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A Retrospective Analysis of Open Burning Activity in Kentucky

Capstone Project Paper
A paper submitted in partial fulfillment of the requirements for the degree of
Master of Public Health
in the
University of Kentucky College of Public Health
By Scott Blakeman, Liberty, Kentucky

July 19, 2017

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Abstract

Objectives: To 1) summarize open burning activity observed by the Kentucky Division for Air Quality for a 12-month period and to 2) identify distinguishing factors of areas having “high” levels of observed open burning compared to areas with “low” levels of open burning.

Methods: Data was collected by performing a records review of open burning investigation documents for the 554 investigation site visits performed by KY DAQ for the time period of January 1, 2015 through December 31, 2015.

Results: The average number of site visits per county was 4.66 visits. The source material with the highest observed frequency was household waste (51.4%). The source material with the lowest observed frequency was tires (8.7%).

Conclusion/Future Direction: The numbers of site visits reviewed were unevenly distributed across both each month and each Area Development District. Counties previously designated as non-attainment for PM and ozone National Ambient Air Quality Standards (NAAQS) observed fewer numbers of investigation site visits compared to the statewide county average. Counties having KY DAQ regional offices had higher numbers of site visits.
Introduction

Open burning, also called backyard burning, is the uncontrolled combustion of a material in an open area that results in any associated air emissions being released directly into the surrounding ambient air without being treated or filtered. This type of combustion does not involve the use of any emissions control technology and thus results in relatively high levels of air pollution per amount of material/fuel burned compared to industrial sources \(^{(1,2)}\). Examples of open burning activities include, but are not limited to, the burning of agricultural fields to prepare for future growing seasons, the burning of household waste in barrels (also referred to as burn barrels), and the burning of piles of various waste materials for ceremonial purposes. Rationales for this activity vary, but mainly include the convenience and ease of not having to haul trash to local garbage disposal sites and to avoid paying garbage collection fees.

Due to the less than ideal conditions observed during an open burning scenario, incomplete combustion typically occurs resulting in the release of emissions byproducts. Depending on the material burned, emissions can contain high levels of particulate matter of both 2.5 microns and 10 microns in diameter (PM\(_{2.5}\) and PM\(_{10}\) respectively), carbon monoxide (CO), heavy metals, volatile organic compounds (VOCs), poly-chlorinated biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) as well as other byproducts of incomplete combustion. Due to the sporadic and unpredictable nature of the practice of open burning, most current emissions inventories do not include those resulted from open burning. This makes the characterization and assessment of environmental impact from open burning difficult.
To assess the potential public and environmental health impact from open burning, multiple factors must be considered. These include the material burned, when the burning occurs, for how long it occurs, and the emissions resulting from the burning. The majority of open burning research is focused on analyzing the resulting emissions from different burning scenarios, but little has been performed to assess actual open burning activity occurring.

The aim of this study was to (1) comprehensively quantify the open burning activity occurring in Kentucky in a given time period, (2) to identify trends associated with areas of both high- and low-observed open burning and (3) to identify implications of said trends on public education. This research is performed by means of conducting a thorough records review of open burning investigation reports and associated documents obtained from the Kentucky Division for Air Quality (KY DAQ).

**Background**

Open burning is regulated on a state-by-state basis. 401 KAR 63.005 is the regulatory citation addressing open burning in Kentucky. Under this regulation, all open burning is prohibited with the exception of approved practices as defined in the 401 KAR 63.005. These practices include: ceremonial fires, the burning of natural brush and yard trimmings, fires used for cooking, fires used for comfort heat on worksites (with restrictions), fires used to prevent the spread of disease, pests or weeds, fires used for forestry purposes, fires used to dispose of dangerous material if no other means is available, fires used for training of first responders and emergency personnel, fires used for agricultural, ecological, and wildlife management, the burning of leaves (in cities with populations under 8,000), fires used to dispose of accidental spills of crude oil, and fires
used to dispose of natural growth, clean wood, and lumber. Furthermore, additional open burning restrictions are enforced in counties that have been previously designated as non-attainment with National Ambient Air Quality Standards (NAAQS) for ozone and PM. These counties include Boone, Boyd, Bullitt, Campbell, Jefferson, Kenton, Lawrence, & Oldham. All open burning is prohibited in these counties from May – September (referred to as ozone season)\(^{(3)}\). This regulation is enforced in Kentucky by a citizen complaint hotline. Reports of open burning are submitted either by phone or email and investigated by KY DAQ field staff. The KY DAQ receives approximately 500 – 700 complaints each year \(^{(4)}\). Violations of 401 KAR 63.005 can receive a penalty of up to $25,000 \(^{(3)}\).

