Metal Concentrations in Leachate from Residential Burn Barrel Ash, Crawford County, Pennsylvania



By
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Submitted in fulfillment of the senior thesis requirements of the Department of Environmental Science at Allegheny College and approved by the senior thesis committee.

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Dr. Rachel O'Brien	**Date**	**Dr. Caryl Waggett**	**Date**

Pledge

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An estimated 28% of US rural residences burn their own waste, though few studies have assessed potential impacts and most have focused on air emissions. Burn barrel ash (BBA) samples from residences across Crawford County were run through a modified Synthetic Precipitation Leaching Procedure (SPLP). Leachate was analyzed for metals using a flame atomic absorption spectrometer (flame AAS). Mean leachate metal concentrations were higher for residences that burn mixed waste (MX) versus paper/cardboard (PC) with the exception of chromium, which was below the method detection limit (MDL) for all sites. Strontium was detected in leachate from every MX site ($x = 1.26$ mg/L) and PC site ($x = 0.22$ mg/L). The mean detected zinc concentration was 0.13 mg/L and 0.023 mg/L for MX and PC sites respectively. Manganese and copper concentrations were below MDL at all PC sites and for all but one manganese ($x = 0.11$ mg/L) and one copper ($x = 0.037$ mg/L) MX site. Only manganese concentrations from one site were above federal drinking water standards while none of the leachates had metal concentrations that exceeded hazardous waste threshold. Metal concentrations in the leachate suggest that BBA leachate is not of the same concern as leachate from other waste materials. Groundwater contamination is unlikely because concentrations are low and various geochemical processes limit the downward transport of metals through the soil profile. However, land and organism contamination might be of concern, and air emissions from backyard burning are a known hazard. Future studies should increase the sample size and analyze more metals in both the ash and leachate.

INTRODUCTION

Since the establishment of the Resource Conservation and Recovery Act (RCRA) of 1976, which regulates wastes from cradle to grave in the United States, traditional disposal and recycling methods for municipal solid waste (MSW) have been subject to stringent regulations and oversight. Sanitary landfills now require siting considerations, including distance from airports, wetlands, and floodplains. Also required are construction regulations including liners and leachate collection systems as well as closure requirements (Federal Register, 1991). Similarly, through the 1990 Clean Air Act (CAA) Amendments, large (>250 tons per day) municipal solid waste incinerators (MSWIs) are required to control emissions of particulate matter, sulfur dioxide (SO_2), nitrogen oxides (NOx), mercury (Hg), lead (Pb), cadmium (Cd), and dioxins/furans (Federal Register, 2006).

Conversely, increased waste management regulation has also increased waste disposal costs, resulting in an increase in the practice of backyard burning (Lighthall & Kopecky, 2000). An estimated 28% of US rural residences burn their own waste, yet there are no federal regulations prohibiting and/or regulating this practice (USEPA, 2005). At the Commonwealth level, the practice is minimally regulated. The Pennsylvania Department of Environmental Protection (PA DEP) (2013) allows for the open burning of residential waste (backyard burning) so long as the fire is on a property occupied by one or two families, and the waste is from "normal occupancy". However, the practice is banned in some regions including the Allegheny County, Erie County, and Monongahela Valley air basins (Wilt, 2007).

In the past, residential waste was predominantly comprised of food scraps, paper products, glass, ceramics, and metal. Today our waste stream includes a complex mixture of plastics, electronics, textiles, metals, treated wood, and other synthetic materials. Even paper products contain bleaches, inks, and stabilizers (PA DEP, 2013). Moreover, Pennsylvanians generate a lot of waste—2,740 pounds per capita per year (van Haaren *et al.*, 2010).

Few studies have been conducted to assess the impacts of backyard burning, and most have focused on air emissions. In test burns, an individual burn barrel emits 14 to 100 times more volatile organic compounds (VOCs) than a well-controlled MSWI (Table 1) (Lemieux, 1997). Dioxin-like compounds (hereafter referred to as dioxins) are among the most studied air

emissions from burn barrels. Dioxins are generally hydrophobic compounds that persist in the environment and bioaccumulate in fatty tissues (USEPA, 2013). They are highly toxic and carcinogenic in humans and have been shown to have endocrine, reproductive, and developmental effects in animals (Kogevinas, 2001). Included in this category are polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and 12 polychlorinated biphenyls (PCBs). Industrial point sources, such as MSWIs, medical waste incinerators (MWIs), and paper mills have been mandated to control dioxins through maximum achievable control technology (MACT) measures. As a result, these sources no longer contribute substantially to dioxin air emissions, while backyard burning—currently accounting for approximately 40% of emissions—has become the largest verified source of dioxins (USEPA, 2013).

Table 1: Estimated number of backyard burning residences required to equal air emissions (mg/day) from a well controlled 200 ton per day MSWI. The avid recycling residence aggressively recycles waste, while the non-recycling residence burns all generated waste. A 200 ton per day MSWI can handle the amount of waste generated by 121,000 avid recycling and 37,000 non-recycling residences.

Pollutant	Avid Recycling Residence	Non-Recycling Residence
Volatile Organic Compounds (VOCs)[1]	0.07	0.01
Polychlorinated dibenzodioxins/furans (PCDDs/PCDFs)[2]	2.5	37
Polycyclic Aromatic Hydrocarbons (PAHs)[1]	83.8	9.31
Chlorobenzenes (CBs)[1]	140	100

Sources: [1]Lemieux, 1997; [2]Lemieux *et al.*, 2000.

The geochemical characteristics of residential burn barrel ash (hereafter referred to as BBA or ash) are not well known. In fact, data analysis of BBA appears in only two US government reports. Of those two studies, only one analyzed leaching of heavy metals from BBA (USEPA Region V, 1994). Metals leach from ash when a solution, often precipitation or groundwater, comes in contact with the solids. When BBA is left in the environment, metals and organics can leach out of the ash in high enough concentrations to be of concern.

Crawford County, with a population of 88,765 and population density of 88 people per sq. mi., is considered a rural county (Center for Rural Pennsylvania, n.d.; US Census Bureau, 2014). Approximately 37,000 (42%) of county residents receive water through community water

systems (CWS) including municipalities, trailer parks, and apartments while the rest rely on private domestic wells (CDC, 2014; EWG, 2009). Despite nearly three million residents using private wells, Pennsylvania is one of the only states without private drinking water well regulations (Swistock *et al.*, 2009). As a result, there are no requirements to have well water tested for safety, potentially exposing many people to unsafe levels of metals through drinking their water. Residents who have unsafe water could drink it for years before realizing that their health is in jeopardy.

Inasmuch as the 1994 USEPA Region V study determined heavy metal concentrations from only one sample, this study aims to better assess whether metals in BBA leachate are of concern. The study has wide ranging implications, since leachate determined to be hazardous could be a serious threat to ground and surface water quality as well as organisms. In this study, BBA samples were acquired from residents around Crawford County, run through a modified Synthetic Precipitation Leaching Procedure (SPLP), and resulting leachate was analyzed for metals using a flame atomic absorption spectrometer (flame AAS). If this study finds that metals are of concern, the issue might warrant follow up from regulators.

MATERIALS AND METHODS

Ash Samples and Personal Interviews

In order to acquire BBA samples, a letter of permission and a questionnaire were created and distributed to selected residents of Crawford County (Appendix A). Requests for sampling were sent to members of the Crawford County Master Gardeners, to employees of the City of Meadville, Allegheny College, and a local company, and to personal friends. Letters of permission and questionnaires were distributed to approximately 80 employees at the local company, though not one employee gave permission. Requests made to the other organizations were done using email and other online means, and individuals printed out the materials if interested in participating. Once letters of permission and questionnaires were filled out, individuals were contacted to arrange an appropriate time for sampling. BBA sampling locations are shown in Figure 1.

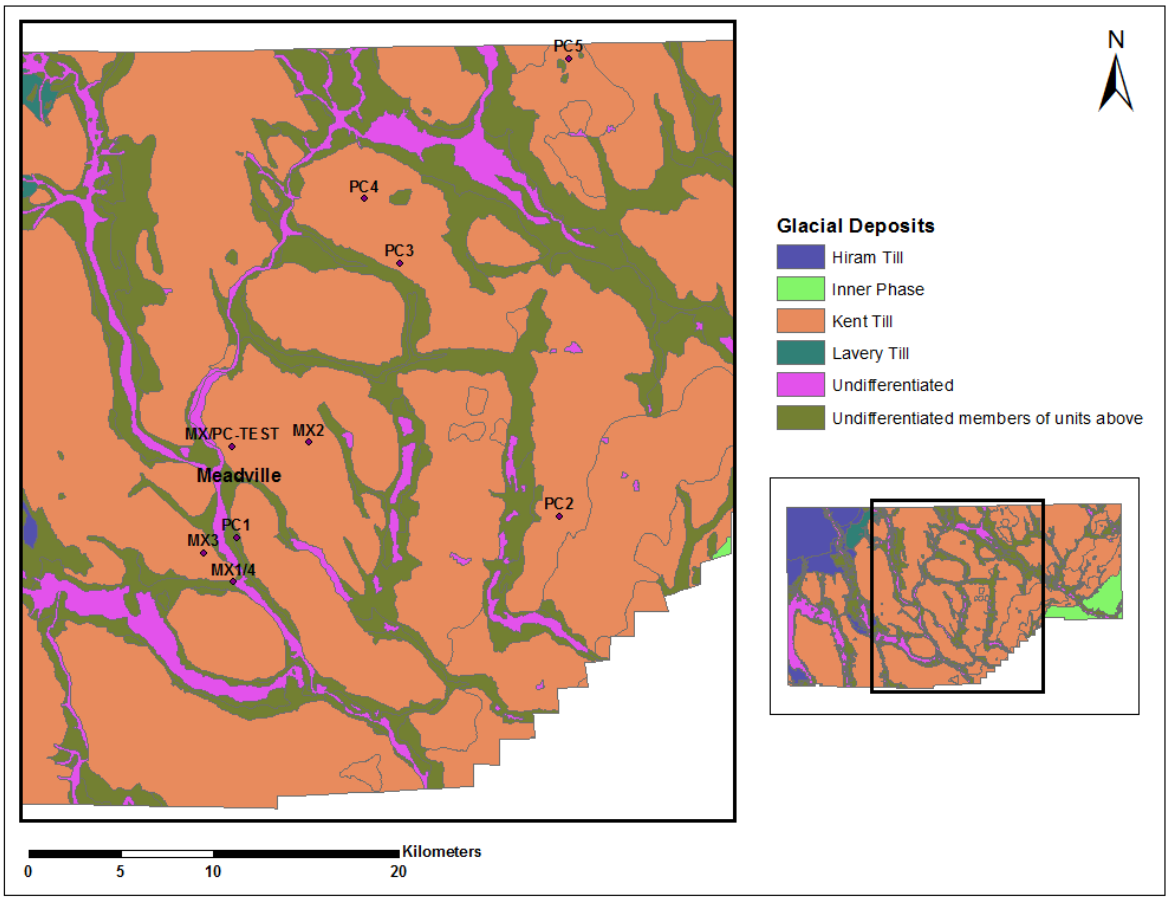

Figure 1: Map of Crawford County showing backyard burning sites where ash was collected. PC = residences that predominantly burn paper/cardboard while MX = residences that burn trash (mixed waste). Both simulated test burns (MX/PC-TEST) were conducted at Robertson Athletic Complex, owned by Allegheny College. BBA samples MX1 and MX4 were taken from the same location but two months apart. Surficial glacial geology is from Shepps *et al.* (1959).

Once on site, ash in the respective burn vessel was homogenized using a plastic trowel. Composite samples were taken using simple random sampling of the homogenized surface material as per the 2002 USEPA RCRA Waste Sampling Draft Technical Guidance. Two 1 L glass jars were labeled with a unique code and filled with ash. Care was taken to avoid objects larger than 95 mm in diameter, since they would require size reduction during the leaching test (USEPA, 1994). BBA was visually inspected for discrepancies between the materials list in the questionnaires filled out by the homeowner and materials that were observed in the ash at the

time of collection. Materials observed in the ash that were not noted by homeowners on the questionnaires were added and highlighted yellow in Appendix B.

After samples were collected, residents were interviewed in person or over phone to supplement the questionnaire. Questions asked related to motivations for backyard burning, other methods of waste management, and availability of curbside pickup. A summary of interview data is in Appendix B.

Simulated Burn

Since this study involved collecting ash from around the county, a simulated burn was also performed to compare metal concentrations in the test burn ash leachate to leachate from the collected BBA. Bags of waste were acquired from dumpsters and trash bins on and off campus. Trash was then sorted based on material type (Figure 2) and weighed with a mechanical utility scale. Two burn piles were made, simulating the mixed waste stream (MX) of a residence that does not recycle, and therefore burns most of their waste, and a residence that burns primarily paper and cardboard (PC) (Table 2). The MX stream test burn pile weighed a total of 30 lbs. while the PC only stream was 20 lbs.

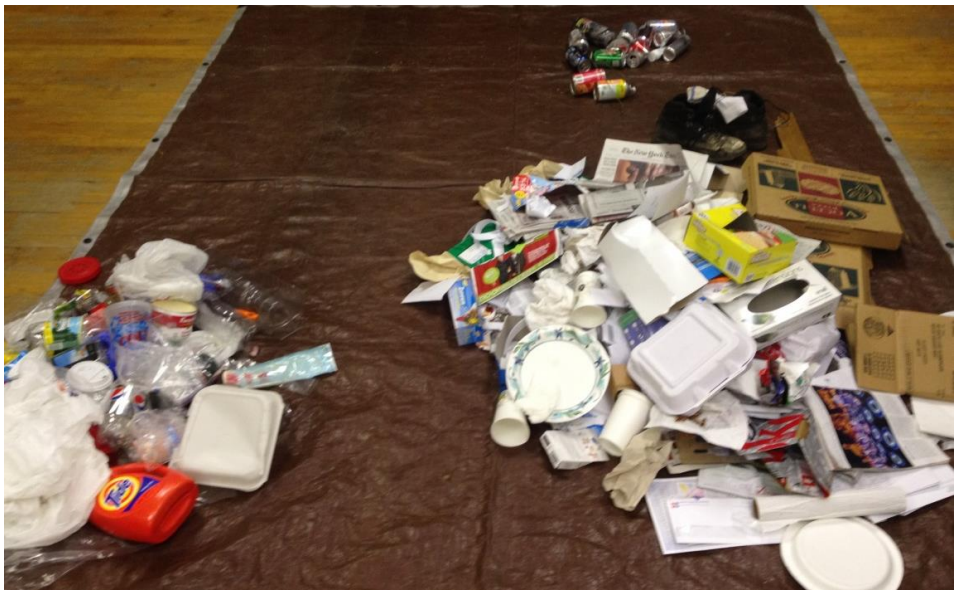

Figure 2: Sorted waste ready to be weighed for the test burn. Pile on the left is plastics 1-7; right foreground to background: paper/cardboard, textiles, steel, and aluminum.

The typical waste stream of the non-recycling residence was modified from Lemieux (1997), removing food waste—which is generally not combusted—and glass due to its inert nature. A breakdown of the two waste streams appears in Table 2.

Table 2: Composition of waste burned in the MX trial. The PC trial consisted of 100% paper/cardboard and was therefore not included in this table. Composition of burn waste modified from Lemieux (1997).

Material	% of MX Stream	Weight (lbs.)
Paper/Cardboard	73.3	22
Plastics 1-7	9.0	2.7
Textiles/Leather	4.4	1.3
Wood	1.3	0.4
Steel*	8.7	2.6
Other Non-Ferrous Metal**	1.3	0.4
Aluminum	2.0	0.6
Total	100	30

***Includes steel cans, hangers, and tubular steel from a lawn chair.**
****Includes copper wire.**

Two burn barrels of equal size were used for the test burn, which was performed at Robertson Athletic Complex, owned by Allegheny College. Both barrels were lit with a match, and were fed waste as space allowed and stirred to allow for a more uniform combustion. The PC trial burned for 53 minutes before smoldering, while the MX trial burned for 98 minutes, nearly twice as long, before smoldering. Barrels smoldered for an hour before BBA samples were taken following the same protocol as samples from the residential burn barrels.

Synthetic Precipitation Leaching Procedure (SPLP)

A modified version of the standard USEPA SW-846 Method 1312 (SPLP) was used to determine the leachability of wastes left *in situ*. SPLP was chosen instead of the more widely used Toxicity Characteristic Leaching Procedure (TCLP), which simulates waste leaching in a landfill and is used to determine hazardous waste for regulatory purposes (Kosson *et al.*, 2009). Standard SPLP calls for an acid rain solution of pH 4.2 to be made from 60% sulfuric acid (H_2SO_4) and 40% nitric acid (HNO_3), mimicking byproducts of SO_2 and NOx. However, acid rain in Crawford

County is closer to a pH of 4.7 (Figure 3). In lieu of creating synthetic precipitation, snow was collected in five gallon buckets, melted, and filtered through a coffee filter. The pH of the melted snow was measured at 4.7 (Table 3).

Table 3: Selected differences and similarities between the standard USEPA SW-846 Method 1312 (SPLP) and the modified SPLP used in this study.

