices produce a minuscule amount of mercury waste compared with other sources; and that the expense is especially onerous for dentists who, like Dr. Kurtz, do not install amalgam fillings). Because dentists like Dr. Kurtz treat patients who may already have such fillings, they must comply with the regulations. *Id.*

regulation, is for living people to choose voluntarily to have amalgam fillings replaced with an alternative material.[242]

ii. Filling Extraction in the Context of Mainstream Funeral Practices

As demonstrated by the Colorado initiative, a person with specialized tools can extract teeth from a corpse in short order.[243] Despite Colorado's substantial efforts to test the tooth-extraction waters, however, much more research is necessary before the proposal can be deemed technically feasible.[244]

The difficulties largely reside in other death practices—such as embalming and public viewing—that may occur around the same time as the removal would.[245] Embalming is still mainstream practice in the United States.[246] So, for example, if Ben's family wants Ben's body embalmed for a public viewing and funeral service prior to being cremated, the embalmer will have more work to do if she first has to remove several teeth. Again, the issue is not so much the time involved. Rather, rigor mortis might have set in strongly, and Ben's powerful jaw muscles might have to be forced open.[247] Then the embalmer, probably not operating with the benefit of dental records, has to detect whether there are any amalgam fillings.[248] These are almost always set in molars, so she will have to take a good look inside. Even then, amalgam fillings may lay hidden under dental crowns.[249]

Once she finds Ben's fillings, it will probably not be difficult to pry

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[242] As in-place amalgams are considered to be quite stable in terms of mercury release, it is important that those who would have them removed and replaced consider that the removal process may destabilize the mercury and create a greater exposure hazard. *See, e.g.*, STEPHEN M. KORAL, INT'L ACADEMY OF ORAL MEDICINE & TOXICOLOGY, SAFE REMOVAL OF AMALGAM FILLINGS (2007), www.iaomt.org/articles/files/files288/Safe%20Removal%20of%20Amalgam%20Fillings.pdf. Dentists who perform this procedure should be well trained to capture the mercury. *Id.* Also, dental work is likely to be too expensive for most people to undergo discretionary amalgam removal. For these reasons, it may be safer and more economical for whole teeth to be removed from corpses with fillings intact.

[243] TETRA TECH, *supra* note 64, at 10-11. Note, however, that the mouth of the test corpse was already open. *Id.*

[244] Telephone Interview with Michael P. LuBrant, Dir., Univ. of Minn. Mortuary Science Program (Nov. 5, 2007) [hereinafter LuBrant].

[245] *Id.*

[246] Mark Harris, *supra* note 79; *see generally* AM. ASS'N OF RETIRED PERSONS, FUNERAL AND BURIAL PLANNERS SURVEY (2007), http://assets.aarp.org/rgcenter/consume/funeral_survey.pdf.

[247] Specialized tools exist to help with this task. TETRA TECH, *supra* note 64, at 11. The jaw may be dislocated anyway as part of the embalming process. MITFORD, *supra* note 35, at 48.

[248] *See* Carrier, supra note 130.

[249] LuBrant, *supra* note 244.

them out with specialized tools;[250] however, the tissues surrounding the new gaps may then swell and bruise,[251] making it more challenging to create a scene of peaceful repose.[252] The Colorado team identified other challenges, including "[p]otentially creating points where embalming or other fluids might leak . . . , [d]isturbing the capillaries so that the embalming fluid does not reach all areas of the face, leading to noticeable discoloration during the viewing, [and] [l]eaving spaces in the mouth that cause the cheeks to sink."[253] Alternatively, if the teeth are to be removed following the viewing and service, the remover must contend not only with potential rigor mortis, but also the task of undoing any work that was done to seal the mouth cavity—a common feature of embalming that involves substantial wiring and/or hardware.[254]

It would be far easier for the mortician, at least, if everyone exchanged amalgam fillings for some new substitute while still alive.[255] The next easiest scenario would be to forgo embalming altogether. Indeed, 61% of cremations are "direct," with no embalming and no viewing.[256] Embalming is mandatory only in rare circumstances.[257] In fact, with modern refrigeration technology and the careful use of dry ice[258] embalming is largely unnecessary,[259] although it is difficult to conceive how someone who is severely disfigured in death could otherwise be displayed for mourners.

There is no question, in terms of providing a service that the public generally appreciates and expects to remain available, that the mortuary science of embalming has had—and continues to have—a very large role in the "American way of death."[260] Arguably, this would not be the case

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[250] TETRA TECH, *supra* note 64, at 11.

[251] LuBrant, *supra* note 244.

[252] *Id.*

[253] TETRA TECH, *supra* note 64, at 10.

[254] LuBrant, *supra* note 244.

[255] *But see supra* note 242 (raising safety concerns regarding the removal of amalgams and noting that this procedure is probably too costly for most people).

[256] CREMATION ASS'N OF N. AM., *supra* note 1, at 16; E-mail from Paul Rahill, Pres., Matthews Cremation (Nov. 26, 2007) (on file with author).

[257] Some states have laws that make it illegal to transport an unembalmed body across state lines or to wait longer than a specified time to inter or otherwise dispose of a body without embalming. GRAVE MATTERS, *supra* note 55, at 28.

[258] GRAVE MATTERS, *supra* note 55, at 107 (explaining how one may forgo the use of a funeral home altogether and have a simple, dignified home funeral before final disposition).

[259] *See* U.S. Green Burial Council, http://www.greenburialcouncil.org/faqs.php (last visited Feb. 11, 2008).

[260] *Cf.* AM. ASS'N OF RETIRED PERSONS, FUNERAL AND BURIAL PLANNERS SURVEY 15 (2007), http://assets.aarp.org/rgcenter/consume/funeral_survey.pdf [hereinafter AARP] (reporting survey results showing that 83% of respondents have not considered having a funeral without an

had the public always known what is typically involved in this practice.[261] The invasiveness of extracting several teeth from a body simply pales in comparison to basic embalming practices.[262]

If embalming ceased altogether, an estimated 827,060 gallons per year of embalming fluid[263] would not be buried or get incinerated in crematories.[264] Americans are increasingly interested in ecological death practices,[265] and the top two reasons for choosing cremation are cost and a desire to save land.[266] Therefore, as society becomes more educated about ecological ways of dealing with the dead and remains interested in saving money by choosing direct cremation without embalming, embalming may become an anachronism.[267] To the extent that direct

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open casket and embalming).

[261] In fact, cremation rates began to rise in the 1960s, in part due to Jessica Mitford's best-selling, searing expose of the funeral industry. Richard T. Gill, *Whatever Happened to the American Way of Death?*, THE PUBLIC INTEREST, Spring 1996, *reprinted in* DYING, DEATH, AND BEREAVEMENT 98/99 at 27 (George E. Dickinson et al. eds., 1998).

[262] *See* MITFORD, *supra* note 35, at 45; *see* GRAVE MATTERS, *supra* note 55, at 15. The body is laid out on a table as if ready for surgery. MITFORD, *supra* note 35, at 45; GRAVE MATTERS, *supra* note 55, at 15. Surgical tools and an array of pastes, plasters, powders, sprays, soaps, waxes, mastics, glues, cosmetics, creams, and chemicals are at the ready. MITFORD, *supra* note 35, at 45; GRAVE MATTERS, *supra* note 55, at 15. Orifices are plugged. GRAVE MATTERS, *supra* note 55, at 17. A tube is inserted into a main vein and, under pressure from a pump, the blood is drained and replaced with three to six gallons of dyed, perfumed chemicals including formaldehyde, glycerin, borax, phenol, alcohol, and menthol. *Id.* at 21; MITFORD, *supra* note 35, at 45, 46. Eyelids are kept shut by lifting them over and down onto a spiked eyeball cap that is glued to the eye; the lids are sewn together or glued. The mouth is closed with the help of a needle injector and thread, or pins and wires and drilled holes. GRAVE MATTERS, *supra* note 55, at 19, 20. The jaw may be dislocated to ease this part of the job. MITFORD, *supra* note 35, at 48. Large breasts may be duct taped or sutured together to maintain form, injected with firming embalming fluid, and un-taped or de-sutured. To eliminate the burgeoning mass of bacteria within the chest and abdomen, a long, hollow needle (a "trocar"), which is attached by tube to a suction pump, is repeatedly thrust into the abdomen to pierce and shred and suck everything out. The resulting cavity is filled with chemical cavity fluid. GRAVE MATTERS, *supra* note 55, at 19, 22-23, 24. The head and limbs are reattached, if necessary; the nose and ears are replaced. Bloated tissue is cut away from the inside and stuffed with cotton to restore desired contours, and emaciated tissue is injected with creams. MITFORD, *supra* note 35, at 47, 48.