**Literature Review**

A systematic literature review was conducted in Pubmed, Google Scholar, and the Kentucky State Virtual Library of scientific literature pertaining to open burning and its effects on both human and environmental health. This literature review was conducted by searching these electronic databases using keywords pertaining to open burning and air pollution emissions.

**Emissions Analysis**

The majority of scientific literature reviewed was focused on emissions analysis from simulated open burning scenarios. Most studies conducted emissions analyses using either a capture/collection hood directly over the burn area or by using an air sampling probe directly in the emissions plume \(^{(2, 5 - 10)}\). Research has been conducted on various open burning activates and on the emissions resulting from burning different materials. The chemical makeup of the material being burned has been linked directly with the
makeup of the resulting emissions \(^{(11)}\). Multiple studies have concluded that the burning of household waste produces high amounts of VOCs, polycyclic aromatic hydrocarbons (PAHs), PCDD/Fs, organic and inorganic ions and metals compared to biomass burning \(^{(11)}\). The open burning of household waste in barrels has been observed to produce substantial amounts of air pollutants \(^{(2,5,7)}\). Burn barrels have been documented to be one of the highest producers of PCDD/PCDF in the United States \(^{(2,5)}\). A study performed by US EPA’s National Risk Management Institute found that, in a pound for pound comparison, emissions of PCDD/PCDF from open burning in barrels can be several orders of magnitude higher than that from a permitted municipal incinerator operating with no emissions control technology \(^{(2)}\).

Analysis of biomass burning such as the burning of land-clearing debris, agricultural refuse, and yard waste have noted high levels of PM (namely PM\(_{2.5}\)), PAHs, aldehydes, and CO \(^{(12,13)}\). Aside from the toxic component of these air emissions, biomass fires typically produce visible emissions significant enough to impair visibility, causing a nuisance, and potential public health harm.

The open burning of tires is a major public health concern worldwide. According to the US EPA, approximately 240 million waste tires are produced each year in the US \(^{(14)}\). The burning of scrap/waste tires is common as waste typically accumulate in large numbers are tire collection facilities, often leading to open burning both from accidental and intentional sources. Waste tires are also burned at individual residence due to the difficulty of disposing of waste tires in some areas. The emissions from tire burning have been well documented \(^{(15)}\). Due to the chemical composition of tires, emissions form
combustion often include high levels of PM\(_{2.5}\) and PM\(_{10}\), heavy metals, hydrogen sulfide (H\(_2\)S), sulfur dioxide (SO\(_2\)), ammonia (NH\(_3\)), PAHs and VOCs\(^{(16)}\).

**Impacts to Human Health**

Through both retrospective analysis of historic air pollution events, such as the London fog of 1952, and short and long term epidemiological studies, air pollutants have consistently been linked to increased mortality and hospital admission\(^{(17)}\). According to the World Health Organization (WHO), 72% of air pollution-related deaths are due to cardiovascular disease and stroke, 14% from chronic obstructive pulmonary disease (COPD) or acute lower respiratory infections and other and 14% from lung cancer\(^{(18)}\). Though the health burden of poor ambient air quality is much higher in developing countries, ambient air quality and its related health effects are still of high concern in higher income countries such as the US. Uncontrolled sources of air pollution, such as open burning, go unquantified and contribute unknown amounts of pollutants to emissions inventories. Emissions from open burning, by nature, are emitted at ground level since no emissions stack is used. Because of this, little dispersion of the resulting pollutants occurs and thus local concentrations of emission can be relatively high. Compounds such as PM, CO, VOCs, PCDD/PCDF, PAHs, along with other compounds, have been linked to plethora of adverse health outcomes. Though many factors influence any given persons exposure limit, generally highly susceptible populations such as children, the elderly and those with compromised body systems are more prone to developing adverse health outcomes.