Criteria	Standard SPLP	Modified SPLP (This Study)
pH of acid rain solution	4.2 for locations east of Mississippi River	4.7
Acid rain solution	Reagent water with 60/40 by weight mixture of H_2SO_4/HNO_3	Acid snow melt
Particle size reduction	When over 9.5 mm diameter	Particles larger than 9.5 mm removed
Liquid/solid ratio	20:1 acid rain to ash ratio	20:1 acid rain to ash ratio
Shaker	End-over-end shaker	Eberbach Corporation reciprocating shaker
Shaking time	18 ± 2 hours	18 ± 2 hours
Filter	0.6-0.8 µm glass filter	Whatman GF/F 0.7 µm glass filter
Preservation	Yes (with HNO_3 to pH <2)	No (Analyzed within 60 days)

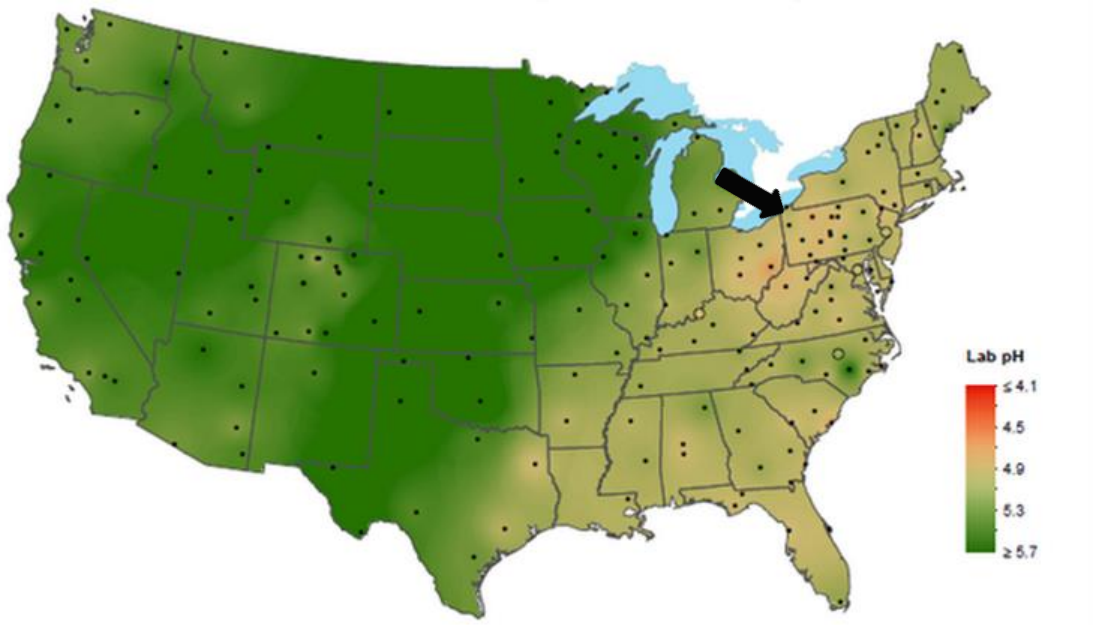

Figure 3: Precipitation pH across the contiguous US in 2012 (National Atmospheric Deposition Program). The black arrow points to the approximate location of Crawford County, Pennsylvania.

Thirty-seven percent concentrated hydrochloric acid (HCl) was diluted with deionized water (DIW) under a fume hood to make a 10% v/v concentrated HCl solution for acid washing. All lab equipment that came in contact with ash or leachate was acid washed and triple rinsed with distilled deionized water (DDIW).

The contents of the two 1 L glass jars from each site were combined in a small HDPE pail. Contents were homogenized using the plastic trowel for two minutes, or until the sample appeared homogeneous. This process was performed under a fume hood to control dust and odors. Three composite replicates were taken from the surface. Visibly dry BBA was weighed to 37.5 g, while visibly wet BBA was mixed with the plastic trowel and weighed. The wet ash was then poured into a filtration funnel and filtered through a Whatman GF/F 0.7 µm pore diameter borosilicate glass microfiber filter and into a filtration flask using a Fisher Scientific Maxima C Plus M2C vacuum pump, until no moisture was visible. The replicate was reweighed, and the difference in weight determined the amount of additional ash needed. Weighed ash was placed in a 1 L narrow mouth HDPE Nalgene bottle with 750 mL of precipitation solution.

Twelve bottles at a time were mixed vertically using an Eberbach Corporation reciprocating shaker on high speed for 18 ± 2 hours. After 18 hours, 250 mL of the leachate was poured into a filtration funnel and filtered through a 0.7 µm glass filter into a filtration flask using a vacuum pump. Filtered leachate was swirled in the flask and poured into 50 mL replicate. These vials contained the final leachate samples to be analyzed via flame AAS. The procedure was run with a method blank to control for the potential of laboratory equipment contributing to metal concentrations in the leachate. In addition, sample pH was determined (Appendix D).

Flame Atomic Absorption Spectrometry (Flame AAS)

To analyze metal concentrations in samples of leachate, WinLab32 for AA Version 6.4.0.019 was used to operate the Perkin-Elmer AAnalyst 700 atomic absorption spectrometer, located in Steffee Hall of Life Sciences, Allegheny College.

Basic Principals

Flame AAS works by aspirating aliquots of a solution into the flame (Perkin-Elmer, 1996). The solution is first nebulized (turned into an aerosol), dehydrated, solidified, melted into a liquid, and then vaporized under the heat of the flame, into a gas. The ionic forms of the element in solution are thereby atomized into a neutral, gaseous species. The gaseous atoms absorb energy from the flame and are excited. As the atoms lose the energy, they emit light (Figure 4). An element specific lamp is used to determine concentrations of metals by beaming light through the flame. Only some of the incident light is transmitted through the sample (Kegley & Andrews, 1998). The amount of light that reaches the detector (measured as absorbance) is directly proportional to concentration by Beer's Law:

$$\mathbf{A = \varepsilon bc}$$

Where A is absorbance, b is the path length of light through the sample, c is the concentration of the metal of interest in the solution, and ε is an experimentally determined constant that is specific for a particular substance (Kegley & Andrews, 1998).

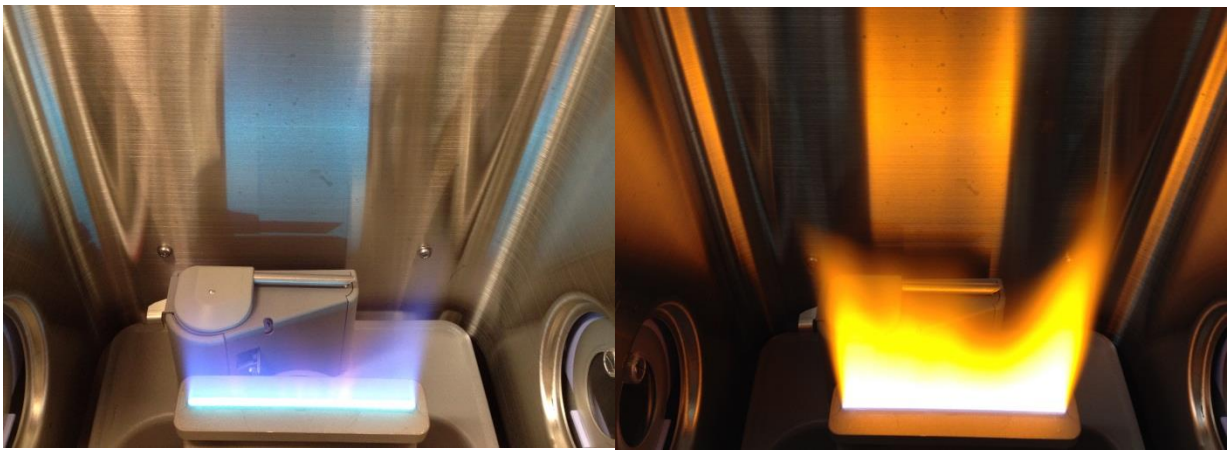

Figure 4: Air-acetylene flame aspirating DDIW (left) and a leachate sample analyzed for Mn (right).

Elements Analyzed and Flame AAS Calibration

A total of 33 replicates (representing 11 sites), a method blank, and an instrument blank of DDIW were analyzed for six elements—strontium (Sr), zinc (Zn), manganese (Mn), copper (Cu), lead (Pb), and chromium (Cr). Barium (Ba) was ultimately not analyzed due to issues with the flame AAS, using both the nitrous-acetylene and air-acetylene flames. Some elements, such as Sr, require a matrix modifier to reduce interference or enhance detection (Table 4). Absorbance is measured in absorbance units (AU), so the flame AAS must be calibrated to convert AU it into meaningful concentration units (mg/L). Calibration standards of known concentrations were made for each element using precipitation solution and plotted against AU (Appendix C). The calibration standards were made based on the flame AAS detection limit, the recommended optimum concentration ranges, measured concentrations of metals in municipal solid waste incinerator bottom ash (MSWIBA) leachate, and metal concentrations in leachate from a trial run (Table 4). Sr was calibrated using a one-point calibration curve as recommended by Perkin-Elmer (1996, p. 19).

Table 4: Calibration standards by element based on method detection limit (MDL) and optimum concentration.

Element	Flame AAS Detection Limit[1] (mg/L)	Optimum Concentration[2] (mg/L)	Calibration Standards (mg/L)	Matrix Modifier	Calibration Curve Type[5]
Strontium (Sr)	0.03	0.3-5	4	0.5% (w/v) KCl solution[3]	Linear through zero
Zinc (Zn)	0.005	0.05-2	0.1, 3, 10	N/A	Non-linear through zero
Manganese (Mn)	0.01	0.1-10	0.05, 0.1, 0.5	N/A	Non-linear through zero
Lead (Pb)	0.1	1-20	0.2, 0.5, 1	N/A	Non-linear through zero
Copper (Cu)	0.02	0.2-10	0.05, 0.1, 1	N/A	Non-linear through zero
Chromium (Cr)	0.05	0.2-10	0.1, 0.3, 0.5	0.5 mL H_2O_2 per 50 mL[4]	Non-linear through zero

Sources: [1]Table 1 in USEPA, 2007; [2]Table 3111:I in APHA, 1992; [3]Perkin-Elmer, 1996, p. 67; [4]APHA, 1992, p. 155; [5]Appendix C.

REGULATIONS ON BACKYARD BURNING

Research on burning regulations was collected at the federal, Commonwealth, county, and municipal levels. A state-by-state map of backyard burning regulations (Figure 5) was created in ArcGIS 10.1 using data researched through USEPA (2014), Combustion Portal (n.d.), and Google.

Crawford County

There are no federal regulations restricting backyard burning (USEPA, 2005), and Pennsylvania allows the practice, so long as the fire is on a property occupied by one or two families and the waste is from normal occupancy (PA DEP, 2013). Although the PA DEP allows counties and municipalities to pass ordinances tougher than their own, Crawford County does not regulate backyard burning. Additionally, townships within the county do not regulate the practice.

The City of Meadville, however, prohibits backyard burning of trash. Meadville's Ordinance states that "all solid wastes generated by or accumulated at a residence in the City of Meadville shall be collected by the city contractor for disposal in accordance with the city contract" (Meadville City Code § 931.02a) and that it is prohibited "to dispose of solid waste refuse and recyclables except in conformity with the regulations of this article" (Meadville City Code § 931.10b) (Appendix G). Burning of leaves is allowed so long as the burn occurs between noon and 6:00 pm, the leaves are dry, and they are not burned in the street (Meadville City Code § 302.14) (Appendix G).

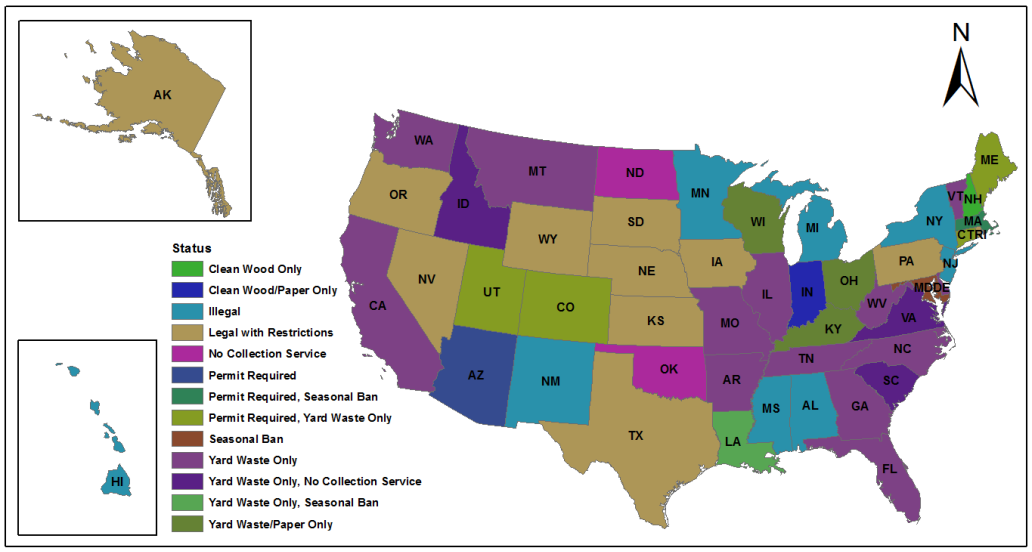

Figure 5: Backyard burning laws by state. Neither the CAA nor RCRA prohibits backyard burning of most wastes. State governments are left to regulate the practice, leaving a patchwork of state and local laws. See Appendix E for links to regulations and fact sheets used to generate the map.

Across the US

Since regulation of backyard burning is left to the state governments, every state has a different set of nuanced regulations (Figure 5). Only eight states make residential backyard burning of household waste illegal. Eleven states allow the practice of mixed waste burning, though all of those states restrict it in some way. Restrictions include bans on burn barrels or burn piles, restrictions on materials, prohibition of accelerants, and bans on black smoke. Twenty-six states allow only the burning of yard waste, clean wood, and/or paper. Five states grant people who do not have access to curbside waste pick up permission to burn, while six require permits in order to burn waste (Appendix E).

RESULTS AND DISCUSSION

Backyard Burning Questionnaire/Interview

Out of the eight residences sampled, five used a 55 gallon steel barrel to dispose of their trash. Only one residence used an accelerant to start the fire—the rest used newspaper/paper or just

matches. Plastic film/bags were found or reported at every burn site, even in barrels from residences that claimed to burn only paper/cardboard (PC). Although the quantity of these materials were far less in barrels PC residences, it is possible that these materials increased metal loading in the ash.

All eight respondents stated that BBA was disposed of in an uncontrolled manner—meaning that the ash and its potentially hazardous constituents were left exposed—as opposed to disposal in the trash. This includes two that disposed of BBA in a pile, two in the woods/over a hill, one that let it stay in place, one that buried it, one that tilled it into the garden, and one that spread it in the yard. Only residents at MX2 noted that BBA from the combustion of potentially toxic waste—such as construction and demolition debris, tires, furniture, and pretreated wood—was disposed of in the trash. Ash from regular household waste was still placed in a pile next to the compost heap. In addition, BBA from the test burns were disposed of by Allegheny College's Physical Plant at their compost yard. In a USEPA Region V (1994) study, residences in Illinois were phone-surveyed with the result that an estimated 35% of respondents set ash out for disposal in a landfill. The other 65% managed ash through uncontrolled methods—dumping (36%), tilling in garden or yard (12%), burying (9%), or placing it in a pile (8%).

Those who burn their own waste have various motivations. Convenience was the number one motivation for 50% of residences, followed by habit (15%), avoided cost (12%), lack of collection service (10%), saving landfill space (8%), other reasons (4%), and privacy (1%) (USEPA Region V, 1994). Despite convenience and habit being the two most common motivations, no one surveyed in this study mentioned these as reasons for burning. That being said, it is reasonable to assume that those factors might contribute to the continuing practice of backyard burning amongst the eight surveyed residences.

Avoidance of waste collection costs can be an especially strong motivating factor in isolated rural areas where waste collection—if it is offered— is usually more expensive than in cities. Moreover, many cities integrate waste costs into a utility bill or property taxes (USEPA Region V, 1994). Compared to the aforementioned study, where 12% of residences burned in order to avoid costs, four of the eight residences in this study (50%) were motivated by cost. Some

residences who utilize curbside trash pickup still chose to burn as well. Four respondents were motivated by environmental reasons, with three of them burning in the name of landfill avoidance. The respondents seem to be motivated by the perception that burning waste is more resourceful than hauling it off to a landfill, where much of it will never decompose.

All of the residences also use alternative, environmentally preferred, methods of waste management including composting, recycling, waste reuse/reduction, and donating old belongings. While mandatory curbside waste pickup would lead to a safer way of managing MSW, it would probably lessen the incentive to reduce and reuse waste. An evident theme amongst the residences was that since they could not just throw all of their waste in a trash bin, they had to find other means for disposal and repurposing. See Appendix B for a summary table of responses from all of the residences.