[263] Glendale Memorial Nature Preserve, Ecologically Sound Burial Alternatives (2007), http://www.glendalenaturepreserve.org/.

[264] In 2005, 61% of cremations were "direct" (without embalming). CREMATION ASS'N OF N. AM., *supra* note 1, at 6; E-mail from Paul Rahill, Pres., Matthews Cremation (Nov. 26, 2007) (on file with author). A recent survey found that almost half of Americans believe that having an open casket service is important, and the vast majority have not considered having an open casket without embalming. AARP, *supra* note 260, at 15-16. One might deduce, then, that the majority of cremations that are not "direct" are of embalmed bodies.

[265] *See* AARP, *supra* note 260, at 15.

[266] CREMATION ASS'N OF N. AM., 2006 DATA & PROJECTIONS TO THE YEAR 2025 19 (2007), *available at* http://www.cremationassociation.org/docs/CANA-Final06Prelim.pdf.

[267] *See* AARP, *supra* note 260, at 17 ("For environmental reasons, the European Union has considered banning formaldehyde [the main ingredient of embalming fluid]. Respondents were asked whether they would support this ban in the United States. Over one-third (36%) reported that

cremations avoid the logistic challenges of embalming and viewing outlined above, a filling-extraction program would be more feasible.

iii. Who Owns the Teeth? Who Pays to Collect Them?

Generally speaking, there is no legally recognized property right in a dead body,[268] and modern laws in the United States regarding the treatment of dead bodies derive from the government's police power to guard public health.[269] Based on its police powers, the state probably could mandate the removal of amalgam fillings from dead bodies to prevent mercury releases to the environment,[270] but a voluntary approach also holds promise. For example, the living could give advance consent to remove teeth with amalgam upon death using an organ-donor model.[271]

A donor model would serve several key purposes. First, it would allow the decision to be made by the living donor and would not leave the bereaved family to make a tough decision in a vulnerable time. Second, not only would it alert funeral and crematory workers to the presence of amalgam fillings, it may even help to locate them.[272] Lastly—and importantly—it would enable filling extractions to comply with the laws of many states that prohibit funeral service professionals

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they would support this ban. . . . If formaldehyde were banned, almost half of respondents (47%) say that they would be most likely to consider cremation as an alternative. Almost one-quarter of respondents (23%) said they would consider a natural or green burial as an alternative.").

[268] *But see* Tanya K. Hernandez, *The Property of Death*, 60 U. PITT. L. REV. 971, 982 (1999) ("[E]ven though probate courts in the United States universally recognize that there is no property in a dead body in a commercial sense, the courts do respect a decedent's right to assert burial preferences and to otherwise dispose of his or her own body by will as part of the freedom of testation. . . . Because personal care of the body of a decedent was traditionally the primary responsibility of the family, the judiciary viewed family members as having a kind of property right to the possession of a deceased family member's body for burial.").

[269] 23 CAL. JUR. 3D *Dead Bodies* § 1 (2006).

[270] Burial is also a pathway for mercury to enter the environment. SCARMOUTZOS & BOYD, *supra* note 4, at 35. For opposition to the state's intrusion into death practices, see Mary L. Clark, *Keep Your Hands Off My (Dead) Body: A Critique of the Ways in Which the State Disrupts the Personhood Interests of the Deceased and His or Her Kin in Disposing of the Dead and Assigning Identity in Death*, 58 RUTGERS L. REV. 45 (2005) (noting that the manner in which kin wish to express concern for the dead may at times "conflict with the needs of the community as a whole").

[271] TETRA TECH, *supra* note 64, at 27. All fifty states have adopted some version of the Uniform Anatomical Gift Act, which "authorizes donations of body parts for transplant or medical research." William Boulier, *Sperm, Spleens, and Other Valuables: The Need to Recognize Property Rights in Human Body Parts*, 23 HOFSTRA L. REV. 693, 712 (1995). *See generally* MARY ROACH, STIFF: THE CURIOUS LIVES OF HUMAN CADAVERS (2003) (presenting fascinating perspectives on organ donation).

[272] Mark McMillan, *supra* note 34.

from possessing any precious dental metal.[273] In other words, if Ben (or his family) gave permission to have his amalgam fillings—which often contain silver—removed, no one will get in trouble for doing the job.

There are various possibilities for distributing the costs of carrying out tooth extractions. For example, a fee could be added to the cost of each mercury amalgam filling, and the fee would be paid to the party extracting the filling at death.[274] This would raise the cost of fillings and encourage the phase-out of these fillings altogether—a goal already established in several states.[275] Alternatively, or in conjunction, insurance companies could be induced to offer coverage for removal-and-replacement of amalgam fillings while the insured is still alive.[276] Another option is to make violators of pollution laws contribute to a dedicated fund.

If the public were more broadly educated about the problem of cremercury, a substantial portion of the public would conceivably be willing to arrange to have their fillings removed upon death. This is especially true among the many who are choosing cremation (and eschewing embalming) for ecological reasons.[277] The donor model might be one effective way to manage the process.

iv. After the Extractions

Collecting small, mercury-contaminated objects is not a novel activity in many states:

> State and local governments have promoted public and private collection programs for both bulk elemental mercury and discarded mercury-containing products. Some businesses are also collecting unwanted mercury or mercury-containing products (e.g., thermostats). . . . Most of this mercury is sent to retorters, and it is likely that the supply of mercury will increase due to successful collection programs and efforts to eliminate mercury from schools,

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[273] *Id.*

[274] This might be administered in a manner similar to California's Electronic Waste Recycling Fee, a point-of-sale tax that covers the recycling costs of certain electronic devices in order to divert harmful pollutants from landfills. *See, e.g.*, State of California Board of Equalization, Special Taxes: Electronic Waste Recycling Fee, http://www.boe.ca.gov/sptaxprog/ewaste.htm (last visited Mar. 30, 2008).

[275] U.S. EPA, Mercury, State Legislation and Regulations (2008), www.epa.gov/epaoswer/hazwaste/mercury/laws.htm (listing bans in Colorado, Maine, and New Hampshire).

[276] *But see supra* note 242 (describing safety concerns when having an amalgam filling removed).

[277] *See, e.g.*, Green Burial Council, Green Burial Council Standards for Funeral Providers, http://www.greenburialcouncil.org/green_funeral_home.php (last visited Nov. 26, 2007).

laboratories, and businesses.[278]

The states, however, may need federal aid to successfully manage such programs. EPA's Roadmap notes that "states do not have the resources or desire to manage surplus mercury for the long term and are looking to the federal government to address this issue."[279] It is especially likely that states will need federal help if Congress enacts a currently proposed mercury export ban[280] and if the fillings collected from cadavers are deemed to be waste mercury as opposed to being suitable for recycling—a determination that may rest solely on socio-cultural concerns.[281] EPA recognizes that:

> [U]ltimately, it will be important to look at ways to permanently "retire" non-federally owned or managed commodity-grade mercury that will eventually have little or even negative economic value. Disposal of commodity-grade mercury would require regulatory changes, as current regulations under the Resource Conservation and Recovery Act (RCRA) require high-concentration mercury wastes to be retorted for mercury recovery and reuse.[282]

Under RCRA, EPA must manage hazardous wastes, from generation to storage, transportation, treatment, and disposal.[283] Thus, the Agency has established pre-disposal treatment and recycling standards for mercury wastes, including emissions limits for the combustion of mercury-laden hazardous waste.[284] RCRA provides a baseline for the states, some of which have designated particular mercury-containing wastes, including dental amalgam, for tougher treatment and disposal

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[278] ROADMAP FOR MERCURY, *supra* note 8, at 44. A "retort" employs a distillation process to isolate mercury. Telephone Interview with Jim Berlow, Dir., Hazardous Waste Minimization and Mgmt. Div., U.S. EPA Office of Solid Waste, (Nov. 5, 2007) [hereinafter Berlow].

[279] ROADMAP FOR MERCURY, *supra* note 8, at 44.

[280] Berlow, *supra* note 278; *see also* Cheryl Hogue, *House Panel Approves Bill To Eliminate U.S. Exports By 2010,* CHEM. & ENG'G NEWS, Nov. 1, 2007, http://pubs.acs.org/cen/news/85/i45/8545news5.html.