PCDD/PCDF are known human carcinogens and are suspected to have mutagenic properties\(^{(19)}\). The routes of exposure of PCDD/PCDF are through eating contaminated
food, breathing contaminated air, or coming in contact with contaminated surfaces. Being in close proximity to an open burning site(s) can increase the risk of any of these routes of exposure. Dioxins are also known to persist in environmental systems and accumulate over time. This leads to the possibility of PCDD/PCDF introduction and bioaccumulation into food chains.

Numerous studies have concluded that both acute and chronic exposure to PM has a negative impact on health. PM 2.5 exposure has been linked to respiratory disease \(^{(20)}\) and cardiovascular disease \(^{(21,22)}\). Vulnerable and susceptible populations such as children \(^{(21,23)}\), the elderly \(^{(21,24)}\) and those with compromised immune/respiratory systems are more adversely affected by PM exposure \(^{(21)}\).

The health effects from ambient VOC exposure depend on both the specific compound involved and the concentration of exposure. Due to the diversity and number of VOC compounds, it is not possible to discuss the health implication of exposure to each one. Many VOCs are also designated as Hazardous Air Pollutants (HAPS). Compounds such as benzene, styrene, toluene, along with other VOCs have been noted to be either confirmed or suspected human carcinogens \(^{(25)}\).

**Literature Gaps**

The majority of research pertaining to open burning is centered on analyses of the resulting air emissions, both from specific material burned as well as from different open burning scenarios. This has created gaps in the literature including: assessment of temporal and spatial trends of open burning, assessment of frequency of different open burning activities and distribution of different open burning activities across different geographical areas. The purpose of this analysis is to fill these gaps through analyzing retrospective data of open burning activity observed by the KY DAQ.
Methods

This research is a descriptive study of data collected from a comprehensive records review of open burning investigation documents obtained from the Kentucky Division for Air Quality. The main objective of this analysis was to quantitatively describe the findings of open burning incident investigations performed by KY DAQ staff. The data reviewed encompassed 119 out of the 120 counties in Kentucky. The Louisville Metro/Jefferson County program is organized and operated separately from the Kentucky Division for Air Quality and their data is collected in a different manner; therefore, the Louisville Metro/Jefferson County data could not be consistently compared to, nor included with, the data of all other Kentucky counties. The documents reviewed encompassed a time frame from January 1, 2015 through December 31, 2015. The records reviewed for this analysis were in the form of reports that were completed following onsite investigations, as well as supplementary investigation photographs.

The records reviewed as part of this data collection encompassed a total of 554 investigations. All investigations were a result of a formal complaint received by KY DAQ. All records were reviewed through a comprehensive search of the KY DAQ TEMPO 360 (TEMPO) database. The records contained in TEMPO that were reviewed as part of this analysis included inspector investigation reports, investigation photos, and incident reports from other government agencies (fire department reports, police reports, emergency management reports, etc).

Collection Procedures

To be included in this sample for review, an incident had to have been reported to the KY DAQ between the dates of January 1, 2015 and December 31, 2015, have a
corresponding onsite investigation, and have subsequent investigation documents uploaded in the TEMPO database. Through the submission of a formal open records request submitted to KY Department of Environmental Protection - Kentucky Open Records Act office (KY DEP KORA), permission was granted by the KY DAQ to obtain and review open burning investigation-related documents for this time period. The TEMPO database was searched by filtering by “incident type: Open Burning”, “Start Date: January 1, 2015” and “End Date: December 31, 2015”.

Variables

This analysis categorized 11 variables, which were the basis for how each record was reviewed. Variables were established based on the sections in a standard investigation report template, as well as through literature review of research relating to open burning activity. These variables included month, reporter, county, and Area Development District (ADD); also included as variables were burn source materials observed, including tires, electronic waste (eg. circuit board, wire, electronic remains), construction waste (drywall, treated lumber, insulation, remains of once standing structure), yard waste (natural brush, tree limbs, storm debris, land-clearing waste), furniture (mattresses, general household furniture), household waste (beverage containers, cardboard boxes, food containers, general household refuse. etc), and whether a burn barrel was used. All source variables were assessed using the question, “was this variable observed burning (or previously burned) during the site visit?” Each investigation and associated documents were reviewed and each variable assessed. Data was presented in both total number of site visits per ADD with the given material observed, as well as the percentage of that ADD’s total site visits. Microsoft Excel was
used to tabulate each investigation, with each row representing an individual investigation and each column representing an individual variable. Each cell included either a “Y” (yes) or “N” (no), indicating whether that particular variable was burned at that location. The month, county, ADD, and description of reporter (private citizen, anonymous, KY DAQ/Department for Environmental Protection (DEP) employee, and other government agency) were also noted in respective columns.