Metals in Ash and Leachate

This study did not look at total metal content in the ash prior to leaching. However, two other studies analyzed metals in the ash. Compared to soils in the Eastern US, ash in Lemieux (1997) had far higher concentrations of Zn and Cu, while Mango (2014) found that Sr, Zn, Cu, and Cr concentrations exceeded the upper range for metals in soil (Table 5). Additionally, burning waste can elevate metal concentrations in soils near burning locations (Mango, 2014).

Table 5: Concentration of metals in ash as compared to metal concentrations in Eastern US soils.

Metal	Burn Barrel Ash[1]	Burn Pile Ash[2]	Eastern US Soils[3]
Sr	102-117	<0.5-1,280	<5-700
Zn	721-11,500	84-12,500	<5-2,900
Mn	152-541	1.68-2,170	<2-7,000
Cu	343-4,910	16-<10,000	<1-700
Cr	92-300	54-1,230	1-1,000

Sources: [1]Lemieux, 1997; [2]Mango, 2014; [3]Shacklette & Boerngen, 1984, p. 6.

BBA leachate from residences that burned mixed waste contained more detectible metal concentrations as well as higher mean concentration values (Figure 6). All metal concentrations were below Toxicity Characteristic (TC) levels—used for hazardous waste designation—as well as USEPA drinking water standards, with the exception of Mn, which exceeded the National Secondary Drinking Water Standard (NSDWS) of 0.05 mg/L (TCEQ, n.d.; USEPA, 2006). Mn was detected at one site, MX2, in all three replicates with a mean detection of 0.11 mg/L (Appendix D). Although Mn is an essential nutrient found in certain foods, it can cause brain damage at high concentrations (ATSDR, 2011). One possible source of Mn from MX2's waste could be fertilizers that were bound to some of the yard waste/woody debris. Very few of the sources of Mn (Table 8) match up with materials known or identified to have been burned at site MX2 (Appendix B).

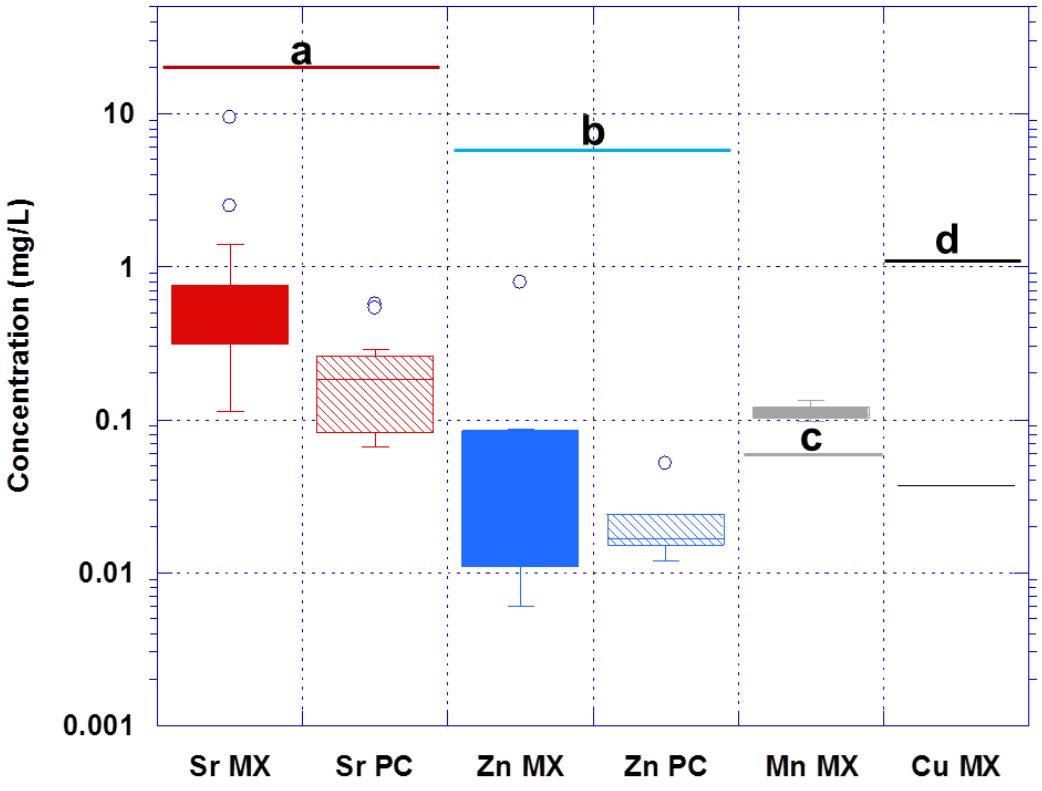

Figure 6: Box and whisker plot of detected concentrations of metals in BBA leachate plotted against USEPA drinking water standards. PC = paper and cardboard; MX = mixed. Mn and Cu concentrations were below the flame AAS detection limit for all PC replicates and Cr was not detected in any sample. Circles indicate anomalously large concentrations for replicate. a = Sr Drinking Water Equivalent Level (DWEL) of 20 mg/L; b = Zn National Secondary Drinking Water Standard (NSDWS) of 5 mg/L; c = Mn NSDWS of 0.05 mg/L; d = Cu Treatment Technique (TT) of 1.3 mg/L (USEPA, 2006). None of the detected metals have toxicity characteristic (TC) standards (TCEQ, n.d.).

Strontium was the only metal to be detected in every replicate (Tables 6 & 7). This indicates that Sr is likely a ubiquitous trace metal in plants—possibly originating from burned leaves, yard waste/woody debris, paper, and cardboard. The mean concentration for MX was 0.67 mg/L (σ = 0.63, range = 0.11-9.43 mg/L), while PC was 0.22 mg/L (σ = 0.17, range = 0.067-0.57) (Table 6). Concentrations were generally higher in MX than in PC replicates, though MX1 replicates had a mean of 4.44 mg/L, far higher than any other sample. Although the reasons are unknown, both the MX and PC test ash leachates contained concentrations of Zn, Mn, Cu, and Cr that were all below method detection limit (MDL). However, both test leachates had higher mean Sr concentrations than any other site in their categories with the exception of the excessively high levels of Sr in MX1. In addition to Sr, MX1 also had higher concentrations of Zn and Cu than any other site (Table 7).

Table 6: Concentration of metals in BBA leachate. Mean is calculated from all replicates with detected concentrations. Three replicates were taken from each of the 11 unique BBA samples, yielding a total of 33 analyses. <MDL = all replicates fell below the detection limit of the flame AAS for the analyzed metal.

	Mixed			Paper/Cardboard		
	$\bar{x}$	n	Range	$\bar{x}$	n	Range
Sr^{2+}	1.26	15	0.11-9.43	0.22	18	0.067-0.57
Zn^{2+}	0.13	8	<0.005-0.79	0.023	6	<0.005-0.052
Mn^{2+}	0.11	3	<0.01-0.097	<MDL	0	<0.01
Cu^{2+}	0.037	1	<0.02-0.037	<MDL	0	<0.02
Cr^{3+}	<MDL	0	<0.05	<MDL	0	<0.05

Table 7: Detected metal concentrations in BBA leachate, averaged by sample site. Standard deviation (σ) and percent relative standard deviation (%RSD) included for all metals with more than one replicate with detectable concentrations.

	Sr			Zn			Mn			Cu	Cr
	x̄	σ	%RSD	x̄	σ	%RSD	x̄	σ	%RSD	x̄	x̄
MX1	4.44	4.36	98.3	0.40	0.55	137.6	<0.01	N/A	N/A	0.037	<0.05
MX2	0.67	0.05	8.0	0.072	0.02	31.5	0.11	0.02	17.4	<0.02	<0.05
MX3	0.12	0.01	7.6	0.008	0.00	28.3	<0.01	N/A	N/A	<0.02	<0.05
MX4	0.32	0.01	3.9	0.022	0.00	9.9	<0.01	N/A	N/A	<0.02	<0.05
MX-TEST	0.74	0.02	3.0	<0.005	N/A	N/A	<0.01	N/A	N/A	<0.02	<0.05
PC1	0.26	0.02	7.5	0.014	0.00	14.5	<0.01	N/A	N/A	<0.02	<0.05
PC2	0.16	0.00	1.1	<0.005	N/A	N/A	<0.01	N/A	N/A	<0.02	<0.05
PC3	0.21	0.00	2.4	0.031	0.02	59.7	<0.01	N/A	N/A	<0.02	<0.05
PC4	0.071	0.00	6.5	<0.005	N/A	N/A	<0.01	N/A	N/A	<0.02	<0.05
PC5	0.084	0.00	5.8	<0.005	N/A	N/A	<0.01	N/A	N/A	<0.02	<0.05
PC-TEST	0.55	0.02	3.9	<0.005	N/A	N/A	<0.01	N/A	N/A	<0.02	<0.05

Zinc concentrations ranged from <0.005-0.79 mg/L (mean = 0.13, σ = 0.27) for MX and <0.005-0.052 mg/L (mean = 0.023 mg/L, σ = 0.17) for PC (Table 6). Additionally, Zn was detected at four of the five MX sites, while only at two of the six PC sites (Table 7). Zn is one of the most widely used metals (USGS, 2013), which might explain its frequent detections in BBA leachate. Since it is found in many products in the MX stream, such as metals, batteries, rubber, paints, and plastics (Table 8), it is logical that the concentrations of Zn in this stream are higher than those from the PC stream BBA leachate. While Zn is another essential nutrient, excess exposure can affect the gastrointestinal, hematological, and respiratory systems (ATSDR, 2011). It is possible that wood preserved with Zn compounds might explain the relatively high Zn concentrations in the leachates from site MX2, where a sizeable amount of pretreated wood was observed in the burn barrel. The property owners were in the process of renovating their house, and they were disposing of the old wood in their burn barrel (Appendix D).

None of the PC replicates contained concentrations of Cu above the detection limit. Only one of the MX replicates, MX1-1, had measureable Cu concentrations—at 0.04mg/L (Table 7). Possible sources of Cu at MX1 include leather, plastics, yard waste/woody debris, electronics, and

batteries (Appendix B; Table 8). Along with many of the other metals, Cu is an essential element for humans, though too much exposure is harmful (ATSDR, 2011).

All leachates for both waste stream categories tested for Cr were below the flame AAS detection limit of 0.05 mg/L. Solo-Gabriele *et al.* (2002) leached chromated copper arsenate (CCA) treated wood ash using both SPLP and TCLP, and found that even in ash from as little as 5% CCA wood, the leachate sometimes exceeded TC thresholds, thereby characterizing it as hazardous waste. It was unexpected to find that Cr was never detected in the samples since treated wood was combusted in the MX test burn and was a large constituent of the waste at MX2 (Tables 6 & 7; Appendix B). Cr in the form of Cr (VI) (hexavalent chromium) is a known carcinogen, while Cr (III) (trivalent chromium) is critical for body processes (ATSDR, 2011).

Table 8: Possible sources of metals in MSW components. Information on Sr is lacking in the literature, despite its detection in every replicate.

Metal	Possible Sources in MSW	References
Sr	Ceramics, glass products, paint pigments, fluorescent lights, pyrotechnics, magnets, fiberglass, pharmaceuticals, zinc, and toothpaste.	ATSDR, 2011 USGS, 2013
Zn	Galvanized metal, surface treated wood, carbon-zinc, zinc-air, and alkaline batteries, paints, rubber, dyes, ointments, plastics, paper, fruit scraps, medicines, brass, bronze, diapers, garden waste, leather, plastic film, tape film, steel food cans, footwear, electric motors, and glass.	Krook *et al.*, 2006 ATSDR, 2011 Long *et al.*, 2011 USGS, 2013 Merrymon, 1993 Rigo & Chandler, 1994
Mn	Grains and cereals, animal feed, brick coloring, fertilizers, ferrous alloys, aluminum alloys (including aluminum cans), food cans, carbon-zinc, Ni-Cd, and alkaline batteries.	ATSDR, 2011 USGS, 2013 Rigo & Chandler, 1994
Cu	CCA wood, surface treated wood, leather and fabric treatments, piping, telecommunication and electrical wiring, electronics, plastics, paper, vegetables, fruit scraps, laminates, lawn and plants, electric motors, nonferrous cans, and alkaline batteries.	Solo-Gabriele *et al.*, 2002 Krook *et al.*, 2006 ATSDR, 2011 Long *et al.*, 2011 USGS, 2013 Rigo & Chandler, 1994
Cr	CCA wood, surface treated wood, plastics, chrome plating, dyes and pigments, leather, nonferrous alloys, stainless steel, steel cans, catalysts, paper, newspaper, housewares, textiles, footwear, and green glass.	Solo-Gabriele *et al.*, 2002 Krook *et al.*, 2006 ATSDR, 2011 USGS, 2013 Merrymon, 1993 Rigo & Chandler, 1994

Factors Influencing Leachability

Leaching values in this study and the USEPA Region V (1994) study suggest that leachability of metals in BBA is not of the same concern as MSWIBA. While MSWIs employ pollution controls, they also operate at far higher temperatures than burn barrels, resulting in more complete waste combustion (Lemieux *et al.*, 2000). The authors of the USEPA Region V (1994) hypothesize that it is the difference in temperatures that explains the far higher leaching values in MSWIBA than in BBA (Table 9). The fact that burn barrels leave a lot of partially combusted residuals likely means that metals in those materials are still bound to them and are not exposed to geochemical reactions in the way that ash is.

Table 9: Leaching values of mixed and paper/cardboard waste ashes from this study compared to metal concentrations in the leachate of other wastes.

		Study leachate (mg/L)		Leachate in literature (mg/L)								
		Mixed	Paper/ Cardboard	Burn barrel ash 1	MSWIBA 2-5	MSW landfill leachate 6	eWaste open burning 7	Medical waste incineration fly ash 8	Catch basin sediment 9	Stormwater pond sediment 9	Street sweepings 10	Coal fly ash 11
Metal	Sr	0.113-9.43	0.067-0.572	N/A	1.54-4.51	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Zn	<0.005-0.794	<0.005- 0.052	N/A	0.0054-91.72	0.03-1000	N/A	0.71-2.80	<0.054-0.624	<0.054-10.4	<0.054-2.69	N/A
	Mn	<0.01-0.097	<0.01	N/A	<0.004-12.62	0.03-1400	N/A	N/A	N/A	N/A	N/A	N/A
	Cu	<0.02-0.037	<0.02	N/A	<0.006-10.17	0.005-10	N/A	0.24-0.33	<0.069	<0.069	<0.069-0.190	N/A
	Cr	<0.05	<0.05	<0.040	0.0096-2.62	0.02-1.5	<0.01	0.07-0.14	<0.054-0.099	<0.054-0.093	<0.054-0.077	<0.0003-7.3

Sources: [1]USEPA Region V, 1994; [2]Feng *et al.*, 2007; [3]Hyks *et al.*, 2011; [4]Yu *et al.*, 2013; [5]Forteza *et al.*, 2004; [6]Kjeldsen *et al.*, 2002; [7]Gullett *et al.*, 2007; [8]Sukandar *et al.*, 2006; [9]Jang *et al.*, 2010; [10]Jang *et al.*, 2009; [11]Kosson *et al.*, 2009.

Strontium leaching values for this study had a larger range (0.11-9.43 mg/L) than either Feng *et al.* (2007) at 1.54-2.19 mg/L or Hyks *et al.* (2011) at 1.61-4.51 mg/L (Table 9). However, these concentration ranges are not orders of magnitude off from one another, and since there have been few studies to look at strontium, the detections in this study are plausible. Zn and Mn concentrations are far lower in BBA than in MSWIBA and MSW landfill leachate, while the mixed BBA leachate samples closely resemble catch basin sediment leachate Zn concentrations. Cr, which was not detected in any of the replicates, was generally detected—if detected at all—

in low concentrations in comparison leachates. Cu, while virtually undetected in the study, and often found in low concentrations in comparable studies, showed up in concentrations as high as 10.17 and 10 mg/L in MSWIBA and MSW landfill leachate respectively.

While SPLP is the standard procedure for evaluating the leachability of solid wastes left *in situ* and exposed to precipitation, it is also limited. It is empirical—in that results are presented simply as the contaminant concentrations leached when using the test—without accounting for the many dynamic factors in a real world environment (Kosson *et al.*, 2009). Many factors affect constituent leaching, including pH and quantity of rainfall, redox conditions, temperature, hydraulic conductivity, pH, ageing, particle size and weathering of the ash. (Kosson *et al.*, 2009; Wiles, 1996; Meima & Comans, 1999).

Ecosystem Contamination

Metals introduced into the environment through human activities—including the burning of waste—have a number of different fates. Some potential fates include being adsorbed or desorbed by soil particles, dissolved in or precipitated out of solution, taken up by plants, remaining in place, running off, or migrating through the soil profile (Sherene, 2010; McLean & Bledsoe, 1992). However, metals are typically retained at the soil surface and only minimally moved into the groundwater, surface waters, or the atmosphere as long as the soil retention capacity is not exceeded (McLean & Bledsoe, 1992). Alkaline waste leachates, including leachate from MSWIBA, tend to contain oxidized species. For example, Cr (VI) in leachate is oxidized from Cr (III) in the ash. However, alkaline wastes contain oxidizable compounds that buffer redox potential to low values. These include sulfides, ferrous and metallic Fe and Al, and non-combusted organic matter (Cornelis *et al.*, 2008). In areas with high water tables, reducing conditions are more common—an issue because oxidizing conditions tend to favor metal retention in soils, while reducing conditions lead to accelerated migration of metals (McLean & Bledsoe, 1992).