[281] If society accepts tooth removal as a way of preventing cremercury pollution, there would probably be little resistance to the careful reprocessing of the mercury into some usable resource. *Cf.* Envtl. Data Interactive Exchange, *Swedish Crematorium Heats Stockholm Housing,* Nov. 8, 2002, *available at* http://www.edie.net/news/news_story.asp?id=6246 (discussing the diversion of heat from crematories to homes in Stockholm: "[A] number of bishops and members of the public have declared the initiative appropriate and environmentally friendly.").

[282] ROADMAP FOR MERCURY, *supra* note 8, at 45.

[283] *See generally* EPA Land Disposal Restrictions Program, RCRA, 40 C.F.R. § 268 (2005).

[284] U.S. EPA, *Mercury: Laws and Regulations*, http://www.epa.gov/mercury/regs.htm (last visited Nov. 4, 2007).

requirements.[285]

If, in a given area, mercury fillings were extracted from cadavers in sufficient quantity to exceed RCRA's small-quantity exemption,[286] and the mercury constituted greater than 260 parts per million of the collected "waste," the material would be sent to one of several "retorters" in the United States to undergo what is essentially a distillation process: the waste would be heated, volatilizing and extracting the mercury, which would then be collected and possibly recycled.[287] The remaining teeth could then be interred in a safe and dignified manner, just as a crematory's collection of metal artificial joints might be.[288]

v. Some Notes About Changing the Culture

Death practices are often deeply embedded within culture; they change slowly—if at all.[289] Throughout history, humans have treated the bodies of deceased persons according to innumerable, seemingly immutable traditions based on particular beliefs about the very nature of death itself.[290] Further, the practices of one culture may be anathema to

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[285] *Id.*

[286] The limit for the small quantity exemption is 100 kg per month (220 lbs. per month). Berlow, *supra* note 278. "[G]iven certain economies of scale, perhaps it may be easier for a large, industrial sort of facility to accumulate some [mercury] before disposal." E-mail from Andrew Helmlinger, Attorney Advisor, U.S. EPA, to author (Mar. 6, 2008) (on file with author).

[287] Berlow, *supra* note 278. The economics of mercury disposal are likely to change if the pending mercury export ban is enacted by Congress. *Id.* For example, the rule might establish a national repository for waste mercury. *Id.* Other economic factors include the market value of recycled mercury and the fact that amalgam fillings contain significant quantities of recoverable silver. *Id.* There might, however, be a conflict with laws in some states that prohibit the possession of precious dental metals (i.e., gold and silver) from deceased persons unless a donor program or similarly protective process were in place. *See also* U.N. Env't Programme, *supra* note 19, at §123 ("The cost of acceptable disposal of mercury waste in some countries is such that many producers now investigate whether alternatives exist in which they would not have to produce and deal with mercury waste. Mercury waste management, as it is most commonly done today, in accordance with national and local regulations, increasingly requires long-term oversight and investment. Proper management of mercury wastes is important to reduce releases to the environment, such as those that occur due to spills (i.e., from broken thermometers and manometers) or releases that occur over time due to leakage from certain uses (e.g., auto switches, dental amalgams). In addition, given that there is a market demand for mercury, collection of mercury-containing products for recycling limits the need for new mercury mining.").

[288] GRAVE MATTERS, *supra* note 55, at 63 (describing how crematory operators must remove such objects before cremains are processed through a crusher and how a crematory operator might then inter the objects).

[289] *Cf.* AARP, *supra* note 260, at 19 (reporting, for example, that 44% of respondents 65 years or older said they were "not at all interested" in a manner of burial that is "more environmentally friendly than a traditional burial with embalming").

[290] *See, e.g.*, Kearl's Guide to the Sociology of Death, Quests for Longevity and Symbolic Immortality, http://www.trinity.edu/~mkearl/death-1.html (last visited Feb. 9, 2008).

another. Cremation, for instance, is forbidden by Orthodox Judaism, and was not approved by the Catholic Church until 1963.[291]

The Parsis of India have an ancient tradition of laying the deceased out in the open to be taken in by vultures.[292] The Parsis face a dreadful dilemma, however: the vultures upon whom they have counted for centuries are now disappearing, largely because of feeding on cattle carcasses so contaminated by an agricultural chemical that the vultures die of renal failure.[293] Some Parsis are switching to cremation, and because access to huge volumes of fuel wood is apparently as difficult as access to gas-fired crematories, a high-tech "solar" crematory has been developed using large, reflective mirrors to focus sunlight into an incineration chamber.[294] The Parsis' ancient method—using vultures—is based on the Zoroastrian religious belief that the dead should not be allowed to contaminate air, water, or earth; therefore, as ecologically friendly as solar cremation might sound, many Parsis feel that it violates their religion by contaminating the air.[295] Still, recognizing that they may no longer rely on the presence of vultures, this ancient culture is shifting to a new practice.

The first modern crematory in America was constructed in 1874.[296] In a relatively short time, domestic cultural death practices have changed dramatically; the ongoing rise of the cremation industry exemplifies such change.[297] Given this context, addressing cremercury pollution by removing teeth should not be ruled out because of perceived public or industry discomfort (or outright repugnance). Mercury pollution rarely presents itself in as stark a manner as a body rotting instead of being swiftly cycled back into nature by vultures. However, intense mercury

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[291] GRAVE MATTERS, *supra* note 55, at 55.

[292] Wired Magazine, *Innovation in the Dead Zone*, Feb. 10, 2003, *available at* http://www.wired.com/culture/lifestyle/news/2003/02/57610.

[293] Paul Peachey, *Rotting Body Row As India Mourns Missing Vultures*, TERRA DAILY, Sept. 2, 2006, *available at* http://www.terradaily.com/reports/Rotting_Body_Row_As_India_Mourns_Missing_Vultures_999.html.

[294] Wired Magazine, *supra* note 292.

[295] *Id.*

[296] MARY ROACH, STIFF: THE CURIOUS LIVES OF HUMAN CADAVERS 258 (2003). Although ancient Egyptians are often considered the first embalmers, embalming as mainstream practice in the United States only dates back to the Civil War, when the long-distance shipping of soldiers' bodies fueled the development of tissue preservation methods. Jason Goodman, *Arsenic and Old Graves*, WATER & WASTEWATER PRODUCTS, Vol. 6, No. 5 (2006), http://www.wwn-online.com/articles/51584/; Adam Gopnik, *In the Mourning Store, Burying the Civil War Dead*, THE NEW YORKER, Jan. 21, 2008, *available at* http://www.newyorker.com/arts/critics/books/2008/01/21/080121crbo_books_gopnik.

[297] Gill, *supra* note 261, at 27.

pollution is every bit as gruesome,[298] and to the extent that cremercury is released because society is unwilling to curb it, this toxin will continue to accumulate and to threaten public health and the global environment.

The public health laws that regulate the disposition of dead bodies in the United States necessarily aim to complement widely held religious and cultural beliefs,[299] but neither the laws nor the beliefs are static. In the late nineteenth century, when most people considered burial to be more adherent to religious custom,[300] a vigorous "cremationist" movement lauded cremation as spiritually beneficial.[301] Further, as increasingly crowded urban conditions broadened public health concerns, cremationists touted cremation's sanitary advantages over burials, which were commonly believed to issue pathogenic miasmas.[302] Cremation eventually became more acceptable, but well into the twentieth century, it remained curiously free from regulation.[303] This has changed, and crematories are now subject to myriad regulations that vary widely across the country.[304] These laws, like others targeting professional death services generally, effectively address some aspects of public health but are largely aimed at preserving the dignity of the dead and at preventing unscrupulous business practices by morticians.[305]

While these are all worthy goals, current regulations fail to address the full range of issues raised by disposition practices in the United States.[306] Cremercury emissions, which are largely unregulated, can—

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[298] *See, e.g.*, Masazumi Harada, Minamata Disease and the Mercury Pollution of the Globe, http://www.einap.org/envdis/Minamata.html; Heart Spring, Symptoms of Mercury Poisoning, http://heartspring.net/mercury_poison_symptoms.html (last visited Aug 30, 2008).

[299] Curiously, in California, this includes punishment for a funeral services professional who uses foul language in the presence of a corpse. CAL. BUS. & PROF. CODE § 7700 (Westlaw 2007).

[300] *See, e.g.*, GRAVE MATTERS, *supra* note 55, at 55 ("The practice [of cremation] was slow to take hold in the mostly Christian nation of the time . . . .").