**Statistical Methods**

Data was entered into a dataset using both Microsoft Excel (Excel for Mac, 2008) and IBM SPSS Statistical Analysis (SPSS Version 24). Descriptive analysis was conducted to summarize each study variable. Mean rates (total observations of variable per total site visits) of occurrence were calculated for each burn item variable and compared to the state average for the sum of site visits. The total site visits per County and ADD were totaled and entered into Quantum Geographic Information Software (QGIS, version 2.14.2). Shapefiles for Kentucky County borders and Kentucky ADD borders were obtained through the Kentucky Geological Survey Geospatial Data Library. Summary tables and graphs were produced in IBM SPSS. Summary data was arranged and analyzed per ADD due to the availability of additional and supplemental data per ADD, such demographic, health and geographic data.

**Results**

The total number of open burning complaints received by the KY DAQ during the January 1 - December 31, 2015 time period was 682. In total, 554 resulting incident investigations met the criteria to be included in this sample. This resulted in an inclusion rate of 81.2%. Reasons for exclusion included multiple complaints for the same
location/address, an incorrect or unfounded address, or lack of response from DAQ staff (incident was not responded to).

The following counties did not have any open burning investigation site visits during the January – December 2015 time period: Bourbon, Boyle, Carlisle, Carroll, Edmonson, Green, Hancock, Hickman, Jackson, Monroe, Robertson, Rockcastle, Union, and Wayne. These counties were therefore not included in the 554 incidents meeting the sample criteria. Jefferson County was excluded from analysis due to the existence of Jefferson County Air Pollution Control District (APCD), and the implementation of different regulation and regulatory/enforcement practices. Map 1 depicts the number of complaint site visits per county. The average number of site visit per county was 4.66 visits. All 15 ADDs were included in the sample. The average number of site visits per ADD was 36.93 visits. Incident totals were unevenly distributed among the 15 ADDs, with the highest number occurring in the Bluegrass ADD (77 site visits, 13.9% of total site visits) and the lowest occurring in the Buffalo Trace ADD (12 site visits, 2.2% of total site visits). Table 1 summarizes the total number of site visits and percent of total site visits per ADD.
Month-to-Month patterns were unevenly distributed across each month with the lowest month being January (25 site visits) and the highest month being August (68 site visits). Table 2 outlines the total complaints reported for each month of the sample time frame. The majority of complaints noted the reporter as anonymous (49.5%) followed by private citizen (31.6%), KY DAQ employee (10.8%) and other government agency (8.1%).
Table 2 - Month-to-Month Summary

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Site Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>25</td>
</tr>
<tr>
<td>February</td>
<td>35</td>
</tr>
<tr>
<td>March</td>
<td>49</td>
</tr>
<tr>
<td>April</td>
<td>60</td>
</tr>
<tr>
<td>May</td>
<td>56</td>
</tr>
<tr>
<td>June</td>
<td>51</td>
</tr>
<tr>
<td>July</td>
<td>34</td>
</tr>
<tr>
<td>August</td>
<td>68</td>
</tr>
<tr>
<td>September</td>
<td>51</td>
</tr>
<tr>
<td>October</td>
<td>51</td>
</tr>
<tr>
<td>November</td>
<td>42</td>
</tr>
<tr>
<td>December</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>554</td>
</tr>
</tbody>
</table>