Particles typically involved in adsorption-desorption reactions include mineral particles, organic particles, and colloids—particles that are in the size range between true solutions and

suspensions (Eby, 2004, p. 343). Soil texture plays a large role in metal mobility. Clay sized particles adsorb higher concentrations of metals than sand sized particles (Sherene, 2010). Silicate minerals, also referred to as clays, contribute to metal adsorption—though to varying degrees. For instance, adsorption capacity for Zn^{2+} is especially high in sepolite and bentonite, but much lower in perlite (Sanchez *et al.*, 1999). In addition, pore structure of the soils and ash affects the rate of transport (Sherene, 2010). Organic matter (OM) is prevalent in burn barrels, which combust waste very incompletely, especially in comparison to a MSWI (USEPA Region V, 1994). OM plays a critical role in sorbing metals, thereby decreasing metal mobility and bioavailability. Soil and BBA pH determine leachability and mobility of metals, with neutral to slightly alkaline conditions resulting in lower metal mobility (Sherene, 2010).

Some metals, such as arsenic and chromium, can be a significant threat to groundwater. As (III) is more toxic than As (V) and is four to ten times as soluble. Cr (VI) is fairly mobile and has the unusual property of high mobility in alkaline environments. On the other hand, Pb and Zn tend to stay near the soil surface and are less of a threat to groundwater. Zn is also readily adsorbed by clay minerals, carbonates, or hydrous oxides (USEPA, 1992). In fact, Černík *et al.* (1995) found that soils near a brass foundry were contaminated with Zn only 20 cm into the soil profile. Without remediation, the center of mass of the Zn plume will take 300 years to migrate to a depth of 40 cm.

The Cussewago Sandstone is the most important bedrock unit in the area for drinking water because it generally has high yields and good water quality (Schiner & Gallaher, 1979). The extent of this formation is only mapped in Western Crawford County; four of the nine sites sampled in this study are on the map. Of those sites, only MX3 and the test site are underlain by the formation, and it is relatively thin. These sites have approximately 122 and 90 feet of overburden above the sandstone respectively, while the sandstone layer is approximately 15 and 14 feet thick at each site (Table 10). The overburden of around 100 feet is a significant buffer to adsorb and precipitate the metals out of the leachate.

Based on the leaching data from this study, groundwater contamination does not seem to be a realistic concern, especially given that most burn barrels are burning the waste from a single

household. However, land and organism contamination might be of concern. Plants take up metals, potentially bioaccumulating them in the food web. Humans and animals, including pets, could be exposed to potentially hazardous levels of metals based on data from Table 5.

Table 10: Surficial and bedrock geology of the backyard burn sites. Geology of the sites can have an impact on the transport and fate of certain metals. Shepps *et al.* (1959) did not map Eastern Crawford County, so there are no Cussewago Sandstone data for five of the nine sites.

Sample Site	Municipality	Site Elevation (ft. asl)	Soil Series[1]	Glacial Deposits[2]	Bedrock Geology[3]	Cussewago Sandstone Elevation (ft. asl)/ Thickness (ft.)[4]
MX1/4	Union Twp.	1072	Red Hook loam (Rh)	Undifferentiated members of units above	Berea Sandstone through Venango Formation, undivided	Not present
MX2	West Mead Twp.	1516	Frenchtown silt loam (FhA)	Kent Till	Shenango Formation	Not mapped
MX3	Union Twp.	1318	Cambridge silt loam (CaB)	Kent Till	Cuyahoga Group	1196/15
MX/PC-TEST*	City of Meadville	1335	Cambridge silt loam (CaC)	Kent Till	Cuyahoga Group	1245/14
PC1	West Mead Twp.	1117	Chenango gravely silt loam (CoB)	Undifferentiated members of units above	Berea Sandstone through Venango Formation, undivided	Not present
PC2	Randolph Twp.	1522	Cambridge silt loam (CaB)	Kent Till	Pottsville Formation	Not mapped
PC3	Woodcock Twp.	1448	Cambridge silt loam (CaC)	Kent Till	Cuyahoga Group	Not mapped
PC4	Cambridge Twp.	1386	Venango silt loam (VnB)	Kent Till	Berea Sandstone through Riceville Formation, undivided	Not mapped
PC5	Rockdale Twp.	1522	Venango silt loam (VnB)	Kent Till	Cuyahoga Group	Not mapped

Sources: [1]Yaworski *et al.*, 1979; [2]Shepps *et al.*, 1959; [3]Berg *et al.*, 1980; [4]Schiner & Gallaher, 1979.
***MX/PC-TEST geological information is based on "The Badlands" where Allegheny College Physical Plant dumped the ash. This site is behind Robertson Athletic Complex, where the test burns were conducted.**

Recommendations

Although metals in BBA leachate are not of concern, air emissions from backyard burning certainly are. Many organics are emitted at hazardous levels, and without a smokestack to adequately disperse and dilute pollution (Lemieux, 1997). One burn barrel emitting many times more VOCs than an incinerator is cause for serious concern (Table 1). As industrial sources of pollution continue to be more stringently regulated, far greater attention should be paid to confronting this in practice ubiquitous in rural America.

For Crawford County

The practice of backyard burning remains legal with minimal restrictions at both the Commonwealth and County level. While banning the practice across Crawford County is an option, it is likely that this would not influence people to change their habits. Many people who backyard burn have been doing so for generations, and some even feel that it is their "God-given right" to do so (USEPA Region V, 1994). Reducing the incidence of backyard burning in Crawford County will require a multi-tiered approach.

A crucial step in ensuring that people dispose of waste correctly is to ensure that the necessary infrastructure is in place. Some rural areas do not have collection service offered, or if they do, it is not mandatory. Ensuring that collection service for both trash and recycling is available and encouraging residents to use it, might decrease the prevalence of burning. Ensuring that each township has a cleanup day at least once a year (as noted in Appendix B) would reduce the amount of hazardous and bulky wastes burnt.

A set of best management practices (BMPs) in the form of a flyer or pamphlet should be sent out to all rural residents. The BMP guide should first educate residents about the dangers of backyard burning. It should also encourage alternatives such as reducing, reusing, recycling, grasscycling, and composting waste (PA DEP, 2013; Appendix B). The guide should explain that if residents do decide to burn, they should:

1) Pile the ash in one place to limit the extent of potential metal contamination as well as litter dispersion from unburnt plastic and inert wastes;
2) only combust dry wastes;
3) ensure that a draft is present to ensure more complete combustion; and
4) avoid burning electrical waste, PVC, shingles, pretreated wood, asbestos, tires, and any other materials that are toxic in nature and banned under PA DEP regulations (2013).

Future Work

The flame AAS struggled to detect trace concentrations of metals. Furthermore, this analytical method cannot differentiate between different oxidation states. These states can be the difference between an essential nutrient—Cr (III)—and a carcinogenic compound—Cr (VI) (Kosson *et al.*, 2006). Any detection of Cr would be expressed simply as total Cr.

Metals analyzed in leachate do not seem to be of concern. However, more research is needed. Future studies should significantly increase the sample size. Follow-ups should look at more metals and possibly organics in the ash, such as dioxins and semi-volatile organic compounds (SVOCs). Since the concentration of many metals was below the MDL in many instances, future work should be done with the graphite furnace mode of the AAS. Ash could also be analyzed for metal content and plotted against leached concentrations to determine the percentage of metals that leach into solution.

One of the biggest drawbacks of regulatory levels set by the USEPA for non-cancer causing substances is that many of the levels are based on high dose, single time exposure. However, humans are also exposed to potentially hazardous substances through chronic low dose exposure. Evidence is mounting that some compounds, especially endocrine disrupting chemicals, have effects at very low doses. This is challenging the traditional monotonic extrapolations for which regulatory levels have historically been derived (Vandenberg *et al.*, 2012). If drinking water standards were revamped to reflect chronic low dose exposure, the standards would likely have far lower concentrations than the current ones and more samples from this study might exceed these more stringent standards.

Another study should involve the partitioning of MSW by component as done in Long *et al.* (2011), Walsh *et al.* (1981), and Rigo & Chandler (1994) (Appendix F). While all three of these studies split MSW into different categories to determine possible sources of metals found in MSWI bottom and fly ash, none of the studies analyzed Sr. To determine natural sources of Sr, the study should split both paper products into multiple subcategories as done in Rigo & Chandler (1994) and yard waste as well. This will help isolate plant based sources of Sr.

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Appendix A—Letter of Permission and Questionnaire

To Whom It May Concern:

I am a student majoring in Environmental Science at Allegheny College, currently working on my senior thesis.

For my thesis, I will be mixing water with burn barrel ash and analyzing the water for heavy metals that might leach from the ash. I am curious to determine which metals leach from the ash and at what concentrations they occur.

My results will not be shared with the Pennsylvania Department of Environmental Protection or other regulatory agencies.

I am looking for households that are willing to allow me to sample the ash from their burn barrels. All information about participants will remain anonymous in my work.

Please feel free to contact me with any questions you might have about my study.

Thank you in advance for considering this request.

Ian Arturo

914-262-6457; arturoi@allegheny.edu

Yes, I am willing to participate in your study and possibly have my burn barrel sampled this fall.

Name(s): _____

Address: _____

Home Phone: _____Cell Phone:_____

Email: _____

Backyard Burning Questionnaire for Senior Comprehensive Project

How often do you backyard burn? _____

What vessel do you burn in?			**How do you start the fire?**	
Check applicable	**Vessel**		**Check all that apply**	**Method**
	55 gallon steel drum			Newspaper/paper
	42 gallon steel drum			Fire-starting block
	Burn pit			Gasoline
	Burn box			Kerosene
	Burn pile			Lighter fluid
	Outdoor boiler			Charcoal lighter
	Other_____			Other_____

What types of material do you burn?				
Check all that apply	**Materials**		**Check all that apply**	**Materials**
	Leaves			Paint cans
	Yard waste/ woody debris			Oils
	Treated wood			Paper/ paperboard
	Textiles/leather			Cardboard
	Tires			Glass
	Plastic bottles/containers			Aluminum cans
	Plastic film/bags			Other metals
	Vinyl			Food scraps
	Electronic waste (e-Waste)			Other_____
	Batteries			Other_____

How often do you empty the ash? _____

How is the ash disposed of?				
Check all that apply	**Method**		**Check all that apply**	**Method**
	In the woods/over a hill			Buried on property
	Used in garden			Put in trash
	Spread on lawn			Other_____

Name(s): _____

Address: _____

Date: _____

Note: Personal information is only for communication and will be separated from survey results.

Questions? Contact Ian Arturo at 914-262-6457 or arturoi@allegheny.edu

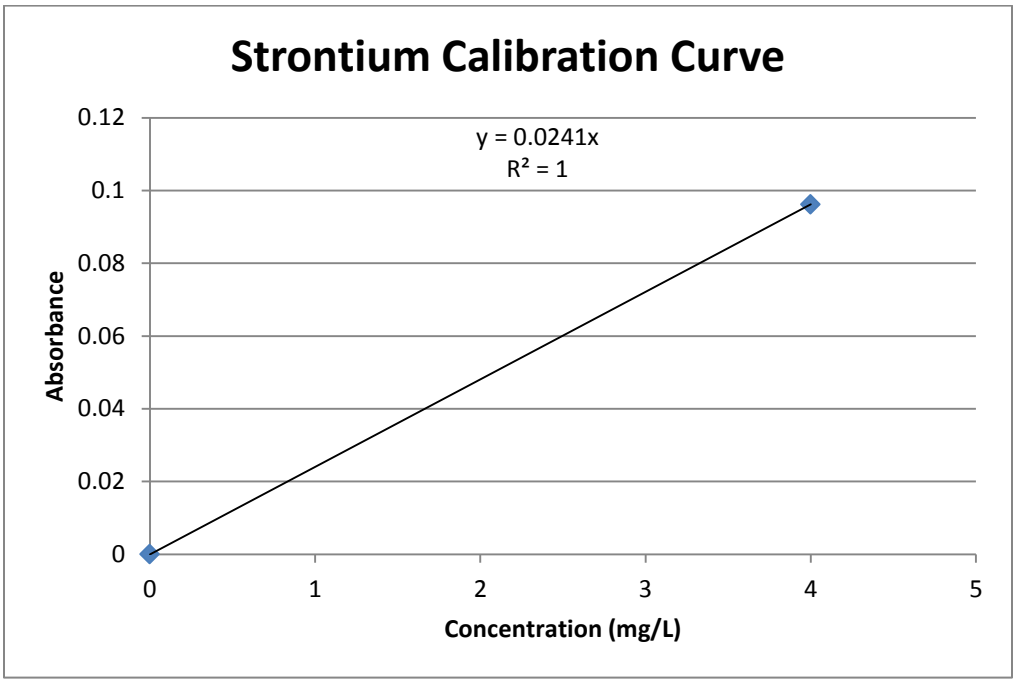
Appendix B—Questionnaire/Interview Results

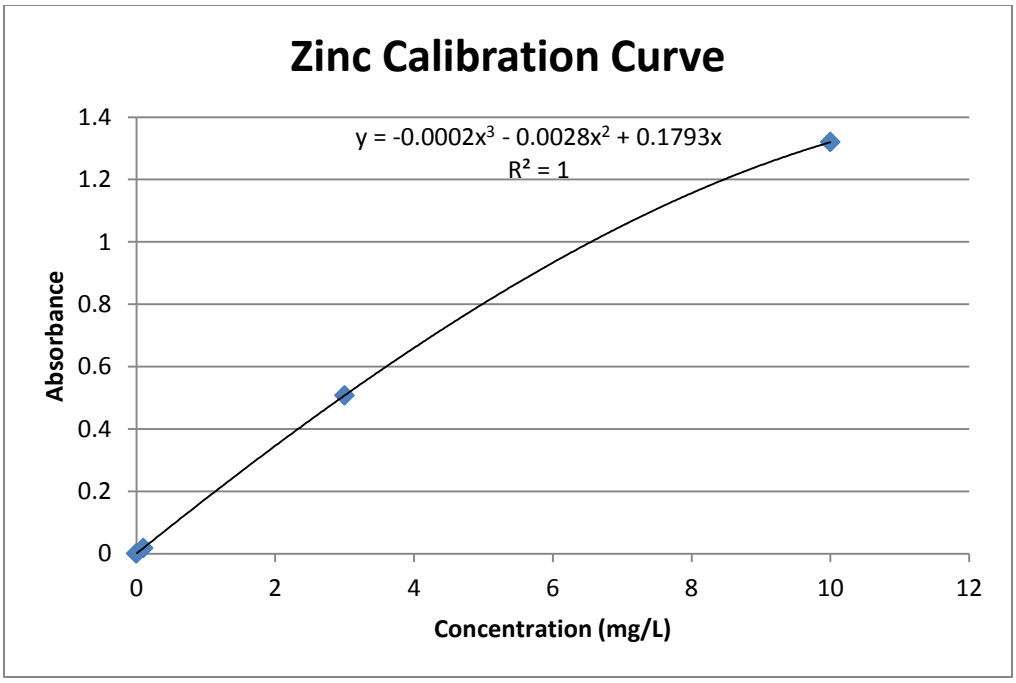
Sample Site	What vessel do you burn in?	How often do you use your vessel?	How do you start the fire?	How often do you empty the ash?	How is the ash disposed of?	What is your motivation for backyard burning?	What other methods are used to manage waste?	Materials Burnt																		
								Leaves	Yard waste/woody debris	Treated wood	Textiles/leather	Tires	Plastic bottles/containers	Plastic film/bags	Vinyl	Electronic waste (eWaste)	Batteries	Paint cans	Oils	Paper/paperboard	Cardboard	Glass	Aluminum cans	Other metals	Food scraps	Other
MX1/4	Burn Pile	1 time per week	Match only	N/A	Pushed into pile	Waste service won't take palates; PC is justifiable; cost (only 1 dumpster now)	Antifreeze sold to company; motor oil to special heaters; tires removed for fee; scrap metal; agricultural film baled and collected		X		X		X	X	X	X	X	X	X	X	X	X	X		Steel cans/parts
MX2	Burn Ring	Once every 2 weeks	Newspaper/paper	2-3 times per year	Put in dumpster (toxic ash)/in a pile (regular ash)	Curbside too costly (not required); economical with living (don't generate justifiable amount)	Non-combustibles/non-degradable brought to relatives; scrap soda cans and metal; computers brought to store; compost; furniture and C&D debris cut up and burnt	X	X	X			X	X	X				X	X	X				X	
MX3	Burn Pit	Almost every day/night in the summer	Newspaper/paper and gasoline	N/A	Stays in pit	Fire used for recreation, a family fun event	Sporadic curbside trash; recycling taken to town; plastic grocery bags reused and recycled; tires reused on farm vehicles; bulky waste to Twp. cleanup day; scrap metal; food waste given to dogs	X	X				X	X						X	X	**X**	X	**X**	X		
MX-TEST	1/2 burn barrel	N/A	Newspaper/paper	N/A	Physical Plant dumped ashes at "Badlands" off of Baldwin St.	N/A	N/A			X	X		X	X	X	X				X	X		X	X		
PC1	55 gallon drum	1 time per week	Newspaper/paper	Once a year	In the woods/over a hill	So it doesn't end up in landfills; only have 1 trash bin (save on cost)	Newspaper and magazines brought to Twp. building							**X**						X	X					