[301] STEPHEN PROTHERO, PURIFIED BY FIRE: A HISTORY OF CREMATION IN AMERICA 17 (2001).

[302] *See* ROACH, *supra* note 296, at 258 (citing STEPHEN PROTHERO, PURIFIED BY FIRE: A HISTORY OF CREMATION IN AMERICA (2001)).

[303] *See* PROTHERO, *supra* note 301, at 130 (suggesting that the general lack of governmental endorsement of cremation substantially hindered the growth of the cremation industry in the U.S.).

[304] Keith E. Horton, Note, *Who's Watching the Cryptkeeper?: The Need for Regulation and Oversight in the Crematory Industry*, 11 ELDER L. J. 425, 427 (2003) ("States regulate the crematory industry via a patchwork of various laws with enforcement responsibilities spread across multiple state agencies, commissions, and boards. Surprisingly, some states allow crematories to operate without a license or inspections.").

[305] *See, e.g.*, MITFORD, *supra* note 35, at 176-77.

[306] "Currently, the crematory industry is largely underregulated." Horton, *supra* note 304, at 426. Industry representatives may strongly disagree. *Cf. id.* at n.6 (citing Robert M. Fells, External Chief Operating Officer and Gen. Counsel, Int'l Cemetery and Funeral Ass'n, Letter to the Editor, U.S. NEWS & WORLD REP., Mar. 5, 2002), *available at* http://www.icfa.org/usnwr_letter.htm).

and should be—curtailed. Similarly, why should someone who has died of cancer be pumped full of carcinogenic formaldehyde[307] only to contaminate the soil and groundwater through burial or to toxify the air by cremation? While the bereaved may find comfort in American death rituals, evidence of this "collateral damage" challenges the notion that mainstream practices actually dignify or pay homage to the dead. As long as medical study depends on the availability of corpses,[308] and as long as coroners must hold a body pending identification or autopsy,[309] there will probably be a need for corpse preservation. The law can continue to provide for the rare, actual need for toxic embalming.[310] Similarly, cremation may be a vital tool for disposing of bodies where, for example, there is an outbreak of lethal contagion or another instance of mass death.[311]

The time for a greener way of death has arrived; the most important way to "green" cremation is to eliminate cremercury. Better yet, why not embrace alternatives that may readily avoid cremation's other impacts as well?

C. ALTERNATIVES TO CREMATION

This Comment primarily attempts to demonstrate the significant danger of cremercury and to suggest ways to mitigate this danger. Mercury emissions are the main environmental problem with cremation, but they are certainly not the only one. In the past, crematories were notorious for visible emissions.[312] These have generally been addressed, but even if mercury fillings were now removed, cremations would still

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[307] Nat'l Cancer Inst., Formaldehyde and Cancer: Questions and Answers, http://www.cancer.gov/cancertopics/factsheet/Risk/formaldehyde (last visited Nov. 25, 2007).

[308] *See generally* ROACH, *supra* note 296.

[309] *Cf.* 22A AM. JUR. 2D *Dead Bodies* § 13 (2007).

[310] *See supra* note 257.

[311] For example, the first publicly operated crematory opened on Swinburne Island, New York, in 1889 and was operated to dispose of the bodies of immigrants who had died from infectious disease. PROTHERO, *supra* note 301, at 57. *But see* WORLD HEALTH ORG., TSUNAMI AFFECTED AREAS, 2005 COMMUNICABLE DISEASE RISKS AND INTERVENTIONS 5 (2005), http://www.who.int/infectious-disease-news/IDdocs/whocds200534.pdf ("Human remains do not pose a risk of communicable disease epidemics after natural disasters. . . . Burial is preferable to cremation in mass casualties and where identification of victims is not possible. The mass management of human remains is often based on the false belief that they represent an epidemic hazard if not buried or burned immediately."); *see also* MITFORD, *supra* note 35, at 63 (quoting a Canadian health minister's view that embalming "serves no useful purpose in preventing the transmission of communicable disease").

[312] Lundquist, *supra* note 166.

emit an array of pollutants and toxins.[313] While the Woodlawn study demonstrated that lowering the operating temperatures could lower some of these pollutants,[314] this would actually *increase* the release of dioxin,[315] which is one of the most potent toxins known.[316] Further, as much as 356 cubic feet of natural gas may be required to complete a single cremation.[317] Combustion of natural gas, a non-renewable fossil fuel, produces carbon dioxide, a greenhouse gas that exacerbates climate change.[318] Cremations also produce sulphur dioxide and nitrogen oxide, which contribute to the formation of acid rain.[319]

For these reasons, in addition to greening cremation by eliminating cremercury, existing alternatives to cremation, such as green burial,[320] should be made widely known and accessible, and new alternatives, like "promession,"[321] should be developed.[322] Demand for such services, tailored specially to accommodate the country's huge population, should be encouraged, in part, as a market incentive for crematories to adopt "greener" practices. For example, if promession can gain a foothold in the United States, it stands to ecologically revolutionize the death care

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[313] POLLUTANTS, *supra* note 61 (listing carbon monoxide, sulphur dioxide, hydrogen chloride, nitrogen oxides, dioxins, mercury, cadmium, lead, and particulate matter).

[314] *See* Rahill, supra note 76.

[315] Telephone Interview with Jane Lundquist, Eng'r, Bay Area Air Quality Mgmt. Dist. (Nov. 21, 2007). Dioxins are released from burning plastics and from burning chlorine compounds normally found in cadavers. POLLUTANTS, *supra* note 61.

[316] World Health Org., Dioxins and Their Effects on Human Health (2007), http://www.who.int/mediacentre/factsheets/fs225/en/index.html.

[317] DAVID L. RUSSELL, How much energy (natural gas) is consumed to burn a body in a crematorium? (Nov. 28, 2006), ALL EXPERTS, http://en.allexperts.com/q/Environmental-Science-1471/Cremation-energy-used.htm.

[318] NAT'L ENERGY INFO. CTR., GREENHOUSE GASES, CLIMATE CHANGE, AND ENERGY (2004), *available at* http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html.

[319] POLLUTANTS, *supra* note 61.

[320] *See generally* Green Burial Council, http://greenburialcouncil.org/ (last visited June 25, 2008). The Green Burial Council has a range of standards for ecological burial practices and is currently devising certification standards for cremation that will "mitigate for mercury pollution." Green Burial Council, Standards, http://greenburialcouncil.org/standards.htm (last visited June 25, 2008).

[321] *See generally* Promessa Organic, http://www.promessa.se/index_en.asp (last visited June 25, 2008). Using liquid nitrogen to freeze-dry bodies, promession mimics natural, biological processes that cycle the vital nutrients of deceased organisms back into the environment to sustain new life. *See generally id.* Mercury removal is an important part of the process. Telephone Interview with Susanne Wiigh-Masak, Founder, Promessa Found. (Aug. 30, 2007). In a short time, promession has caught fire in the European Union and elsewhere. *Id.* (describing inquiries from the United States, Korea, Canada, and South Africa). "[Wiigh-Masak] appears to be doing, in a matter of years, what took the cremationists a century." ROACH, *supra* note 296, at 261.

[322] A full discussion of such alternatives is beyond the scope of this Comment.

industry, and crematories are likely to be its main competitor.[323] Morticians are already losing massive market share to crematories.[324] With their experience in handling deceased persons, they might be able to regain their economic vitality by embracing this promising, thoroughly well-conceived method.

VI. SUMMARY & CONCLUSION

The polluting effects of cremation (and other common funerary practices) are not the most severe problem facing the environment. They are, however, richly emblematic of society's collective miscalculation—or denial—when it comes to a fundamental equation of biological existence: without death, there can be no life.

Under this rubric, it makes no sense to burn a corpse with mercury fillings. Legislation is needed to advance public health goals by mandating stringent standards to reduce or eliminate cremercury. This would necessarily require additional research to craft practical, economical filtration and/or filling extraction practices. A comprehensive approach would also effectively educate the public about the danger of cremercury and about ways to avoid it, including alternatives like green burial and promession. In driving such change, the law can help to satisfy the growing demand for ecological disposition and to boost the economy. In turn, this would encourage the culture—broadly speaking—to look beyond adherence to tradition and to acknowledge our direct connection to the earth that sustains us.

PHILIP DONALD BATCHELDER[*]

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[323] Seventy percent of Swedes are cremated, and one of the primary goals of promession's inventor was to develop a viable, ecological alternative to cremation. Telephone Interview with Susanne Wiigh-Masak, Founder, Promessa Found. (Aug. 30, 2007).