Source Materials

Of the 554 site visit reports reviewed, 48 (8.7%) noted the presence of tire remains, 51 (9.2%) noted the presence of electronic waste, 180 (32.5%) noted construction/demolition debris, 138 (24.9%) noted yard/land clearing waste, 68 (12.3%) noted the use of presence of a burn barrel, 99 (17.9%) noted furniture remains, and 285 (51.4%) noted the remains of household waste. Analysis across the 15 ADD yielded an uneven distribution across the collection of variables. Figures 1 – 7 outline the percentage of site visits occurring in each ADD where each variable was observed. Observations of tires were observed to be highest in the Kentucky River ADD (7, 14.29%) and Pennyrile ADD (4, 13.33%). Purchase ADD and Cumberland Valley ADD did not have any site
visits noting the observation of tires. Electronic waste was observed to be the highest in Kentuckiana ADD (6, 26.32%), and the lowest in Barren River ADD and Pennyrile ADD, which both had no site visits observing electronic waste. Observations of construction/demolition waste were observed to be highest in the Green River ADD (11, 45.45%) and FIVCO (5, 41.67%), and the lowest were Lake Cumberland ADD (7, 17.95%). Yard/land clearing waste was observed to be the highest in the Big Sandy ADD (17, 51.52%) and the lowest in the Buffalo Trace ADD (1, 8.33%). The use of a burn barrel was observed to be the highest in the Buffalo Trace ADD (4, 33.33%), and the lowest in Lincoln Trail (2, 4.44%), Northern Kentucky (1, 4.76%) and Purchase (2, 6.67%) ADDs. Furniture was observed the highest in the Northern Kentucky (7, 33.33%) and Buffalo Trace (4, 33.33%) ADDs, but the lowest in the Barren River ADD (4, 8.16%). Household waste showed a near even distribution across all ADDs, the lowest were observed in Lincoln Trail (17, 37.78%) and Bluegrass (29, 37.66%) ADDs.

Discussion

Through the quantification of different open burning practices, we can gain a better understanding of open burning trends and behaviors. This study documents frequencies of open burning activity across Kentucky over a 12-month time period.

Over half (51.4%) of all site visit investigations noted the open burning of household waste. This relatively high amount could support the hypothesis that open burning rationales are influenced by the perceived connivance and cost savings of burning household garbage as opposed to using weekly garbage collection. A follow up study or studies could be performed in which correlation analysis is performed between
county waste collection availability and/or socioeconomic status demographic data and counties with high/low open burning incidence. Some members of the general public or those who practice open burning may hold the belief that burning garbage has an overall lower environmental impact compared to sending accumulated household waste to a landfill. The existence or adoption of this false belief is not supported by any documented research findings.

Nearly one third of all site visits (32.5%) observed construction/demolition waste as an open burning source material. There is an obvious motivation to dispose of accumulated waste at a construction site. This data indicates that open burning could be chosen as the proffered means of waste disposal at construction/demolition sites.

Land clearing/yard waste was only observed in 24.9% of the site visits. This is low considering both the exemption of natural brush from Kentucky’s open burning regulation and the high visible pm emissions produced from natural biomass fires\(^{(12)}\).

On average, counties with previous non-attainment designation for either PM or ozone NAAQS standards observed fewer site visits per county (average of 4.43 visits/county) than the rest of the state (average of 4.66 visits/county). Table 3 shows the total site visits per previously designated non-attainment county. This difference in averages could be a result of increased regulatory attention on these counties or increased education available to residents in hopes of maintaining the current attainment status with PM and ozone NAAQS. Counties with the previous non-attainment designation have a further restriction from May – September of each year, in which otherwise allowable open burning activity such as the burning of natural brush, is also prohibited. Even
though KY DAQ determines compliance with this requirement, other government agencies, namely local fire departments, are often involved in spreading information regarding the seasonal ban.

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Site Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boone</td>
<td>3</td>
</tr>
<tr>
<td>Boyd</td>
<td>13</td>
</tr>
<tr>
<td>Bullitt</td>
<td>2</td>
</tr>
<tr>
<td>Campbell</td>
<td>2</td>
</tr>
<tr>
<td>Kenton</td>
<td>4</td>
</tr>
<tr>
<td>Lawrence</td>
<td>6</td>
</tr>
<tr>
<td>Oldham</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3 - Kentucky Previous Non Attainment County Open Burning Summary

<table>
<thead>
<tr>
<th></th>
<th>Number of Site Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average site visit/county</td>
<td>4.43</td>
</tr>
<tr>
<td>State Average site visits/county</td>
<td>4.66</td>
</tr>
</tbody>
</table>

Counties home to KY DAQ regional offices observed a higher number of site visits per county (average of 12.75 site visits/county) compared to the state average (4.66 site visits/county)(Table 4). This is likely due to either increased education in areas close in proximity to KY DAQ facilities, and subsequently personnel and resources, or due to higher amounts of KY DAQ/DEP employees filing complaints in their counties of employment. Counties with KY DAQ field offices had averaged nearly the same percentage of employee reported complaints (10.46%) compared to the state average (10.8%). If indeed the increase in education in areas close to KY DAQ field offices has increased public awareness of open burning (in theory increasing the number of reported
complaints), then steps should be taken to increase education beyond the counties of KY DAQ regional office locations.