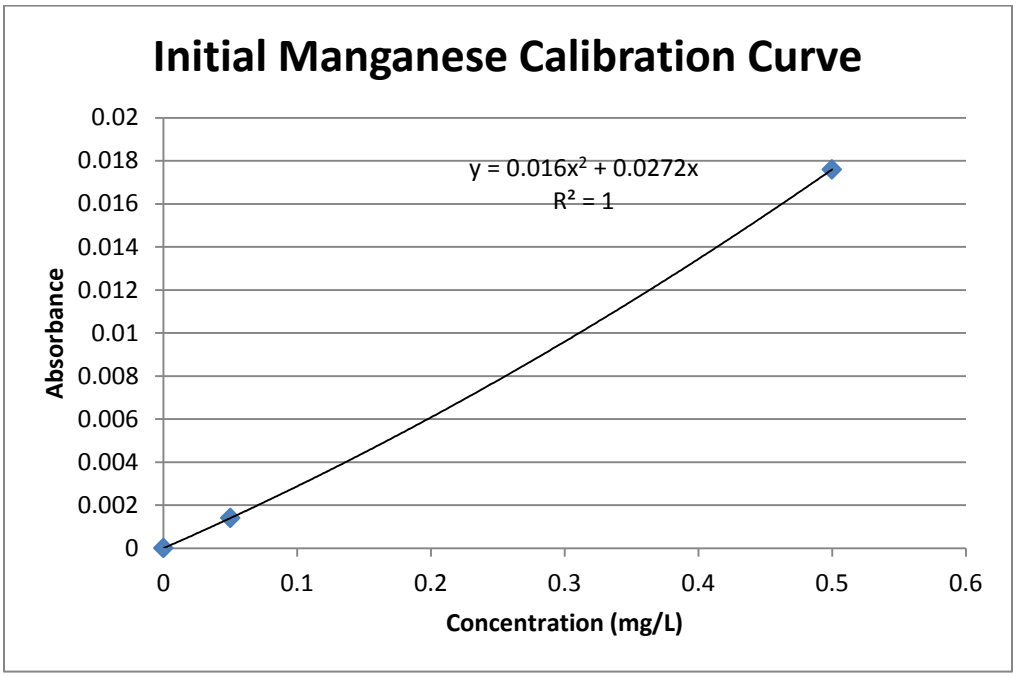
Sample Site	What vessel do you burn in?	How often do you use your vessel?	How do you start the fire?	How often do you empty the ash?	How is the ash disposed of?	What is your motivation for backyard burning?	What other methods are used to manage waste?	Materials Burnt																		
								Leaves	Yard waste/woody debris	Treated wood	Textiles/leather	Tires	Plastic bottles/containers	Plastic film/bags	Vinyl	Electronic waste (eWaste)	Batteries	Paint cans	Oils	Paper/paperboard	Cardboard	Glass	Aluminum cans	Other metals	Food scraps	Other
PC2	55 gallon drum	1 time per week in the summer	Newspaper/paper	When barrel is full	Tilled in garden	Better than never decomposing in a landfill	Recycling and yearly special waste at Twp. building; curbside trash; compost; purchasing products with less packaging; scrap metal							**X**						X	X		**X**			
PC3	55 gallon drum	2-3 times per week	Newspaper/paper	When barrel is full	Spread in yard	Goes back onto grass; better than "sitting in a pit"	Recycle newspapers, magazines, and cardboard through curbside; curbside trash; scrap metal; garbage disposal for food scraps; occasional composting; donate appliances and furniture	X	X					**X**						X	X					**Aluminum foil**
PC4	55 gallon drum	1-2 times per week	Newspaper/paper	Never (throw out barrel)	Dumped in the woods/ over a hill	Inferior paper recycling; waste reduction	Curbside trash; recycle metal, glass, plastic, and cardboard at Cambridge Springs center; compost; call junk haulers; Twp. special wastes day						X	X						X	X					
PC5	55 gallon drum	Every two weeks	Newspaper/paper	Never	Buried on property (in future)	Cost; environmentally conscious	Reduce; reuse; compost; scrap metal; recycle in Waterford; bulky objects to dump				X			X						X	X			X		
PC-TEST	1/2 burn barrel	N/A	Newspaper/paper	N/A	Physical Plant dumped ashes at "Badlands" off of Baldwin St.	N/A	N/A							X						X	X					

*Yellow highlight indicates observed materials in burn vessel that were not filled out in the questionnaire.

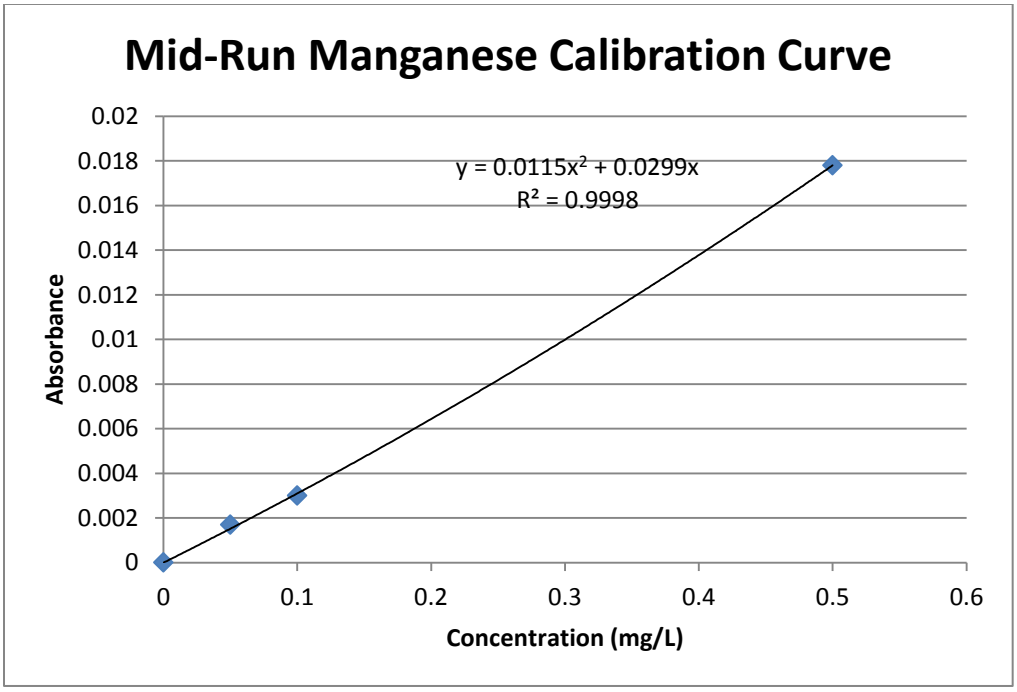
Appendix C—Flame AAS Calibration Curves


Strontium Calibration Curve
y = 0.0241x
R² = 1
Absorbance
0.12
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
5
Concentration (mg/L)

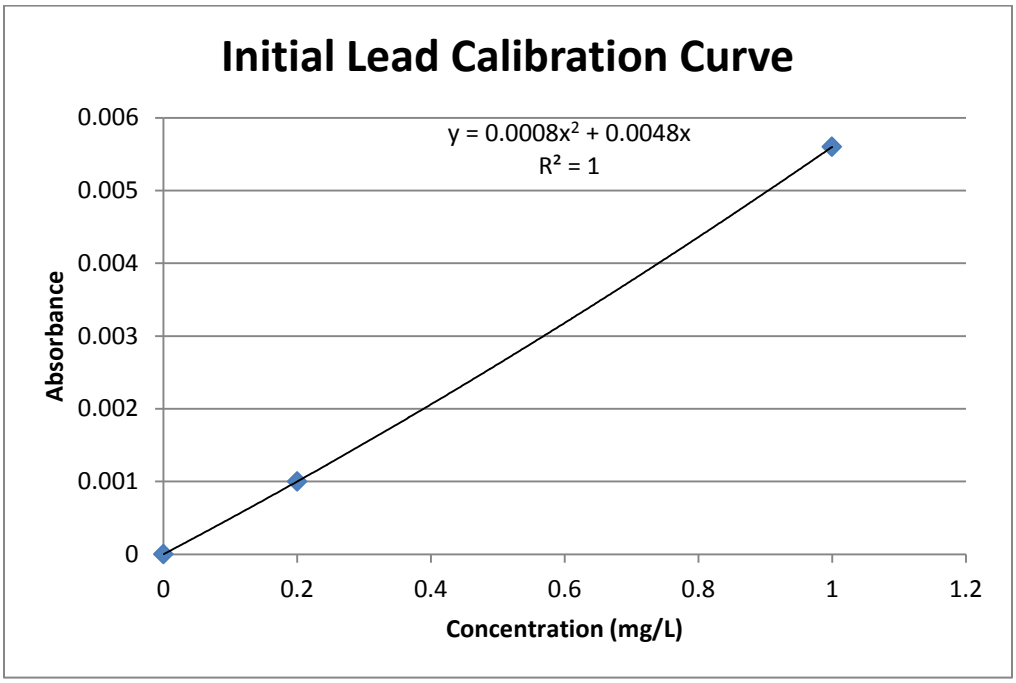

Zinc Calibration Curve
y = -0.0002x³ - 0.0028x² + 0.1793x
R² = 1
Absorbance
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Concentration (mg/L)



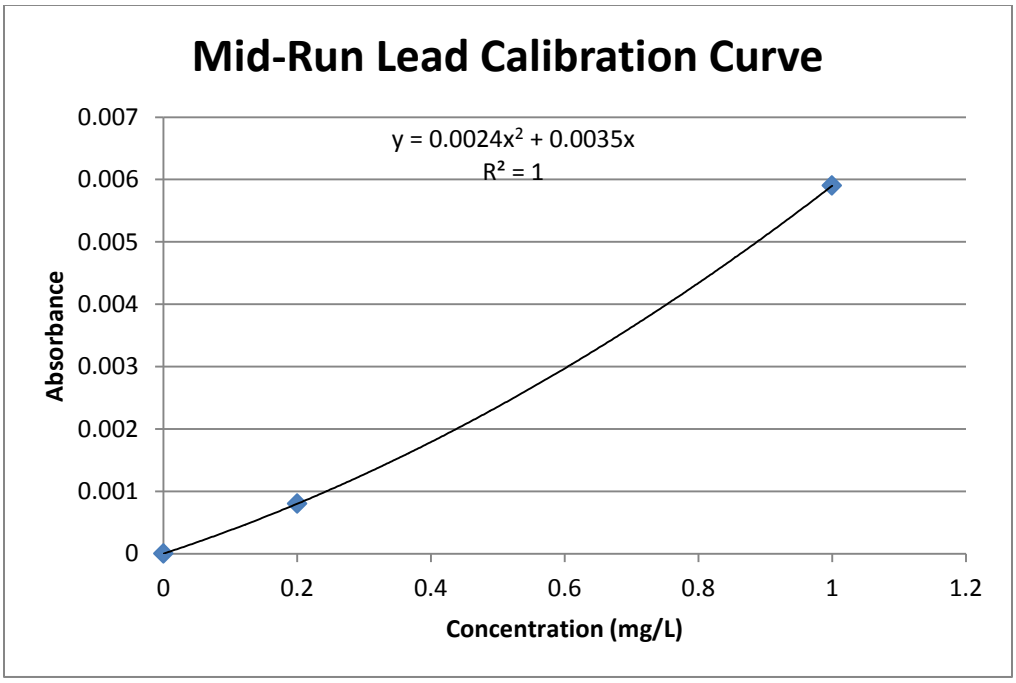
Two-coefficient equation used. WinLab 32 tossed 0.1 mg/L standard.



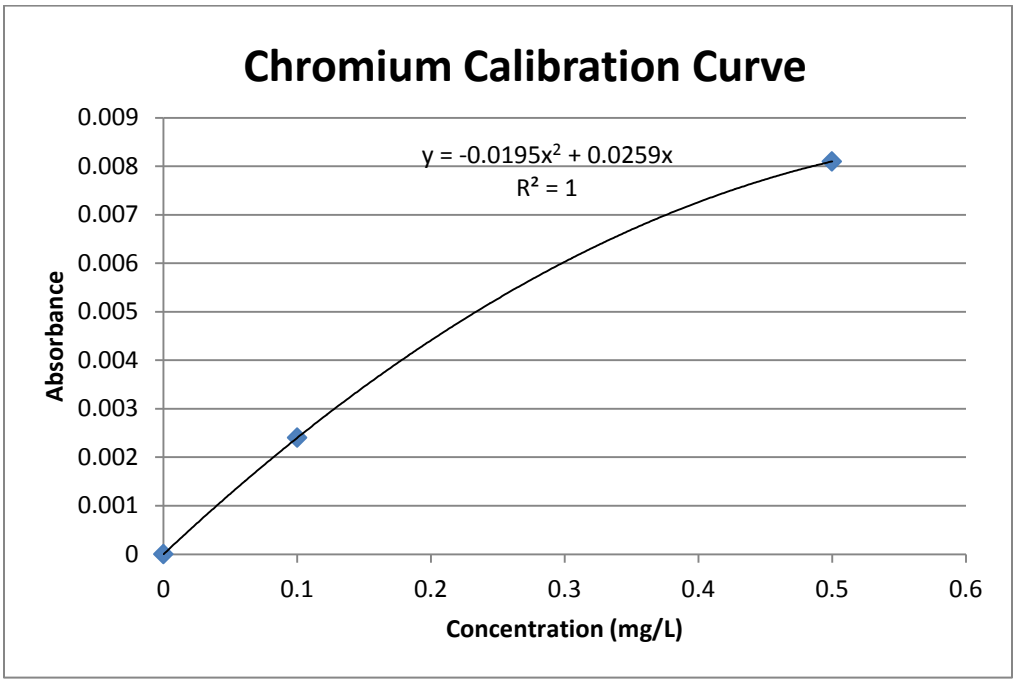
Unable to determine exact equation. WinLab 32 notes the following: two-coefficient equation used; correlation coefficient = 0.999735; slope = 0.03153, intercept = 0.



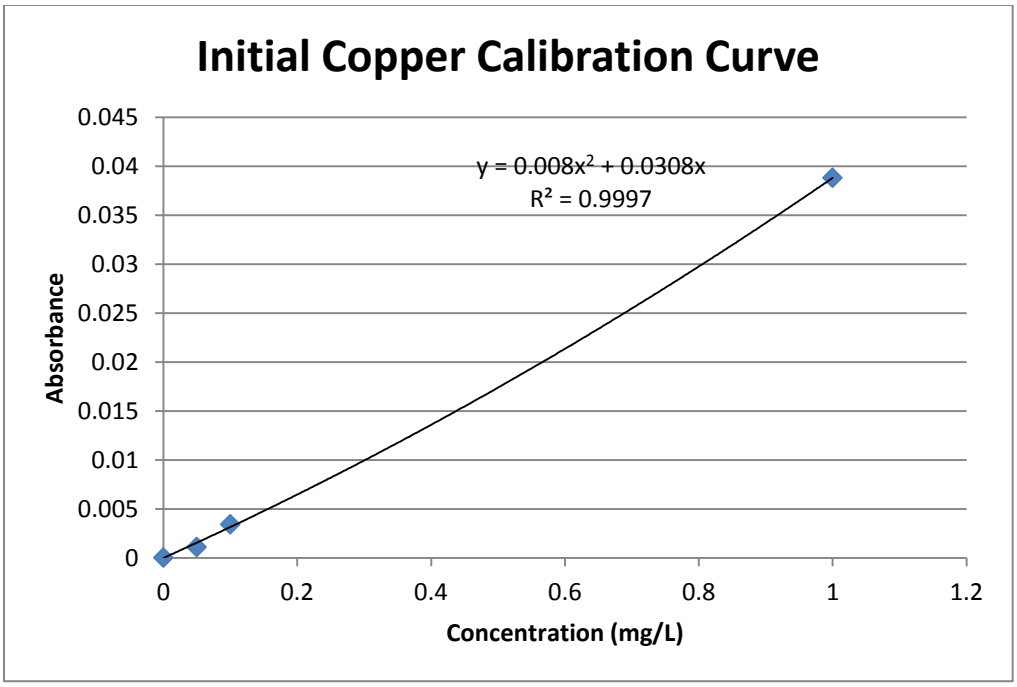
Two-coefficient equation used. WinLab 32 tossed 0.5 mg/L standard.