[324] Gill, supra note 261, at 27.

[*] 2009 J.D. Candidate, Golden Gate University School of Law, San Francisco, California. I am grateful to the many people who helped to inform and improve this Comment, including the students and faculty at Golden Gate University who supported my efforts. Special thanks to my courageous and lovely companion, Ms. Mary Mack. I dedicate this Comment to those people who are breaking taboos about death practices to encourage a shift to more sensible and ecological methods. In case anyone is wondering: I want to be freeze-dried and scattered in the leaves under a California buckeye tree. But not yet.

Borough of Kulpmont Air Pollution Control Ordinance

BOROUGH OF KULPMONT
NORTHUMBERLAND COUNTY, PENNSYLVANIA
ORDINANCE NO. _____

AN ORDINANCE OF BOROUGH OF KULPMONT, NORTHUMBERLAND COUNTY, PENNSYLVANIA ESTABLISHING AIR QUALITY MONITORING AND EMISSION STANDARDS AND PROVIDING FOR CIVIL PENALTIES FOR AIR POLLUTION.

WHEREAS, the United States of America Clean Air Act, as amended, including Amendments of 1990, and the Commonwealth of Pennsylvania Air Pollution Control Act of January 9, 1960 (P.L. 2119) (35 P.S. Section 4001, et seq.), as amended, provide in part for the better protection of the health, general welfare and property of the people of the Commonwealth by the abatement, reduction and prevention of the pollution of the air by smokes, fumes, gases, odors, mists, vapors, and similar matter, or any combination thereof; and

WHEREAS, the Federal and Commonwealth Legislatures have granted the power to local municipalities to adopt more stringent air pollution standards than those provided within the cited Acts pursuant to 35 P.S. Section 4012; and

WHEREAS, local municipalities have been empowered with the right to enact ordinances in protecting and preserving the ambient air quality; and

WHEREAS, Borough of Kulpmont ambient air quality is a matter of vital concern to the residents of the Borough; and

WHEREAS, the Borough of Kulpmont Council is of the opinion that increased introductions of air contaminants within the Borough would have an adverse effect on the ambient air quality; and

WHEREAS, the Borough of Kulpmont Council has determined that the impact of increased air contaminants should be borne by those introducing the contaminants; and

WHEREAS, the Borough of Kulpmont Council has determined that existing Federal and Commonwealth standards o f Air Pollution Control measures are less stringent than desired; and

WHEREAS, pursuant to the Borough Code of the Commonwealth of Pennsylvania to prohibit nuisances, including, but not limited to accumulations of garbage and rubbish, and the storage of abandoned or junked automobiles, on private or public property, and the carrying on any offensive manufacture or business.

WHEREAS, the Borough finds that the Pennsylvania Department of Environmental Protection does not possess sufficient staff, funding, or resources to continuously verify compliance with applicable environmental protection requirements;

WHEREAS, Pennsylvania ranks number one in releases of mercury pollution from coal and oil-fired power plants;

WHEREAS, Pennsylvania is one of 19 states with a statewide fish consumption advisory due to mercury contamination and is one of only 3 states where the *general population* is asked to restrict their consumption of *all* types of fish from *any* body of water in the state;

WHEREAS, Pennsylvania ranked third-highest for mercury contamination among the 13 states studied between 1997 and 2002;

WHEREAS, Pennsylvania's is heavily polluted with dioxin from power plants and incinerators, particularly the 30 years of excessively high dioxin pollution from the Harrisburg trash incinerator;

WHEREAS, the incineration of bodies, body parts, infectious and chemotherapeutic wastes collectively represent the second largest known sources of dioxin and mercury pollution in the U.S., according to the U.S. Environmental Protection Agency;

WHEREAS, incinerators in Pennsylvania are not required to use modern equipment that can continuously monitor mercury and dioxin emissions;

WHEREAS, as required by 35 P.S. §4012(a), the Borough finds that the provisions of this Ordinance are not less stringent than those of the Clean Air Act, the Pennsylvania Air Pollution Control Act, or the rules and regulations promulgated thereunder;

NOW, THEREFORE, IT IS HEREBY ORDAINED AND ENACTED BY THE Borough of Kulpmont COUNCIL, Northumberland County, Pennsylvania, and IT IS HEREBY ENACTED AND ORDAINED by the authority of the same AS FOLLOWS:

ARTICLE I - TITLE, PURPOSE AND AUTHORITY

Section 1. SHORT TITLE

This Ordinance shall be known and may be cited as the "Borough of Kulpmont Air Pollution Control Ordinance".

Section 2. PURPOSE

The purpose and intent of this ordinance is to ensure that the operation of any incinerator of bodies, body parts, infectious and/or chemotherapeutic wastes within Borough of Kulpmont, Northumberland County, Pennsylvania does not degrade the ambient air quality so as to adversely impact the health, safety, general welfare and property of the people of Borough of Kulpmont and does not adversely impact plant and animal life or the comfort and convenience of the public and the natural resources of the Commonwealth through the addition of mercury or dioxin/furan pollution to the ambient air and to exercise the authority granted to the Township under the Pa. Air Pollution Control Act.

Section 3. APPLICABILITY

This ordinance shall apply and be in full force and effect in Borough of Kulpmont, Northumberland County, Pennsylvania.

Section 4. AUTHORITY

This Ordinance is enacted pursuant to the authority granted to Borough of Kulpmont by all relevant Federal and State laws and their corresponding regulations, including, without limitation, the following:

Pennsylvania Constitution, Article I, Section 27;

Air Pollution Control Act 35 P.S. § 4012, which preserves the rights of municipalities to adopt air pollution ordinances and regulations not less stringent than the requirements of the Clean Air Act, the Pennsylvania Air Pollution Control Act, or rules and regulations promulgated thereunder;

Solid Waste Management Act, 35 P.S. § 6018.101 et seq., which preserves the rights and remedies of municipalities concerning solid waste within their borders;

Municipal Waste Regulations, 25 Pa. Code §§ 271 and 275, et seq; and

Clear Air Act, 42 U.S.C. § 7401, et seq.

ARTICLE II - DEFINITIONS

The following words and phrases when used within this Ordinance, unless the context clearly indicates otherwise, shall have the meaning ascribed to them in this Article:

(1) Corporation – Any corporation organized under the laws of any state of the United States or any country. The term "corporation" shall include all entities that possess limited liability characteristics, including limited partnerships, limited liability partnerships, non-profit organizations, business trusts, limited liability corporations, governmental bodies and mu nicipal authorities organized under the laws of any state or the United States or any country.

(2) Person – Natural persons, not including corporations.

(3) Biowaste Incinerator – Any structure or machine operated for the combustion (oxidation) of any combination of the following: deceased human or other animal bodies or body parts, or waste that is otherwise regulated as pathological, infectious or chemotherapeutic waste. Biowaste incinerators shall include, but are not limited to medical waste incinerators, pathological waste incinerators and crematoria.

(4) Facility – a biowaste incinerator.

(5) TEQ_{DF}-WHO_{98} – a unit of measurement for dioxins and furans, standardized to toxic equivalents, calculated in accordance with the World Health Organization's 1998 method.

(6) Continuous Emissions Monitoring System (or "CEMS") – a pollution monitoring system that can provide emissions data for a sampling period that covers the entire operating time of a facility. Such devices used in this Ordinance must be certified by the U.S. Environmental Protection Agency's Environmental Technology Verification (ETV) Program or its successor agency.

(7) Borough Council – The Borough of Kulpmont, Northumberland County, Pennsylvania Council.

(8) Owner – The person or corporation that has the legal right of proprietorship of a facility. In cases of emergency, facility operators may be notified in lieu of owners to promote timely responses to the emergency.

(9) Responsible Party – If the facility is owned and operated by a person, the responsible party is that natural person. If the facility is owned and/or operated by a corporation, this term shall include all officers and directors of any corporation that owns or operates the facility.

ARTICLE III - CERTIFICATIONS AND MONITORING

Section 1. Certifications Required By Owners to the Borough Council. As a requirement for the operation of a biowaste incinerator which may release mercury or dioxins/furans and thereby cause air pollution or adverse environmental effects, the Borough Council shall, in considering the type of facility and degree of potential air pollution or potential adverse environmental effects, require certain certifications by the owner of said facility.

(a) The owner of a facility shall certify that any facility under their control will not exceed the limits for contaminants specified within this ordinance.