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Site Visit</th>
<th>Employee Reported Incident</th>
<th>Percentage of site visits reported by Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boyd</td>
<td>13</td>
<td>4</td>
<td>30.77</td>
</tr>
<tr>
<td>Franklin</td>
<td>12</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>McCracken</td>
<td>9</td>
<td>1</td>
<td>11.11</td>
</tr>
<tr>
<td>Perry</td>
<td>19</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>Daviess</td>
<td>16</td>
<td>1</td>
<td>6.25</td>
</tr>
<tr>
<td>Boone</td>
<td>3</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Laurel</td>
<td>13</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Warren</td>
<td>17</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Average</td>
<td>12.75</td>
<td>1.57</td>
<td>10.46</td>
</tr>
<tr>
<td>State Average</td>
<td>4.66</td>
<td></td>
<td>10.8</td>
</tr>
</tbody>
</table>

Counties in the eastern regions of Kentucky observed higher rates of site visits when adjusting for population. Map 2 depicts county site visits per county, per 100,000 people. Counties in south-central Kentucky appear to have clustering of relatively low rates of site visits. Future spatial analysis of hot spot/cold spot clustering would be beneficial for assessing the level of clustering amongst these different regions. No in depth spatial analysis was conducted as part of this review.

**Limitations**

This study involved key limitations. The source information prompting each onsite investigation was mostly citizen and anonymous complaint driven. This reliance
on public reporting of possible open burning activity inhibits the assessment of true environmental impact of the overall activity of open burning. Locations of locally high population density, such as neighborhoods and residential areas, are more likely to receive a formal complaint from an open burning incident than an areas such as rural areas and areas with larger property sizes having less population density. Likewise, areas such as this could easily harbor high amounts of open burning activity that does not get observed and/or reported. A complaint driven reporting system also requires a would be reporter to have access to KY DAQ contact information in order to successfully report the incident. Lack of consistency in individual inspection reports reviewed also presents a limitation for this study.

**Conclusions/Future Direction**

The aim of this study was to quantify open burning activity observed over a 12-month period in Kentucky and to identify trends associated with both high and low areas of burning activity. Based on this data, uneven distributions of reported open burning were observed. Correlations were observed between counties previously designated as non-attainment for PM and ozone NAAQS, as well as counties having KY DAQ regional offices. These correlations possibly indicate that either increases in regulation or increases in education outreach have an affect on the number of reported open burning incidents. Future analysis of these counties could provide valuable information for targeted education and outreach. This study also indicated that the majority of observed open burning sites involve the burning household waste, yard/land clearing debris, and construction/demolition waste. Knowing the frequencies of observed burning of these materials, targeted initiatives such as improved/revised local waste collection procedures
and recycling education/outreach can be developed. Furthermore, having a quantified understanding of open burning trends provides environmental regulatory agencies such as KY DAQ tools to evaluate existing programs and develop new methods to address the environmental burden of open burning.
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23) Woodruff TJ, Parker JD, Schoendorf KC. Fine particulate matter (PM2.5) air pollution and selected causes of postneonatal infant mortality in California. Environ Health Perspect 2006;114(5):786-90.


Appendices:

Figure 1: Observation of Tires at Visited Open Burn Sites

Figure 2: Observation of Electronic Waste at Visited Open Burn Sites
Figure 3: Observation of Construction/Demolition Waste at Visited Open Burn Sites

Figure 4: Observation of Yard/Landclearing Waste at Visited Open Burn Sites
Acknowledgments

I would like to first thank the Kentucky Division for Air Quality for granting me access to documents and records stored within KY DEP TEMPO database. I would also like to thank my capstone committee, Dr. Mannino, Dr. Johnson, and Dr. Gan for their support and assistance. Finally, I would like to thank my family, friends, and wife for encouraging me and supporting me throughout this academic endeavor.

The views and/or results referenced in this document in no way reflect the views or opinions of the Commonwealth of Kentucky or Kentucky Division for Air Quality.

There are no financial disclosures.
Bibliographical Sketch

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