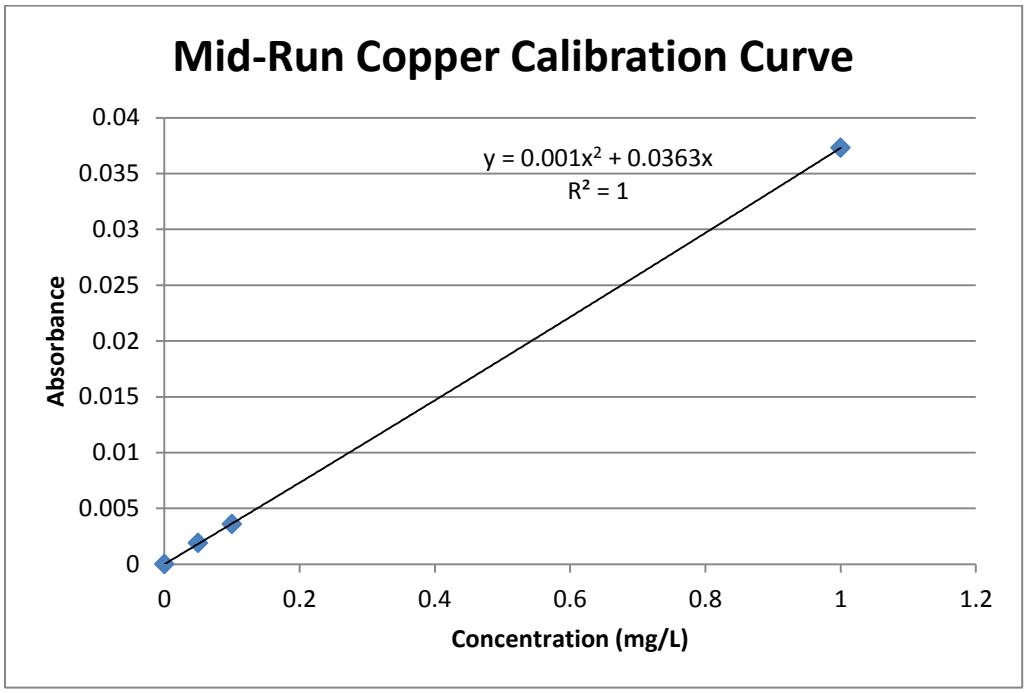
Two-coefficient equation used. WinLab 32 tossed 0.5 mg/L standard.



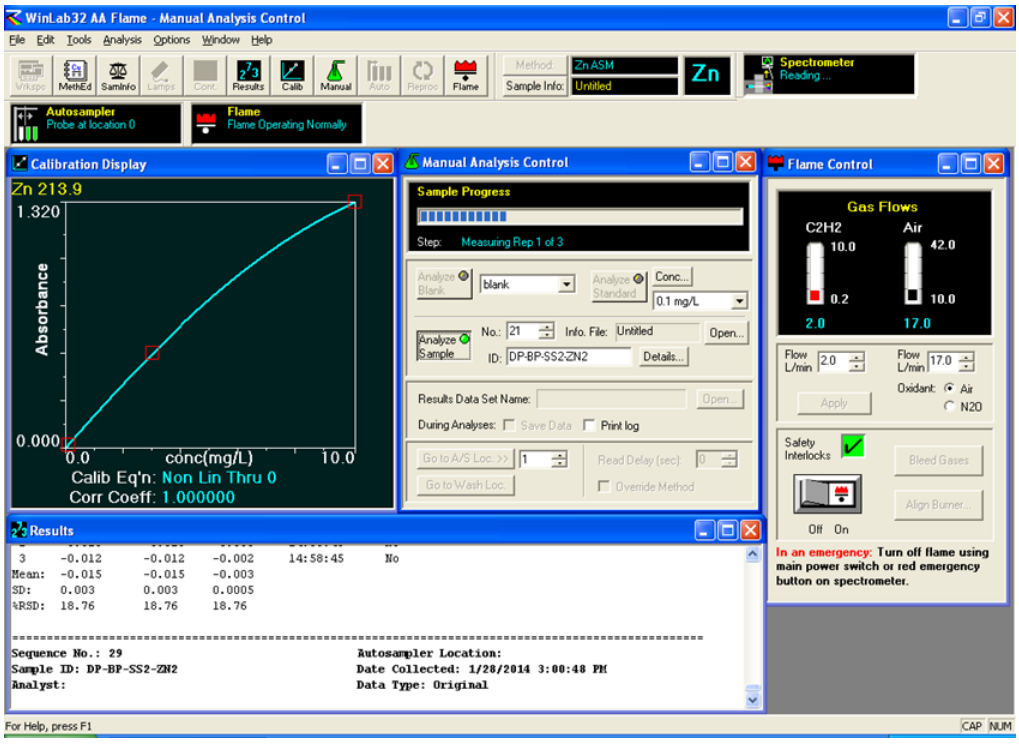
Two-coefficient equation used. WinLab 32 tossed 0.3 mg/L standard.



Unable to determine exact equation. WinLab 32 notes the following: two-coefficient equation used; correlation coefficient = 0.999579; slope = 0.02817; intercept = 0.



Unable to determine exact equation. WinLab 32 notes the following: two-coefficient equation used; correlation coefficient = 0.999988; slope = 0.03670; intercept = 0.



Screenshot of WinLab32 displaying the analysis of a leachate replicate for Zn. Note the calibration curve on the left.

Appendix D—Flame AAS Data by Replicate

			Strontium			Zinc			Manganese			Lead			Copper			Chromium						
	Detection Limit (mg/L)		0.03			0.005			0.01			0.1			0.02			0.05						
	Regulatory Level (mg/L)		20 d			5 c			0.05 c			0.015 b			1.3 b			0.1 a						
	MSWIBA Leachate (mg/L)		1.54-4.51			0.0054-91.72			<0.004-12.62			<0.001-1906			<0.006-10.17			0.0096-2.62						
		pH	**Conc. (mg/L)**	**SD**	**%RSD**	**Conc. (mg/L)**	**SD**	**%RSD**	**Conc. (mg/L)**	**SD**	**%RSD**	**Conc. (mg/L)**	**SD**	**%RSD**	**Conc. (mg/L)**	**SD**	**%RSD**	**Conc. (mg/L)**	**SD**	**%RSD**				
Leachate from Mixed Waste	**MX1-1**	7.46	2.481	0.24	9.48	0.011	0.023	204.30	<0.01			<0.1			0.037	0.056	152.5	<0.05						
	MX1-2	8.96	9.43 e	0.02	0.92	0.794	0.92	115.90	<0.01			0.195	0.047	24.15	<0.02			<0.05						
	MX1-3	8.78	1.394	0.01	0.78	<0.005			<0.01			<0.1			<0.02			<0.05						
	MX2-1	7.61	0.696	0	0.38	0.046	0.001	1.11	0.135 fg	0.021	15.52	<0.1			<0.02			<0.05						
	MX2-2	7.49	0.611	0	0.31	0.085	0.004	5.18	0.107 fg	0.011	9.86	<0.1			<0.02			<0.05			a Maximum Contaminant Level (MCL)			
	MX2-3	7.39	0.71	0.01	0.82	0.086	0.003	3.52	0.097 fg	0.011	11.58	<0.1			<0.02			<0.05			b Treatment Technique (TT)			
	MX3-1	7.67	0.113	0	3.27	<0.005			<0.01			0.222	0.13	58.53	<0.02			<0.05			c National Secondary Drinking Water Standards			
	MX3-2	7.56	0.131	0	2.66	0.009	0.000	5.42	<0.01			0.31	0.075	24.14	<0.02			<0.05			(NSDWS)			
	MX3-3	7.69	0.119	0.01	3.84	0.006	0.004	69.61	<0.01			<0.1			<0.02			<0.05			d Drinking Water Equivalent Level (DWEL)			
	MX4-1	11.91	0.311	0.01	2.73	<0.005			<0.01			0.182	0.083	45.90	<0.02			<0.05			e Concentration exceeded calibration curve.			
	MX4-2	11.98	0.312	0	0.55	0.023	0.002	10.41	<0.01			0.126	0.155	123.30	<0.02			<0.05			Replicate was diluted 5:1 and re-run. SD and			
	MX4-3	12.03	0.333	0.01	1.39	0.02	0.002	12.51	<0.01			0.078	0.317	409.20	<0.02			<0.05			%RSD based on dilution with acid rain.			
	MX-TEST-1 h	7.32	0.728	0	0.34	<0.005			<0.01			0.44	0.066	14.89	<0.02			<0.05			f Mid-run calibration curve used			
	MX-TEST-2	7.32	0.725	0.01	0.80	<0.005			<0.01			0.611	0.026	4.31	<0.02			<0.05			g Concentration exceeded NSDWS			
	MX-TEST-3	7.31	0.765	0.01	1.20	<0.005			<0.01			0.606	0.092	15.11	<0.02			<0.05			h Black colored mold growing on vial walls			
	Detection x̄		**0.6735**			**0.134**			**0.113**			**INC**			**0.037**			**N/A**						
	Detection SD		**0.626**			**0.269**			**0.0197**			**INC**			**N/A**			**N/A**						
	Detection %RSD		**93.0**			**200.75**			**17.43**			**INC**			**N/A**			**N/A**						
	Range		**0.113-9.43**			**<0.005-0.794**			**<0.01-0.097**			**<0.1-0.611**			**<0.02-0.037**			**<0.05**						
Leachate from Paper/Cardboard	**PC1-1**	8.39	0.26	0	1.20	0.015	0.003	20.56	<0.01			0.242	0.047	19.38	<0.02			<0.05						
	PC1-2	7.93	0.247	0.01	2.18	0.016	0.005	33.50	<0.01			<0.1			<0.02			<0.05						
	PC1-3	8.26	0.286	0	0.37	0.012	0.005	37.82	<0.01			0.262	0.066	25.06	<0.02			<0.05						
	PC2-1	7.7	0.16	0	1.10	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC2-2	7.6	0.163	0.01	4.69	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC2-3	7.76	0.163	0	2.24	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC3-1	7.56	0.21	0	1.98	0.024	0.004	17.02	<0.01			0.169	0.085	50.29	<0.02			<0.05						
	PC3-2	7.58	0.2	0	1.89	0.052	0.009	17.95	<0.01			0.115	0.077	67.00	<0.02			<0.05						
	PC3-3	7.6	0.205	0.01	2.38	0.017	0.003	18.63	<0.01			0.137	0.111	80.80	<0.02			<0.05						
	PC4-1	7.92	0.067	0.01	9.79	<0.005			<0.01			0.301	0.047	15.56	<0.02			<0.05						
	PC4-2	7.71	0.07	0	3.84	<0.005			<0.01			0.247	0.105	42.45	<0.02			<0.05						
	PC4-3	7.87	0.076	0.01	14.42	<0.005			<0.01			0.284	0.151	53.31	<0.02			<0.05						
	PC5-1	8.31	0.081	0	2.54	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC5-2	8.36	0.082	0	4.63	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC5-3	8.23	0.09	0.01	6.28	<0.005			<0.01			<0.1			<0.02			<0.05						
	PC-TEST-1	10.6	0.572	0.01	1.54	<0.005			<0.01			0.225	0.05	22.14	<0.02			<0.05						
	PC-TEST-2	11.14	0.537	0	0.45	<0.005			<0.01			0.157	0.179	114.00	<0.02			<0.05						
	PC-TEST-3	11.16	0.533	0	0.28	<0.005			<0.01			0.286	0.057	19.91	<0.02			<0.05						
	Detection x̄		**0.222**			**0.023**			**N/A**			**INC**			**N/A**			**N/A**						
	Detection SD		**0.165**			**0.0149**			**N/A**			**INC**			**N/A**			**N/A**						
	Detection %RSD		**74.12**			**64.78**			**N/A**			**INC**			**N/A**			**N/A**						
	Range		**0.067-0.572**			**<0.005- 0.052**			**<0.01**			**<0.1-0.301**			**<0.02**			**<0.05**						
	Instrument Blank		<0.03			0.07			<0.01			<0.1			<0.02			<0.05						

Appendix E—Residential Waste Burning Laws by State

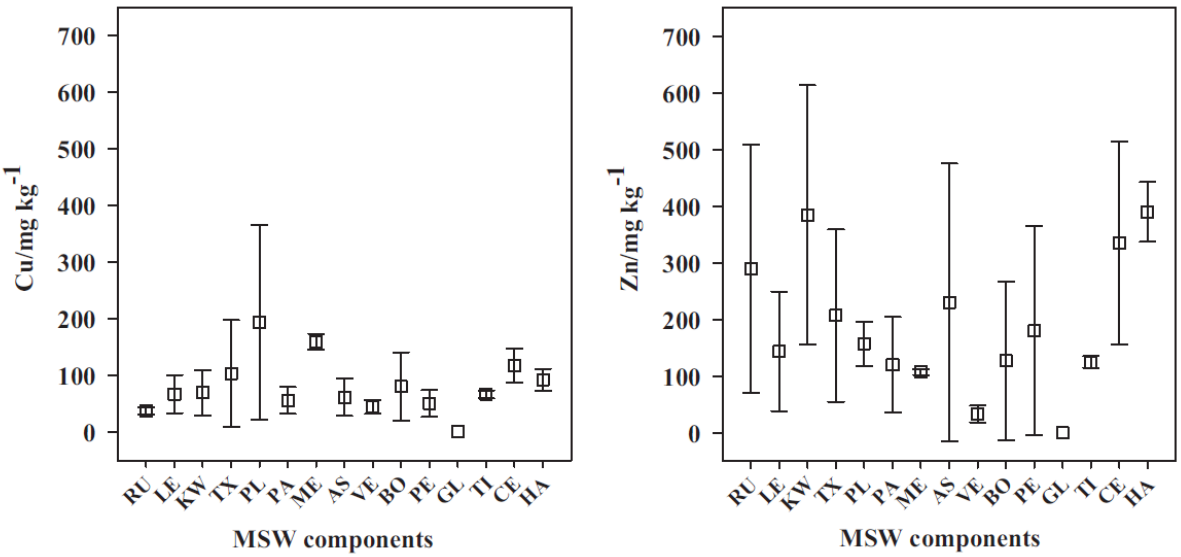
State	Burning Status	Last Amended	Sources	
AK	Legal with Restrictions	2006	http://dec.alaska.gov/air/ap/docs/obrguide.pdf	
AL	Illegal	2006	http://www.epa.gov/region4/air/sips/al/335-3-3.pdf	
AR	Yard Waste Only	1997	http://www.adeq.state.ar.us/air/branch_compliance/yardwaste.htm	http://bentoncountyar.gov/Media/Document/Environmental/BC%20Burning%20Regulations.pdf
AZ	Permit Required	2004	http://www.azdeq.gov/environ/air/permits/burngd.html	
CA	Yard Waste Only	2004	http://www.arb.ca.gov/smp/resburn/resburn.htm	
CO*	Permit Required, Yard Waste Only	2006	http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Open+Burning+Fact+Sheet.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251810374929&ssbinary=true	http://www.colorado.gov/cs/Satellite?c=Page&childpagename=CDPHE-AP%2FCBONLayout&cid=1251595672039&pagename=CBONWrapper
CT	Permit Required, Yard Waste Only		http://www.ct.gov/deep/cwp/view.asp?a=2684&q=531238&deepNav_GID=1619	
DE	Yard Waste Only	2007	http://www.dnrec.state.de.us/air/aqm_page/docs/pdf/reg_13.pdf	http://www.dnrec.delaware.gov/dwhs/Info/Pages/OpenBurningMain.aspx
FL	Yard Waste Only	2008	http://www.dep.state.fl.us/air/rules/fac/62-256.pdf	
GA	Yard Waste Only		http://www.georgiaair.org/airpermit/html/planningsupport/openburning/whatyoucanburn.htm	
HI	Illegal	2012	http://health.hawaii.gov/cab/files/2013/05/x-2012_openburningbrochure-1.pdf	
IA	Legal with Restrictions	2005	http://www.iowadnr.gov/portals/idnr/uploads/air/insidednr/asbestos/open_burning_rules.pdf?amp;tabid=1073	http://www.uiowa.edu/~ipro/Papers%202007/OpenBurning.pdf
ID	Yard Waste Only, No Collection Service		http://www.deq.idaho.gov/air-quality/burning/residential-burning.aspx	
IL	Yard Waste Only		http://www.epa.state.il.us/air/permits/openburn/open-burning-brochure.pdf	
IN	Clean Wood/Paper Only	2001	http://www.in.gov/idem/airquality/2411.htm	
KS	Legal with Restrictions	1996	http://www.kdheks.gov/befs/download/dist_offices/KS_Open_Burning_Regulations.pdf	
KY	Yard Waste/Paper Only		http://air.ky.gov/SiteCollectionDocuments/OpenBurning_63-005_Regulation.pdf	http://air.ky.gov/Pages/OpenBurning.aspx