(b) The owner of a facility shall certify that funds are available in escrow to cover any fine or penalty levied by this ordinance for reason of exceeding set limits of contaminants from any source under their control.

(c) The owner of a facility shall certify that monies will be made immediately available to fund any and all air pollution monitoring of the facility.

(d) The Borough Council may demand any further proof or require the posting of a bond by the owner of a facility as deemed necessary to ensure compliance with any certification and may require the owner to recertify on an annual basis.

(e) Certifications shall not be transferred or assigned to any other person or corporation.

(f) All certifications required under this ordinance shall be made under oath, and subject to the penalties of perjury and false swearing.

Section 2. Air Pollution Monitoring.

(a) The operator of a facility mu st monitor for mercury and dioxins/furans at all times when the facility is in operation. A Continuous Emissions Monitoring System (CEMS) must be used to monitor mercury and dioxins/furans. CEMS for which there exist U.S. Environmental Protection Agency or Pa. Department of Environmental Protection standards must also comply with all such standards. CEMS must be used to measure mercury concentrations on a standard basis for direct comparison with the mercury standard in Article IV Section 1(a). CEMS must be used to measure dioxin/furan concentrations on a standard basis for direct comparison with the dioxin/furan standard in Article IV Section 1(b). It shall be unlawful for any person or corporation to construct, assemble, install or modify, operate or continue to operate any facility which emits or which may emit mercury or dioxins/furans within Borough of Kulpmont, Northumberland County without full compliance with the provisions of this Section.

(b) Pollution monitoring shall be conducted by an engineering firm approved by the Borough Council with results becoming the property of Borough of Kulpmont, Northumberland County, Pennsylvania. All costs of monitoring shall be borne by the person or corporation owning the facility, with the owner of the facility receiving immediate notice if emissions which are subject to the CEMS requirements under this Ordinance exceed 85% of any emissions limitation established by law or regulation, and also if such limitation is exceeded. The owner of the facility shall furnish funding for the monitoring on an advance quarterly basis by cash or certified check made payable to the Borough and drawn upon a bank authorized to do business within the Commonwealth of Pennsylvania. Failure to make advance payment within two working days of the end of each quarter shall require cessation of operation of the facility until such time as payment is received by the Borough.

(c) The engineering firm shall ensure that monitoring data is available in real-time to Borough computers in a format acceptable to the Borough, where they shall be archived and made immediately available on the Borough's website at the expense of the facility owner. Quarterly summary data, specifying mercury and dioxin levels compared to the limits specified in this Ordinance shall be published in the most widely-read local newspaper at the expense of the facility owner. The engineering firm shall ensure that the Borough Council and the facility owner or operator are immediately notified when contaminant levels exceed 85% of, or violate, the maximum levels allowed under this Ordinance and shall duly note the person(s), date and time such notification was given.

(d) CEMS must be started up at least twelve (12) hours before the commencement of facility operation, unless the manufacturer of the CEMS certify, and Borough engineers agree, that the equipment can sample accurately with a shorter warm-up time.

(e) Exhaust gases may not be released into the atmosphere until they have cooled to below 200 degrees Centigrade in order that all dioxins and furans can be monitored. Dioxin/furan emissions monitors must be placed at a point where the exhaust gases have cooled to below 200 degrees Centigrade. Dioxin and furan measurements must be standardized to TEQ_{DF}-WHO_{98} units.

(f) Where applicable, non-detects shall be measured at half the detection limit.

(g) The facility owner and operator shall furnish written consent for the inspection of the facility at any time by the designees of the Borough Council for the purpose of assuring compliance with this Ordinance. Such designees shall be permitted entry upon any property or into any building, premises or place on which or within which a biowaste incinerator may be located and to inspect the emissions monitoring equipment as may be necessary to ensure that such equipment is operational, is operating properly and is being used as intended by the manufacturer and in accordance with this Ordinance.

(h) Exceeding the established levels of contaminant releases as may be shown by continuous emissions monitoring shall constitute prima facie evidence that a violation has occurred.

(i) The facility owner and operator shall permit the installation of such monitoring devices, measuring equipment, indicators or alarms as deemed necessary by the engineering firm approved by the Borough Council.

(j) Violation(s) of any provision within this section shall constitute a misdemeanor and penalties may be assessed whether or not the violations were willful.

Section 3. Proof of Financial Responsibility. As a requirement for the operation of any biowaste incinerator which may release mercury or dioxins/furans and thereby cause air pollution or adverse environmental effects, the Borough Council shall, in considering the type of facility and degree of potential air pollution or potential adverse environmental effects, require proof of financial responsibility or security assuring the proper construction, operation, and maintenance of CEMS in the form of a bond or other legal instrument of a form acceptable to the Borough Council, payable to Borough of Kulpmont which guarantees proper construction, repair, operation and maintenance, inspections and monitoring of the facility and removal if necessary. The amount of such bond or legal instrument shall be sufficient to cover all costs of entry, correction, repair, operation, maintenance, inspection, or monitoring of the CEMS in the event of failure by the owner to comply with the provisions of this ordinance, or any order issued hereunder.

ARTICLE IV - MERCURY AND DIOXIN EMISSION LIMITS

Section 1. Emission Limits.

(a) Mercury Emissions– The mercury emissions limit for each biowaste incinerator shall be 0.05 mg/Nm3. It shall be unlawful to emit more than this limit. In calculating compliance with this limit, data may be averaged on a three hour basis. Such averaging shall not include data from times when combustible materials are not being burned in the incinerator.

(b) Dioxin/Furan Emissions– The dioxin/furan emissions limit for crematoria and o ther facilities that operate sporadically and which burn human bodies or animal carcasses shall be 400 nanograms per body TEQ_{DF}-WHO_{98}. For other types of biowaste incinerators, the dioxin/furan emissions limit shall be 2 nanograms per kilogram (ng/kg) TEQ_{DF}-WHO_{98}. It shall be unlawful to emit more than this limit. In calculating compliance with this limit, data may be averaged on a weekly basis. Such averaging shall not include data from times when combustible materials are not being burned in the incin erator.

(c) In cases where the average weekly emissions exceed the mercury or dioxin/furan emissions limit, waste feed shall be cut off and operations shall be immediately ceased until corrective action is taken.

Section 2. Adoption and Incorporation of Other Limits and Standards

To the extent a more stringent standard, limit, or requirement for the emission of air contaminants or a standard of performance for any facility defined in this Ordinance as a biowaste incinerator is not expressly set forth herein, the Borough adopts and incorporates by reference herein the standards, limits, and requirements for the emission of air contaminants, and standards of performance for stationary sources, as promulgated by the U.S. Environmental Protection Agency pursuant to the Clean Air Act or by the Commonwealth of Pennsylvania pursuant to the Air Pollution Control Act or any other relevant statutes. It is expressly the intent of the Borough in adopting these standards, limits, requirements, and standards of performance, to make them independently enforceable by the Borough of Kulpmont.

Section 3. Best Available Technology

To the extent that either the U. S. Environmental Protection Agency or the Pennsylvania Department of Environmental Protection determines that a control technology is reasonably available to reduce or minimize the emission of air contaminants from a stationary source, each stationary source within the Borough shall modify its facility so as to utilize the control technology within such time as the Borough Council may reasonably determine. The Borough Council shall notify the facility of the time period within which it must modify the facility to utilize the control technology. It shall be the responsibility of the facility to obtain such permits and approvals for the modification of the facility as are necessary under state and federal law.

Section 4. Unlawful Conduct.

It shall be unlawful for any person or corporation to:

(a) Fail to comply with any provision of this Ordinance including butnot limited to the provisions of section 2 above;

(b) Violate or assist in the violation of any of the provisions of this ordinance.

(c) Attempt to circumvent any provision of this Ordinance through misrepresentation or failure to disclose all relevant facts. Nothing in this Ordinance shall be construed to affect the application of provisions of the Crimes Code, Title 19 of the Pennsylvania Consolidated Statutes relating to perjury, false swearing or unsworn falsification to authorities.

(d) Intentionally obstruct, impair or interfere with the administration of this Ordinance by the Borough Council or their designees by force, violence, physical interference or obstacle or any other unlawful act. Nothing in this Ordinance shall be construed to affect the application of Section 5101 of the Crimes Code, Title 2le of the Pennsylvania Consolidated Statutes as to obstructing administration of law or other governmental function.

(e) Tamper or interfere with any sample, process, device, equipment, computer hardware or software, indicator or alarm, report, electrical power, pipe, gas or other media so as to affect or alter any sample, process, device, equipment, indicator or alarm, report, electrical power, pipe, gas or other media used in the gathering and analysis of samples or the reporting of sample analysis as may be required the Borough Council in the administration of this ordinance.

ARTICLE V - DECLARATION OF PUBLIC NUISANCES

The emission of mercury or dioxins/furans into the atmosphere of Borough of Kulpmont except in conformity with this Ordinance is hereby declared to be public nuisance, abatable in the manner prescribed by law.

ARTICLE VI - COMPLIANCE ORDERS

Whenever the Borough Council has reason to believe that there has been a violation of this Ordinance or other State or Federal Law, or any of the rules and regulations promulgated pursuant thereto or a misrepresentation of any certification, the Borough Council shall, in addition to any other remedy available to it, and in the absence of an emergency situation requiring prompt action, give written notice of such violation to, the owner or operators of the facility, and therein order such corrective measures as are deemed reasonable and necessary to cure the violation. This notice shall state the nature of the violations and shall allow a reasonable time for the performance of the necessary corrective measures. If the owner or operator of the facility fails to carry out the corrective measures set forth in the notice, within the time period stated therein, the Borough Council shall institute such other actions as may be deemed necessary to terminate the violation.

ARTICLE VII - CRIMINAL PENALTIES

In accordance with the Pa. Air Pollution Control Act, 35 P.S. 4012(g), providing that civil and criminal penalties for air pollution violations be uniform throughout the Commonwealth, and further providing that "the penalties and remedies set forth in this act be the penalties and remedies available for enforcement of any municipal air pollution ordinances or regulations, and shall be available to any municipality, public official, or other person having standing to initiate proceedings for the enforcement of such municipal ordinances or regulations" the criminal and civil penalties for violation of this Ordinance shall be the following:

Section 1. Notwithstanding any other provisions herein, any responsible party that violates any provision of this Ordinance or any of the rules and regulations pursuant hereto or who misrepresents any certification upon conviction of such offense in a summary proceeding shall be subject to a fine or no less than Two Hundred Dollars ($200) and no more than Two Thousand Five Hundred Dollars ($2,500), plus costs of prosecution or, in default of the payment of such fine, be imprisoned for not less than one (1) day and no more than one (1) year. Each day of violation or misrepresentation of certification shall constitute a separate offense and each one percent (1%) above the mercury or dioxin/furan emissions limit shall also constitute a separate offense. Violations of both the mercury and dioxin/furan limit shall constitute separate offenses.

Section 2. Any responsible party that, within two years after a conviction in a summary proceeding as provided in Section I above engages in unlawful conduct as defined in this ordinance is guilty of a misdemeanor of the third degree and, upon conviction, shall be sentenced to pay a fine of not less than Five Hundred Dollars ($500) nor more than Five Thousand Dollars ($5,000) for each separate offense or, in default of the payment of such fine, to imprisonment for a period of not less than one (1) day and no more than one year. Each day of violation or occurrence of misrepresentation of certification shall constitute a separate offense.

In addition to proceeding under any other remedy available at law or in equity for a violation of a provision of this Ordinance, the Borough may initiate criminal proceedings against the responsible party pursuant to 35 P.S. Section 4009.

ARTICLE VIII - CIVIL PENALTIES

(a) Any responsible party that violates any provision of this Ordinance, or any compliance order issued pursuant to Article VI hereof, shall pay to the Borough of Kulpmont a civil penalty in the amount assessed by Borough Council. The penalty may be assessed whether or not the violation was willful. The civil penalty so assessed may not exceed Ten Thousand Dollars ($10,000.00) per day for each violation. In determining the amount of the penalty, the Borough may consider the willfulness of the violation; damage to air, soil, water or other natural resource or their uses; financial benefit to the person or corporation in consequence of the violation; deterrence of future violations; cost to the Borough; the size of the source or facility; the compliance history of the source; the severity and duration of the violation; degree of cooperation in resolving the violation; the speed with which compliance is ultimately achieved; whether the violation is voluntarily reported; other factors unique to the owners or operators of the source or facility; and other relevant factors.

(b) When the Borough proposes to assess a civil penalty, it shall inform the owner of the proposed amount of the penalty. The owner charged with the penalty shall then have thirty (30) days to pay the proposed penalty in full, or if the owner wishes to contest the amount of the penalty or the fact of the violation to the extent not already established, the owner shall forward the proposed amount of the penalty to the Borough within the thirty (30) days period for placement in an escrow account with any Commonwealth bank.

ARTICLE IX - ABATEMENT AND INJUNCTIONS

Notwithstanding any other provision herein, if the Borough Council finds any person or corporation is operating a facility without complying with the requirements of this Ordinance, or any of the rules and regulations promulgated thereunder, the Borough Council may, in addition to other remedies that may be available to it, order the immediate discontinuance of such violations, or order other compliance. Failure to comply with such an order of discontinuance, or any other order of compliance issued by the Township, shall constitute a violation of this Ordinance. In addition to all other remedies, upon a failure to comply with such order, the Borough may secure a temporary restraining order, a preliminary injunction, a permanent injunction or other appropriate relief or declare the operation a public nuisance, and order the immediate abatement of same, with the costs of such abatement to be borne and assessed in accordance with law.

ARTICLE X - SEVERABILITY

Each separate provision of this Ordinance shall be deemed independent of any other provision of this Ordinance, and if any provision, sentence, clause, section or part hereof is held to be illegal, invalid or unconstitutional or inapplicable to any person, corporation or circumstances, such illegality, invalidity, unconstitutionality or inapplicability shall not affect or impair any of the remaining provisions, sentences, clauses, sections, or parts of this Ordinance or their application to other parts or circumstances. It is hereby declared to be the legislative intent that this Ordinance would have been enacted as if such illegal, invalid or unconstitutional provision, sentence, clause, section or part had not been included herein, and as if the person, corporation or circumstances to which this Ordinance, or any part hereof is inapplicable had been specifically exempted therefrom.

ARTICLE XI - EFFECTIVE DATE

That this Ordinance shall become effective upon enactment

DULY ENACTED AND ORDAINED THIS DAY OF 2006.

ATTEST:

Silvestri, Michael A.

From: Zuk, Edward J.
Sent: Wednesday, March 16, 2011 6:52 PM
To: Silvestri, Michael A.
Subject: FW: Crematory

From: McLaughlin Builders [mailto:joemclaughlin1956@comcast.net]
Sent: Wednesday, March 16, 2011 3:58 PM
To: Zuk, Edward J.
Subject: Crematory

Ed

I am writing this to you to forward on to council.

Dear council member

I am writing to urge peters twp. to support the crematory that is proposed in the old lazyboy building.(rt 19)

Many residents have given very emotional testimony as opposition to this. While I am sympathetic to their concerns,they simply need as council does

also to prove their point. I'm sure we are all exposed to greater health risks in our everyday life,from florescent light bulbs to the chem-lawn we

spray on our lawns. I have attended all the meetings concerning this topic and have not heard 1 fact I believed from the anti-group.

Our own P.T. staff has done research, air,testing plus an on site visit to see a cremation and i get no impression that they are in agreement with this anti-group.

I did read their report dated 3-10-11 (Emily and Scott) very good work from our staff.

This group makes a very passionate appeal,but they need to stay on topic,as does this council. I know by following your recent comments

on the Marcellus shale topic you have very strongly stated you do not want to spend tax dollars on court battles. This particular issue I also think

it to be evident our solicitor needed to spend a little more time with.

As a lifelong resident of the twp. and a business owner in addition to a commercial property owner on this rt. 19 corridor I urge council to look with an open

mind to the facts and approve this. Planning commission made their minds up before their meeting, please listen to everyone.

The Audia group has worked with staff to find a site, and will be filling an empty eyesore of a building. Not only will they provide us with a new look at that

intersection (which may encourage the neighbor to the north ,sears/ schwotzer to re-evaluate his curb appeal) it will give us a service, a choice and

provide competition. There is a shameless business working here to keep a monopoly.

This business will be a great value to our community, We should be a little more welcoming as a group.

I trust in you to look at the facts and not to punt this one to the courts to decide.

Joseph J. McLaughlin

Dear Members of the Peters Township Council,

What has happened to Peters Township lately?

How can it be that a crematorium is being considered in a heavily populated area of Peters Township when the economic and health risks are so great to our community?

Why is the crematorium business pressuring our township to change the current ordinances and zoning laws to suit their needs instead of respecting the laws that are already in place for our protection?