LA	Yard Waste Only, Seasonal Ban		http://www.deq.louisiana.gov/portal/Portals/0/assistance/ELP/P2/Burning%20Presentation%20for%20web.pdf	
MA	Permit Required, Seasonal Ban		http://www.mass.gov/eopss/docs/dfs/osfm/pubed/flyers/open-burning-fire-factors.pdf	
MD	Seasonal Ban		http://www.mde.state.md.us/programs/ResearchCenter/ReportsandPublications/Pages/ResearchCenter/publications/general/emde/vol2no3/ban.aspx	
ME	Permit Required, Yard Waste Only	2005	https://www.maine.gov/dacf/mfs/archive/fpd/downloads/openburning.pdf	
MI	Illegal	2012	http://www.legislature.mi.gov/(S(dpuhra55qvk2f5ec41dxp1up))/mileg.aspx?page=getObject&objectName=2011-HB-4207	http://www.legislature.mi.gov/documents/2011-2012/publicact/pdf/2012-PA-0102.pdf
MN	Illegal	1996	http://www.pca.state.mn.us/index.php/living-green/living-green-citizen/reduce-reuse-recycle/dont-burn-garbage/dont-burn-your-garbage-laws.html	
MO	Yard Waste Only		http://www.efpd.org/pub/FM%20Community%20Service/Facts%20on%20Open%20Burning%2010-11.pdf	
MS	Illegal	2013	http://www.deq.state.ms.us/MDEQ.nsf/pdf/legal_11Miss.Admin.CodePt.2Ch.1October242013/$File/11%20Miss.%20Admin.%20Code%20Pt.%202.,%20Ch.%201.,%20October%2024,%202013.pdf?OpenElement	
MT	Yard Waste Only		http://deq.mt.gov/FireUpdates/OBtimes.mcpx	
NC	Yard Waste Only		http://daq.state.nc.us/rules/rules/sec1900.pdf	
ND	No Collection Service	2007	http://www.legis.nd.gov/information/acdata/pdf/33-15-04.pdf?20140419213159	http://www.ndhealth.gov/aq/openBurning.htm
NE	Legal with Restrictions		http://www.deq.state.ne.us/Newslett.nsf/61d566801e615aca862568f7006086b8/f54f3a6626eb7580862568f700515949?OpenDocument	
NH	Clean Wood Only		http://des.nh.gov/organization/divisions/air/cb/ceps/npsap/categories/overview.htm	
NJ	Illegal	1994	http://www.nj.gov/dep/aqm/Sub2.pdf	
NM**	Illegal	2004	http://www.nmenv.state.nm.us/aqb/regs/20_2_60nmac_123103.pdf	http://www.nmenv.state.nm.us/aqb/projects/openburn/openburning_index.html
NV	Legal with Restrictions		http://ndep.nv.gov/bwm/swmp/swp11.htm	
NY	Illegal	2009	http://www.dec.ny.gov/docs/air_pdf/factsheet.pdf	

OH	Yard Waste/Paper Only		http://www.epa.state.oh.us/portals/47/facts/openburn.pdf	
OK	No Collection Service		http://www.deq.state.ok.us/factsheets/local/openburn.pdf	
OR	Legal with Restrictions	2000	http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_264.html	http://www.deq.state.or.us/aq/burning/openburning/openburn.asp
PA	Legal with Restrictions		http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-96881/2700-FS-DEP2492.pdf	
RI	Legal with Restrictions	2007	http://www.dem.ri.gov/pubs/regs/regs/air/air04_07.pdf	
SC	Yard Waste Only, No Collection Service	1985	http://www.scdhec.gov/environment/baq/docs/ModelOrdinances/SCExamples/SCDHEC_Burning_Regulations.pdf	
SD	Legal with Restrictions		http://denr.sd.gov/des/aq/openburn.aspx	
TN	Yard Waste Only	2007	http://www.state.tn.us/sos/rules/1200/1200-03/1200-03-04.pdf	
TX	Legal with Restrictions	2006	http://info.sos.state.tx.us/pls/pub/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=111&rl=209	
UT	Permit Required, Yard Waste Only		http://www.airquality.utah.gov/Compliance/OpenBurning/	
VA	Yard Waste Only, No Collection Service	2011	http://lis.virginia.gov/cgi-bin/legp604.exe?000+reg+9VAC5-130-40	http://www.deq.virginia.gov/Programs/Air/AirQualityPlans/OpenBurning.aspx
VT	Yard Waste Only		http://www.anr.state.vt.us/air/Compliance/htm/Openburn.htm	
WA	Yard Waste Only		http://www.ecy.wa.gov/programs/air/outdoor_woodsmoke/residentialburn.htm#Information	
WI	Yard Waste/Paper Only	1999	http://docs.legis.wisconsin.gov/code/admin_code/nr/400/429.pdf	http://dnr.wi.gov/topic/OpenBurning/Summary.html
WV	Yard Waste Only		http://www.dep.wv.gov/daq/CandE/OpenBurningBrochure/Pages/default.aspx	
WY	Legal with Restrictions	2005	http://deq.state.wy.us/aqd/stnd/Chapter10%20R-11(c)Final2-17-05.pdf	

***Exempts counties with less than 25,000 people**
****Bernalillo County and Tribal Lands exempted**

Appendix F—Literature on Metals in MSW by Categorized Components



Box and whisker plots of Cu and Zn concentrations in Chinese MSW components (Long *et al.* 2011). RU = rubber, LE = leaves, KW = kitchen waste, TX = textiles, PL = plastics, PA = paper products, ME = metals, AS = ash, VE = vegetables, BO = bones, PE = fruit scraps, GL = glass (not analyzed), TI = timber, CE = cigarette butts, HA = hair.

Percentage of total Cu and Zn in Chinese MSW stream by major component. Adapted from Long *et al.* (2011). Note that percentages do not sum to 100 due to rounding.

Major Component	% of Metal by Source	
	Cu	Zn
Rubber	1	2.7
Leaves	3	2.2
Kitchen waste	25.5	48.2
Textiles	2.6	1.8
Plastics	25.9	7.6
Paper products	10	7.4
Metals	0.7	0.2
Ash	14.9	19.1
Vegetables	6.1	1.6
Bones	1.7	0.9
Fruit scraps	6.2	7.2
Glass	0	0
Timber	0.7	0.4
Cigarette butts	1.5	0.4
Hair	0.3	0.5
Percent Total	100.1	100.2

Concentration of Cr, Cu, Mn, and Zn for individual MSW components, in mg/kg. Adapted from Rigo & Chandler (1994).

Group	Major Category	Minor Category	Metal Concentration (mg/kg)			
			Cr	Cu	Mn	Zn
Paper	Fine/computer/office		3.4	8	24.6	208
	Books		8.7	40	48.2	88
	Magazines	Glued	16.6	26	50.9	36
		Not glued	5.8	37	50.9	18
	Laminates	Wax/plastic	3.2	7	25.5	16
		Foil	44.6	226	64.5	119
	Newsprint	Glued	1.3	10	19.5	8
		Unglued B&W	3.8	13	45	19
		Unglued Color	215.1	36	81.9	29
	Browns	Corrugated	1.6	3	17.3	10
		Kraft	4.7	11	28.1	22
		Box Board	5.4	12	41	29
	Residual mixed		33	24	51.2	81
Plastic	Film	Color	115.1	25	34.1	1,132
		Flexible	86	20	33	67
		Rigid	119.6	75	53	52
	Food/beverage/household	#1 (PET)	16.7	31	60	97
		#2 (HDPE)	15	24	36.5	142
		#3 (PVC)	2.6	2	11.7	3
		#4 (LDPE)	4.7	10	9.4	89
		#5 (PP)	31.6	16	31.9	40
		#6 (PS)	7.1	9	3.6	98
		Non-identified	44.1	57	41.7	273
	Housewares	Clear	6.4	7	6.1	108
		White	595.2	44	249.5	129
		Blue	8.7	80	11.2	76
		Yellow	1,287	17	22.7	277
		Other	359.3	29	14.1	199
	Toys and other		229.1	98	219.5	349
	Video tape/film		94.1	38	338.1	774
Organics	Yard and garden	Lawn and plant	101.3	690	498.4	365
		branches	24.1	45	184.7	124
	Food waste		22.6	43	101.2	186
	Wood	Finished	113	109	258.3	117
		Unfinished	58.1	46	117.2	205
	Textiles		440.1	67	36.7	142
	Footwear		1,831	25	25.2	764

Group	Major Category	Minor Category	Metal Concentration (mg/kg)			
			Cr	Cu	Mn	Zn
Metals	Ferrous	Beer/soda cans	302.7	323	4,690	886
		Food cans	188.8	99	3,459	1,566
		Band and strap	492	119	14,000	30
	Bimetallic	Electric Motor	289.1	744,800	1,056	7,332
	Non-ferrous	Beer cans	95	1,141	7,694	170
		Soda cans	89.3	1,094	7,307	248
		Food cans	172	645	3,059	445
		Manufactured	1,354	194	132	400,000
		Foil/pack	134.3	279	2,367	120
		Other	200	750	3,557	518
Glass	Recyclables	Clear	28	22	179	60
		Green	943	6	250	21
		Brown	46.2	92	256	251
		Other color	91.5	29	76	1,671
Inorganic	Light construction	Rock/sand/dirt/ concrete/ceramic	187	134	1,074	5,118
		Drywall/plaster	8.6	7	21	21
		Fiberglass insulation	14.1	48	102.5	12
		Other	34	112	111.2	57
Small appliances	Electrical parts	Plastic	251.3	915	29.6	63
Household hazardous waste	Batteries	Carbon	39	140	170,000	63,000
		Ni-Cd	64	53	2,788	685
		Alkaline	74	12,000	170,000	140,000
Fines			115	243	532	654

Concentration of Cr and Zn for major MSW components, in mg/kg. Adapted from Walsh *et al.* (1981) in Merrymon (1993).

Major Component	Metal Concentration (mg/kg)	
	Cr	Zn
Paper	8.2	50
Garden	1.1	106
Metal	15.3	175
Glass	1.1	9.75
Food	1.3	59
Plastic/rubber/leather	2	118
Fines	13.1	322
Ash/rock/dirt	10.1	181
Diapers	1.1	343
Wood	1.1	59.4
Composite	10.7	127

Appendix G—City of Meadville Ordinance Pertaining to Waste Management

Article 931
REFUSE STORAGE, COLLECTION AND DISPOSAL

Sections:

931.01 Definitions.
931.02 Mandatory collection by city contractor.
931.03 Unacceptable waste.
931.04 Refuse and recycling containers.
931.05 Place of collection.
931.06 Time for collection.
931.07 Yard waste collection.
931.08 Large items, bulk items and white goods collection.
931.09 Recyclables collection.
931.10 Prohibited conduct.
931.11 Administration.
931.12 Refuse and recycling fees.
931.13 Enforcement.
931.14 Criminal penalty provision.

931.01 Definitions.
For the purposes of this article, the following terms, phrases, words and their derivations shall have the meanings given herein. When not inconsistent with the context, words used in the present tense include the future, words in the plural number include the singular number, and words in the singular number include the plural number. The word “shall” is always mandatory and not merely directory.

(A) “Ashes” means the residue from the burning of wood, coal, coke or other combustible materials.

(B) “Bags” means plastic sacks designated for refuse with sufficient wall strength to maintain physical integrity when lifted by the top, securely tied at the top for collection, with a capacity not to exceed 32 gallons and a loaded weight not to exceed 25 pounds.

(C) “Bulk waste” or “bulk items” means a piece of furniture or waste material from a residential source other than construction debris or hazardous waste, with a weight greater than 25 pounds and volume greater than that allowed for carts. Pianos, organs, spas, hot tubs, and furnaces are excluded from the definition of bulk waste.

(D) “Cart” means a 35-, 64-, or 95-gallon plastic container, provided by the city, equipped with wheels, handles and a tight-fitting cover. Carts are capable of being mechanically unloaded into the contractor’s collection vehicles. The terms “cart” and “wheeled container” shall be considered interchangeable.

(E) “City” means the City of Meadville, Pennsylvania.

(F) “City billing agent” means the person and/or entity designated by the city to act as the billing agent to send invoices and receive fees related to refuse and recyclables.

(G) “City contractor” means the person holding the refuse collection and disposal contract with the city.

(H) “Curbside” means the nearest point at the side of a roadway.

(I) “Demolition waste” or “construction debris” means the waste materials generated by the construction, alteration or demolition of buildings or structures and shall include but is not limited to lumber, masonry, plaster, concrete, asphalt, shingles, siding, glass, fixtures, piping, wiring and similar materials. It shall not include items designated as “hazardous materials.” The terms “demolition waste” and “construction debris” shall be considered interchangeable.

(J) “Detachable container” or “dumpster” means a watertight, all-metal container, not less than three quarter cubic yards in capacity and equipped with a tight-fitting metal or plastic cover. The term shall also apply to containers of other material of

similar size when approved by the city. Detachable containers two cubic yards and under shall be equipped with at least four wheels. Detachable containers shall have no jagged edges or holes.

(K) “Food waste” means vegetable and other food scraps, including meat, dairy products, grease and bones, paper which has been contaminated with food, fat or grease, and compostable paper including paper towels, paper plates, tissue and waxed paper.

(L) “Garbage” means all discarded putrescible waste matter but not including sewage or sewage sludge, human excrement, source separated recyclables or leaf waste.

(M) “Generator” means a person or municipality that produces or creates municipal waste.

(N) “Hazardous waste” means waste designated as hazardous by the United States Environmental Protection Agency or the Pennsylvania Department of Environmental Protection.

(O) “Large items” means items that are too large to be placed inside the cart or inside of a 32-gallon bag, with an individual weight no greater than 25 pounds and which do not meet the definition of a bulk item. These items include lamps, bicycles, large toys and swing sets, vacuum cleaners, and other small household appliances, aluminum and plastic resin lawn furniture, an individual cut and tied bundle of carpeting measuring no more than four feet in length and meeting the weight requirements, as well as other items of similar size, weight and compactable nature.

(P) “Leaf waste” or “yard waste” means plant material (leaves, branches, brush, flowers, roots, wood waste, etc., but not including grass clippings); debris commonly thrown away in the course of maintaining yards and gardens. Leaf waste does not include loose soils, sod, food waste including from gardens or orchards, food compost, plastics and synthetic fibers, lumber, any wood or tree limbs over four inches in diameter, human or animal excrement, noxious weeds and soil contaminated with hazardous substances. With the exception of holiday trees, materials larger than four inches in diameter and four feet in length shall not be considered leaf waste and shall not be subject to collection.

(Q) “Multifamily dwelling” means structures containing four or more dwelling units within a single structure. This shall include apartment buildings, but shall not include rooming houses or single-family dwellings converted into rental units with common kitchen and bath facilities or attached single-family residences.

(R) “Municipal waste” means any garbage, refuse, industrial lunchroom or office waste and other material, including solid, liquid, semisolid or contained gaseous material, resulting from operation of residential, municipal, commercial or institutional establishments and from community activities and any sludge not meeting the definition of residual or hazardous waste in the Solid Waste Management Act from a municipal, commercial or institutional water supply treatment plant, wastewater treatment plant or air pollution control facility. The term does not include source-separated recyclable materials.

(S) “Owner” shall be the person(s) identified as owners of the real estate among the official records of the county and such other persons who may have the right of possession and control of the premises under a lease, agreement or similar arrangement.

(T) “Person” means every natural person, firm, corporation, partnership, association or other entity.

(U) “Recyclables” means mixed waste paper (including corrugated), newspapers, magazines, bi-metal and aluminum cans, glass bottles and jars, plastic containers Numbers 1 through 7 and other items as designated by the Pennsylvania Department of Environmental Protection.

(V) “Refuse” means all putrescible and nonputrescible solid wastes, except body wastes, and includes but is not limited to garbage, rubbish, ashes, dead animals, abandoned automobiles, and solid industrial and mercantile wastes.

(W) “Residential dwelling unit” or “dwelling unit” means a group of rooms located within a building and forming a single, habitable unit with facilities that are used or are intended to be used for living, sleeping, cooking and eating. A rooming house, single-family residence converted into rental units with common kitchen and bathroom facilities and attached single-family residences shall be considered a single residential dwelling unit for purposes of this code.

(X) “Residential” or “residence” means any house, dwelling, multifamily dwelling, apartment house or any building put to residential use or containing one or more residential dwelling units.

(Y) “Rubbish” means nonputrescible solid wastes, except ashes, and consists of both combustible and noncombustible wastes, such as paper, metal containers, wood, glass, bedding, crockery and similar materials.

(Z) “Solid waste” means ashes, garbage, refuse and rubbish and municipal waste as heretofore defined.

(AA) “White goods” means all major appliances, such as washers, dryers, refrigerators, freezers, stoves, dishwashers, hot water tanks, and trash compactors and other items of similar weight, material, size and nature. (Ord. 3711 § 1, 2012)

931.02 Mandatory collection by city contractor.
(A) All solid wastes generated by or accumulated at a residence in the City of Meadville shall be collected by the city contractor for disposal in accordance with the city contract.

(B) Exceptions. Exceptions to the mandatory use of the city contractor for solid waste collection include the following:

(1) Multifamily dwellings within a single structure, containing four or more dwelling units.

(2) Buildings and facilities used for commercial, industrial and institutional uses, including but not limited to uses such as schools, colleges including dormitories, hospitals, nursing and personal care facilities, manufacturing facilities, retail sales facilities, professional offices and governmental facilities.

(3) Buildings located in the central business zoning district which contain both commercial and residential uses.

(C) Persons generating solid waste may contract with private haulers to collect materials which are not collected under the city contract.

(D) Generators of solid waste or owners of real estate may contract with private haulers for the collection of any refuse which is in excess of the quantity permitted under the city contract.

(E) All solid wastes accumulated within the city as a result of commercial, mercantile or industrial usage of real estate and improvements thereupon located within the corporate boundaries of the city shall be collected, conveyed and disposed of by the owner of either the real estate upon which said waste was generated or by the owner of the real estate upon which said solid waste was accumulated, by collectors or haulers of such owner’s choice.