It seems ludicrous that a single business owner can ruin the lives of thousands of people by decreasing our home values and decreasing our air quality due to the mercury vapors emitted from crematoriums.

It isn't hard to find facts on the dangers of Mercury. Mercury is the most toxic substance on the US Dept. of Health and Human Services list of hazardous substances. Even in minute amounts, Mercury is extremely toxic.

Why on earth would we welcome a business that openly emits Mercury into the air of a heavily populated area of Peters Township?

Isn't your job as members of the board to protect us and to represent us? Keep the laws in place that protect us!

I used to think of Peters Township as having all the same advantages of Upper St. Clair (beautiful neighborhoods, excellent schools, attractive nature trails, parks, convenient shopping, etc.) without the higher Allegheny County taxes! That's why we moved here. A crematorium business will ruin all of it! With toxic mercury vapors that are proven to pass into the blood brain barrier and cause life threatening illnesses, no one will want to come anywhere near a crematorium - let alone to eat, work, play, shop and live in Peters Township, a crematorium friendly neighborhood.

Obviously, other townships (like Upper St. Clair, Bethel Park, and Mt. Lebanon) have found ways to stop crematoriums from coming into their towns. Why hasn't Peters Township proposed such rules and regulations on crematoriums like the other townships?

What courses of action have you taken to protect us since Ms. Belusko first approached you with her proposal for her crematorium? I understand this is not the first time she has tried to put a crematorium in our area so you must have had time to plan for responsible course of action on our behalf. What steps have you taken?

Have you considered hiring an independent firm to conduct studies on the economical and environmental impact of a crematorium on a community such as Peters?

I assume that our taxpayer dollars over the years have been reserved for such a time as this: should the township be

sued I assume we have reserves and legal protection in place to combat this situation head on.

Many other crematory companies are watching and waiting to see what happens at the upcoming March meetings. If Belusko is allowed to build her crematory business in Peters Township, then other crematory businesses will also come – emitting more toxic mercury vapors into the air and decreasing further the beauty and desirability of Peters Township as a whole.

Please do your jobs to represent our interests and protect our community from harmful mercury vapors and decreasing home values as a result of the proposed crematorium.

Thank you so very much.

Sincerely,

Susan J. Ambrosini
234 Molly Drive
McMurray, PA 15317

post-gazette.com Pittsburgh Post-Gazette LOCAL / REGION

Feds propose first controls on mercury emissions

Wednesday, March 16, 2011
By Don Hopey, Pittsburgh Post-Gazette

The U.S. Environmental Protection Agency has proposed the first-ever national controls on mercury and other air pollution toxics from power plants. The health-based regulations are expected to prevent as many as 17,000 premature deaths and 11,000 heart attacks a year.

The standards, announced Wednesday in response to a court deadline, are designed to reduce emissions of mercury -- a potent neurotoxin -- arsenic, chromium, lead, nickel and acid gases from power plants by 91 percent, while providing the utility industry four years to comply.

There are now no national standards for mercury emissions and acid gases, half of which come from power plants. There are 17 states with mercury controls but Pennsylvania is not among them.

Two Pennsylvania coal-fired power plants, the Keystone power plant in Armstrong County and the Conemaugh power plant in Indiana County, are listed among the top 25 mercury emitters in the U.S., according to a report released today by the Environmental Defense Fund.

"Today's announcement is 20 years in the making, and is a significant milestone in the Clean Air Act's already unprecedented record of ensuring our children are protected from the damaging effects of toxic air pollution," said EPA Administrator Lisa Jackson at a news conference in Washington, D.C. "With the help of existing technologies, we will be able to take reasonable steps that will provide dramatic protections to our children and loved ones, preventing premature deaths, heart attacks, and asthma attacks."

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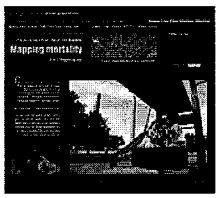

- A PG multimedia display tells the human side of the effects of air pollution
- PG interactive maps show disease rates and major pollution sources

» See an index to the series

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The proposed rule is open for public comment. A final rule is expected in November.

Coal-fired power plants are responsible for 99 percent of mercury emissions from the electric power industry. The toxic pollutants are known to cause neurological damage, according to the EPA, including lower IQ in children. The pollutants also cause environmental damage to rivers, lakes and streams and the fish that live in them. Many states, including Pennsylvania, have fish consumption advisories due to mercury pollution.

"This is historic. It would end the lethal loophole that permits coal-burning power plants to spew poisonous pollution into the air," said Frank O'Donnell, president of Clean Air Watch, an environmental organization focused on air quality. "Indeed, this is the single biggest step for public health protection that the EPA will take this year. Thousands of Americans will live longer and many millions will breathe easier as a result. Not only that, but fish will be safer to eat as toxic mercury is reduced from water bodies."

The EPA estimates that the proposed rule's public health and economic benefits, including the creation of an estimated 31,000 short-term construction jobs and 9,000 long-term maintenance and operational jobs, will greatly exceed the costs of implementation. Every dollar spent to install pollution controls will produce public health and economic business benefits of up to $13 dollars. That could total as much as $140 billion annually.

Ms. Jackson said the installation of toxics pollution controls at the 44 percent of the nation's coal-fired power plants that have no controls could lead to utility bill increases of from $3 to $4 a month for consumers. It might also cause utilities to close some of the nation's oldest and biggest polluting power plants and invest in new power plant construction instead.

More details in tomorrow's Pittsburgh Post-Gazette.

Don Hopey: dhopey@post-gazette.com or 412-263-1983.

First published on March 16, 2011 at 11:43 am

Zuk, Edward J.

From: Kimberly Brenneman [kbrenneman83@gmail.com]
Sent: Saturday, March 05, 2011 8:39 PM
To: Zuk, Edward J.
Subject: Crematory at 3287 Washington Rd.

Mr. Zuk,

I am deeply concerned about the request by Audia Group Investments LLC for a Special Exception on a "Use Not Provided For" for a funeral home with crematory at 3287 Washington Rd. With all the documented evidence of the emanate danger to the children of Peters Township with an active crematory, I am adamantly against this request being granted. I ask that you vote against this request at March 10th meeting.

Our young family will move away from Peters Township immediately, if this request is granted. My children's health and safety is too important to me to stay here with an active crematory.

Sincerely,

Kimberly Brenneman

105 Julrich Dr.

McMurray, PA 15317

March 4, 2011

Planning Commission Members:

Thank you for this opportunity to share my beliefs on the proposed changes to accommodate a crematorium facility at the old Lazy Boy store location. By now you will have undoubtedly heard from impassioned residents opposed to the idea of granting this request. I simply ask that you fulfill your fiduciary duty and act in the best interest of this community and represent us in a fair manner. It is my belief that a decision to make an accommodation for such a facility will have negative health consequence on the local residents, decrease the home values in the surrounding areas, and tarnish your hardworking legacy that you have worked to achieve during your tenure on the council.

With respect to health concerns, there is documented proof that airborne mercury poses a health hazard to those it comes in contact with. The breaking of a single energy efficient light bulb in your home is actually harmful if not disposed of in a proper manner due to its contained mercury. The proponents of this facility will argue that there is no definitive proof that the mercury emissions spewed from a crematorium has been linked to negative health consequences. This reminds me of the cigarette industry claiming over 40 years ago that there is no link between smoking and cancer. Sadly, that false assumption cost countless lives and tarnished an entire industry. It is murky at best to suggest there is no link between crematorium emissions and health hazards. Given that this is an unregulated industry we have no assurance that even basic health considerations will be made for safety. A well respected crematorium operator testified at the last hearing meeting that if power is cut off from the burner, an incinerated body continues to burn for several hours even without air filtration. A committee member of this council has been quoted as saying that putting a crematorium at the proposed location is no different that granting an accommodation for a Burger King restaurant. That statement is both misguided and negligent. Restaurants have health and safety codes to be adhered to and in most cases accommodations have not been made to re-zone for such construction. I put as much solace in that statement of comparison as I do if a man in a dark suit came to my front door and said, "I'm from the government, and I'm here to help." A strict air quality permit to construct (PTC) should be created and enforced in this township to maintain the health of the environment for the residences.

for such a request. I ask that you employ common sense, fairness, and yes, bravery in your decision process. Every decision this council makes should be made under the guise of preserving the integrity of Peters Township. Will you honor that code, or will your legacy be one of ashes?

Thank you for your time and consideration.

Respectfully,

Rob Ambrosini
234 Molly Drive
McMurray, PA 15317