(F) Persons responsible for the collection and disposal of solid waste from commercial or industrial property may contract with the city for collection and disposal of such solid wastes from the commercial or industrial property, provided:

(1) The waste is comparable in quantity and quality to that of a residential dwelling unit;

(2) The required collection is compatible with the city’s collection schedule;

(3) The city’s standard collection and disposal fee is paid. (Ord. 3711 § 1, 2012)

931.03 Unacceptable waste.
The following items or materials shall not be placed for collection or put in containers set out for collection:

(A) Hazardous waste.

(B) Flammable liquids.

(C) Explosives or fireworks.

(D) Radioactive material.

(E) Infectious or toxic household waste.

(F) Ammunition.

(G) Paints or varnishes.

(H) Photo chemicals.

(I) Insecticides.

(J) Weed killers.

(K) Pool/spa chemicals.

(L) Propane tanks.

(M) Oxygen tanks.

(N) Solvents.

(O) Lead acid batteries.

(P) Vehicle oil and fluids.

(Q) Vehicle tires.

(R) Televisions.

(S) Computers, computer printers, and computer components. (Ord. 3711 § 1, 2012)

931.04 Refuse and recycling containers.
(A) All residences required to use the city contractor for collection services shall put the solid waste in carts provided by the city or bags to which is attached a tag purchased from the city, for collection.

(B) Each residence will be provided with a cart to be used for recyclable collection. The cart shall be specifically identified by color designated by the city and other means of identification. This cart shall be used for collection of recyclables.

(C) Each residence will be provided with a separate cart; either a 35-gallon, 64-gallon or 95-gallon cart as determined by the owner, which shall be specifically identified by color designated by the city and other means of identification. This cart shall be used for collection of acceptable solid waste and refuse.

(D) An owner may choose to not acquire a cart for collection of solid waste or refuse for a particular residence in which case the owner shall acquire tags from the city administrator, the treasurer's office, police dispatch or online at the city's website, www.cityofmeadville.org, for application to bags which shall be used for collection of acceptable solid waste and refuse. If a cart is not used, all refuse and solid waste must be placed in a bag with a tag and set out for collection.

(E) Owners of premises may change the size of the refuse collection container or change from bags to cart for refuse collection in accordance with the policy and procedure and upon payment of fees adapted from time to time by resolution of city council. Owners of new residences, or vacated residences without cart refuse service, shall be given the choice of cart size at no charge at the time of their initial occupation of the residence. Further cart size requests will require payment of a cart exchange fee, which will be a minimum of $25.00, and which will be adjusted by the city on an annual basis as part of its general fee ordinance.

(F) All bags shall be securely fastened at the top, watertight, leak proof and in good condition. All carts shall be maintained in a clean and sanitary condition.

(G) Bags shall not have a capacity greater than 32 gallons or weigh more than 25 pounds.

(H) Carts filled with refuse shall not weigh more than 60 pounds for each 35 gallons of capacity and shall be loaded so that the cover or lid fits on top of the waste in the container.

(I) Carts are owned by the city and are city property. The carts delivered to each residence shall be identified as the cart or carts to be used for services at that location and remain with the residence for use by current and successive owners, and current and successive residents of the premises.

(J) Damage to carts shall be reported to the city contractor or city administrator so that the carts can be repaired or replaced as necessary.

(K) Owners of residences provided with carts by the city for refuse or recycling collection shall be liable for all carts lost, destroyed or damaged, except when the loss or damage has been caused by the city contractor or by persons over whom and under circumstances where the owner had no control. (Ord. 3711 § 1, 2012)

931.05 Place of collection.
(A) All solid waste, yard waste and recyclables shall be placed for collection at curbside as follows:

(1) If the property abutting the street is reasonably level, the carts or bags shall be placed on the owner's driveway or yard area adjacent to the street within eight feet of the curb or street.

(2) If the property abutting the street is sloped at a grade making placement of a cart difficult, a cart may be placed at the nearest reasonably level area.

(B) Where extraordinary circumstances exist, as determined by the city, the city shall make arrangements with the owner of the property and the city contractor for a suitable location which shall be designated and used. (Ord. 3711 § 1, 2012)

931.06 Time for collection.
(A) Solid waste, yard waste and recyclables shall be set out for collection on the day of the week for which collection is scheduled. Notice regarding the collection schedule shall be provided by the city.

(B) Carts and bags may not be placed at the curb for collection before 5:00 p.m. (prevailing time) on the day before the scheduled day for collection, and must be removed within 24 hours after collection. (Ord. 3711 § 1, 2012)

931.07 Yard waste collection.
(A) Between April 1st and November 30th, yard waste may be placed for collection on days scheduled for such collection, which collection shall occur every other week, as designated by the city, on refuse collection day.

(B) Curbside collection of falling leaves from trees will be provided in the fall of each year in accordance with a schedule established by the city and subject to the rules and regulations adopted by the city.

(C) Yard waste may include plant materials from yards or gardens, such as leaves, branches, brush, flowers, roots and wood waste, but shall not include loose soil, grass clippings, garbage, food waste, plastic or synthetic fibers, lumber, wood or tree limbs over four inches in diameter or four feet in length or fecal matter.

(D) Yard waste must be placed in biodegradable paper bags approved by the city and available from the city or designated retail outlets. These bags placed at the curb for collection shall not exceed 40 pounds. (Ord. 3711 § 1, 2012)

931.08 Large items, bulk items and white goods collection.
(A) Large items and bulk items shall be collected on the days scheduled for refuse collection at an additional cost to owner. White goods will be collected on a day scheduled by the city and collected by the city.

(B) Residents may purchase tags for large items which do not exceed 25 pounds in weight. Tags will be available for purchase from the city. Each individual large item shall be considered one unit and the equivalent of one tagged bag of garbage. The contractor shall collect all such tagged units from the structures serviced.

(C) Residents may purchase tags for bulk items and white goods from the city. Bulk items and white goods shall not be placed for collection on the curbside as to interfere with the collection of carts or any street right-of-way.

(D) Tags for bulk items, white goods, large items and bagged garbage will all have an appearance and cost different from each other.

(E) Under extraordinary circumstances, residents may make special arrangements with the city and city contractor for collection at other times. (Ord. 3711 § 1, 2012)

931.09 Recyclables collection.
(A) Recyclables shall be collected on a periodic schedule to be determined by the city from all premises mandated to use the refuse collection services of the city contractor on the same day scheduled for refuse collection. Owners will be notified of the schedule.

(B) All persons in the City of Meadville shall separate recyclables from the solid waste; place recyclables in the cart designated for recyclable collection, and place the recyclables cart out for collection on the day for scheduled collection.

(C) Only the materials defined and officially designated as recyclable materials shall be placed for collection or put in the recyclables cart for collection. Materials and items which are and are not recyclable shall be identified and described in a policy adopted from time to time by resolution of city council and notice of this policy shall be delivered to each customer. (Ord. 3711 § 1, 2012)

931.10 Prohibited conduct.
It shall be unlawful for any owner or other responsible person to:

(A) Fail to comply with the regulations set forth in this article for the handling, collection, storage and disposal of refuse, solid waste and recyclable materials.

(B) To dispose of solid waste refuse and recyclables except in conformity with the regulations of this article.

(C) To place solid waste or refuse or recyclables out for collection except in the designated and permitted containers. (Ord. 3711 § 1, 2012)

931.11 Administration.
The regulations set forth in this article shall be administered and enforced by a city official or officials designated by the city manager. For purposes of this article, the person so designated shall be referred to as “refuse and recycling administrator” or “administrator.” (Ord. 3711 § 1, 2012)

931.12 Refuse and recycling fees.
(A) Charges for Service. A fee for collection of refuse, waste and recycling shall be established by the city for each residential dwelling unit, which is dependent on the size of the cart selected by the owner. Said fee shall be payable monthly, or as otherwise designated by the city or the city’s billing agent, and paid to and collected by the city or the city’s billing agent. The fees are currently assessed at the following rates:

(1) The following annual rates per residential dwelling unit for customers with fewer than 175 billable units billed on one bill, and:

(a) No cart service: $204.00.

(b) Thirty-five-gallon cart service: $240.00.

(c) Sixty-four-gallon cart service: $246.00.

(d) Ninety-five-gallon cart service: $255.00.

(2) An annual rate of $216.00 per residential dwelling unit for customers with 175 or more billable units all billed on one bill.

(3) Additional Rates per Residential Dwelling Unit for Tag Items.

Tag per bag: $1.25.

Tag per large item: $20.00.

Tag per white goods item: $25.00.

(A) The refuse and recycling fees/rates shall be reestablished each year as part of the general fund budget ordinance. If not modified in the general fund budget ordinance, the previous rates shall remain in effect until changed or amended by subsequent ordinance.

(B) Responsible Party. The persons responsible for payment of the refuse and recycling charges is/are the record owner(s) of the premises for which services are provided.

(C) Fees Payable Regardless of Use. The fees and charges for refuse and recyclable collection services are payable for each residence whether the services are used or not used.

(D) Relief from Refuse Charges. Refuse charges and service will be terminated if owner provides the city with proof that the residence is vacant and unoccupied, and that water service has been terminated, and returns the refuse and recycling carts to the city. Service and charges shall resume upon occupancy of the residence. A charge to be established by resolution of the city council shall be payable for the resumption of service.

(E) Delinquent Accounts. Accounts shall be delinquent if not paid on or before the due date set forth on the bill.

(F) Remedies for Nonpayment. In the event payments are not made when due, the city shall have the right to collect the amounts due in any manner permitted by law including, but not limited to, seeking recovery by an action at law, and filing a municipal lien or claim against the subject property. In any collection proceeding, the city shall recover its costs and reasonable legal fees to the fullest extent permitted by law.

(G) Termination of Service on Delinquent Accounts. Premises serviced by accounts with bills, which are unpaid for a period in excess of 60 days from initial billing date, are subject to termination of all services (shut-off). The city or the city's billing agent shall forthwith send notice by mail to the last known address of the owner of real estate involved that waste and recycling collection service to the premises are subject to termination. Unless the entire balance due and owing together with a service charge of $4.00 for each month or part of month by which such payment is late is paid within seven days of the mailing of the notice, services may be terminated. Services shall be resumed after any termination only upon repayment of the bill and all accumulated service charges plus an additional service resumption fee of $15.00. (Ord. 3711 § 1, 2012)

931.13 Enforcement.

(A) Any person who is not acting in compliance with the requirements of this article as determined by the administrator shall be given a written notice by hand delivery, or regular mail, at the last known or readily ascertainable address, of the violation and action required to avoid further enforcement proceedings. If corrective action is not taken in a timely manner, the administrator, with the approval of the city manager, may institute enforcement proceedings in the district magistrate court or in any other court of law for a penalty or such other legal relief as proper and available at law.

(B) For purposes of this article, persons responsible for compliance with these regulations shall include the owners of record of the premises subject to the regulations, as well as all other persons in possession of the subject premises, including but not limited to tenants or managers. (Ord. 3711 § 1, 2012)

931.14 Criminal penalty provision.

Any owner as defined herein who shall violate any provisions of this article shall, upon conviction in a court of competent jurisdiction, be guilty of a summary offense and shall be subject to a fine of not more than $1,000 and costs of prosecution or, in default of payment of such fines and costs, to undergo imprisonment for a period not to exceed 30 days. Each day a violation continues shall constitute a separate violation and shall be deemed a separate offense. (Ord. 3711 § 1, 2012)

Article 1721
PROPERTY MAINTENANCE CODE

*NOTE THAT SECTIONS OF ARTICLE 1721 NOT RELATED TO WASTE HAVE BEEN REMOVED

Sections:

1721.01 Title.
1721.02 Authority.
1721.03 Purpose.
1721.04 Adoption of International Property Maintenance Code.
1721.15 Penalty.
1721.20 Additions, insertions and changes to International Property Maintenance Code.
1721.32 Refuse and garbage accumulations prohibited.

Prior legislation: Ord. 3608.

1721.01 Title.

The title of this article shall be the City of Meadville or Meadville Property Maintenance Code (and may be referred to as “MPMC”). (Ord. 3676 § 1, 2010)

1721.02 Authority.

This property maintenance code is adopted in accordance with authority existing under Sections 4130 and 4131 of the Third Class City Code and Article III of the Optional Third Class City Charter Law. (Ord. 3676 § 1, 2010)

1721.03 Purpose.

The property maintenance code is being adopted to establish recognized minimal standards for maintenance of property to protect the health and safety of occupants and the public. (Ord. 3676 § 1, 2010)

1721.04 Adoption of International Property Maintenance Code.

The International Property Maintenance Code, 2009 Edition, as published by the International Code Council, Inc. (herein referred to as the “IPMC”), is hereby adopted as the property maintenance code for the City of Meadville for the regulation and control of buildings, structures, premises and facilities as therein provided; and each and all of the regulations, provisions, conditions and terms of this International Property Maintenance Code are hereby incorporated, adopted, and made a part hereof as if fully set forth in this code, with the additions, insertions, deletions, and changes as set forth in this article. (Ord. 3676 § 1, 2010)

1721.15 Penalty.

A. Any person who shall violate a provision of this code, or who shall fail to comply with any of the requirements of this code, or who shall fail to comply with an order issued by the code official, shall, except as otherwise specifically provided in this code, be subject to a fine or penalty as follows:

(1) Up to $1,000 for the first two continual and uncorrected violations of the same provision of the code on the same property.

(2) Up to $5,000 for the third and any subsequent, continual and uncorrected violation of the same provision of the code on the same property.

(3) No more than one penalty shall be imposed per month.

B. If a violation of the MPMC is found to pose a threat to the public's health, safety or property, then the following penalties shall be applicable:

(1) A fine of no less than $500.00 and no more than $1,000 for the first two continual and uncorrected violations of the same provision of the code on the same property, and no less than $1,000 and not exceeding $10,000 for the third and any subsequent continual and uncorrected violation of the same provision of the code on the same property, or imprisonment for a term not exceeding 90 days, or both.

(2) Under this subsection, no more than one citation may be issued per five calendar days for a continual and uncorrected violation of the same provision of this code on the same property. (Ord. 3676 § 1, 2010)

302.12 Rubbish and Garbage.

(1) No rubbish, refuse or garbage shall be accumulated or stored outside of an enclosed building or structure, except in appropriate containers which are set outside for collection in the manner required by Article 931 of the Meadville Municipal Code. Appropriate containers are those receptacles or bags as required by the City regulations with contents secured to keep the contents from being scattered or leaked.

(2) All rubbish, refuse and garbage accumulated or stored inside of an enclosed building shall be regularly disposed of by use of a refuse collection service or other lawful means.

(3) No rubbish, refuse or garbage shall be accumulated or stored inside an enclosed building so as to create a nuisance.

302.13 Disposal of Certain Materials. No person shall deposit, or cause to be deposited, any refuse, garbage, offal, pomace, dead animals, decaying matter or similar substance of any kind in or upon any premises, building or structure, so that the same shall may afford food, harborage or breeding areas for vectors, or cause a nuisance.

302.14 Leaf Burning. The burning of leaves shall be subject to the following restrictions:

(1) No person shall burn leaves within the City limits before 12:00 noon and after 6:00 p.m., prevailing time, on any day;

(2) No person shall burn or attempt to burn damp or wet leaves, at any time; and

(3) No person or entity shall cause, permit or allow the burning of any leaves or other materials of any nature or description on or upon the surface of any street or alley located within the City.

1721.32 Refuse and garbage accumulations prohibited.

A. Accumulations of Uncollected Garbage and Refuse. No accumulation of garbage, refuse or rubbish which causes a nuisance or health and safety hazard shall be permitted in any front or side yard area except as permitted for collection in accordance with Article 931 MMC.

B. Refuse and Garbage Removal Notices. Written notice of the violation of this section shall be given in the manner set forth in MMC 1721.14(B) and (C) except that only three days shall be permitted to correct the violation and except that, where service by hand delivery or certified mail has not been made within three days, notice shall be deemed to have been made by posting the notice in a conspicuous place on the premises. If the persons responsible fail to take corrective action to eliminate the violation(s), no additional notices shall be required for continuing uncorrected violations of the same provision upon the same premises for the calendar year.

C. Remedies for Refuse and Garbage Removal Violations. If persons responsible fail to have the refuse and garbage properly removed in accordance with the requirements of this section, the city is hereby authorized to and may take action to remove the refuse and garbage with city personnel or a contractor hired by the city as often as reasonably required, without further notice. The cost of such remedial action and all expenses incidental thereto together with a penalty of 10 percent of the costs and expenses shall be collectible from the owner or other persons responsible in any manner permitted by law. In addition, the city may file a municipal lien or claim against the premises in the amount of the unpaid costs, related expenses including reasonable legal fees and penalty and may pursue any and all other remedies permitted by law to correct the violation including prosecution of the offense.

D. For the reason that failure to remove refuse and garbage poses a unique public health and safety hazard if uncorrected in a short period of time, citations may be filed every five days the violations continue without correction or abatement. No appeal shall be provided from the notice of violation. Persons responsible shall have the opportunity to be heard in any court proceeding instituted for imposition of a penalty for violation. (Ord. 3676 § 1, 2010)