PM10 SAMPLING ON FORT RILEY, KANSAS
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by

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Abstract

Burning grass and other vegetation is a historic concept. Throughout the Flint Hills of Kansas, it is an annual event each spring in March and April. Burning is gaining more attention due to health and safety concerns. First responders, personnel managers, and health officials prepare for the 60 days of smoke generated from these events. On average, Kansas burns between one and two million acres each year (Kansas Department of Health and Environment, Smoke Manage Plan, 2010). Burning helps the landowners prepare the pasture for summer grazing. It helps with grass growth, germination of forbs, and control of woody vegetation. The process of burning produces particulate matter (PM) and releases volatile organic compounds (VOCs). These additions affect the air quality. Increased particulate matter and increased ozone levels (secondary to the increases in VOCs) have mechanical and physiological effects within people. It affects healthy individuals and those with disease. Decreased visibility affects traffic safety and the smoke plumes are large enough to be seen on satellite images. These health and safety concerns have opened the door for larger organizations, such as Fort Riley, to monitor sources and develop regulations to mitigate the health and safety concerns. This study occurred in the spring of 2012 as Fort Riley's first look into this issue. It utilized the SKC Deployable Particulate Sampler (DPS) issued by the U.S. Army Public Health Command. These units, seven in total and six deployed, sampled 24 hours a day seven days a week from March 15th to April 12th, 2012. The samplers are continuous flow monitors that collect 24 hour accumulated particulates of 10 micrometers and smaller. Utilizing the DPS flow rates over time and weighing the filters that captured the particulate matter (10 µm and smaller), the micrograms of particulate per meter cubed of air (µg/m^3) are calculated for that day (i.e., PM10). The data collected from the samplers has been statistically evaluated for the PM10 mean by location and across all locations, and for statistical significance between locations. This paper addresses the variability among the sampling sites, establishes the need for a different type of sampling equipment to accomplish real-time sampling, and sets a foundation for further studies to occur on Fort Riley. Additionally, Fort Riley is using this data to compare the relationship between elevated PM levels and medically-coded upper respiratory encounters at Irwin Army Hospital.

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Introduction

Fort Riley, Kansas is located in the northern third of the Kansas Flint Hills region. This region of Kansas is 80 miles east to west and 200 miles north to south of rolling hills and tall grass prairie. It covers 82,000 square miles including the northern portion of Oklahoma (Wikipedia, 2013). Only 4% of the original tallgrass prairie is intact (The Nature Conservancy, 2013); Kansas has the largest portion of the remaining prairie. Historically, the prairie grass has been managed through burning. Occasionally, it burns as the result of natural processes (i.e., lightning). The planned burning usually occurs in the spring and typically during the months of March and April. The weather greatly affects the timing and the number of acres burnt each year. Much of the burning occurs from March 15th through April 15th but it may start as early as February and continue into May and also periodically happens in the late summer/early fall. Burning kills the woody shrubs and trees, scores the seeds of native forbs, and decreases the thatch from the previous year. An unpublished study by Kansas State University's D. Goodin, estimated by satellite that 1.3-2.0 million acres (the average was 1.67 million acres) within 14 primary counties were burnt yearly between 2003 and 2006 (referenced on page 16 of The Kansas Department of Health and Environment's Smoke Management Plan (SMP, 2010)). These Flint Hills pastures are the summer home for tens-of-thousands of young cattle, called stocker cattle, ages 6 months to 1 year, and a more permanent home for a large population of cow/calf pairs. The region is known for its lush warm season grasses that provide ample nutrition to growing cattle (stockers) which may grow at a rate of two pounds each day during the 90 day stocking period when sunny days and moisture are abundant. Studies have shown that grazing properly managed pastures (pastures managed with burning and the proper cattle stocking rate) enhances forage quality and has a positive impact on the growth rate of stocker cattle (SMP, 2010).

Fort Riley is part of this rich landscape occupying nearly a half a million acres and provides a permanent home for approximately 20,000 people (Craig Phillips, Lead Planner, PAIO, USAG, 2011). The fort has a large transient working population that nearly doubles the population during the day. As a result, each day the population on Fort Riley changes dramatically. Burning pastures during the spring has an effect on the air quality across the region, including Fort Riley. Much of the smoke that affects the living and working areas on Fort Riley comes from the surrounding areas. Fort Riley takes into account the State's SMP produced by the Kansas Department of Health and Environment (KDHE) and completes burns from the Fort's burn plan. The residential/working locations, the wind direction, the weather conditions, and the location of the pasture are all components determining which pastures may be burned on Fort Riley to mitigate the effects of the burning. The surrounding privately owned pastures may not take Fort Riley's working and residential population into account. As a result, the burning on Fort Riley is one factor affecting the Fort's air quality and the burning of the surrounding pastures another.

On any given day during the burning period, the quality of the air changes dramatically. During the heavy burn days, the smoke plumes are visible on satellite images. Nevertheless, the prevailing winds are from the south and southwest and this region has clean air on most days. The region is mostly rural and city size is generally small. Wichita, 100 miles to the south and Topeka, 50 miles to the east, are the only major metropolitans through the central part of Kansas. Manhattan, Emporia and Salina are smaller with some manufacturing and industrial contribution to the region's air quality. Except for calm, hot and humid days during the summer or during days of significant pasture burning, the air quality is some of the best in the United States. The days with poor air quality are usually short lived (see this study, April 3 to April 4, 2012 relating to rain moving in). The typical Kansas winds, frequent thunderstorms and weather fronts with wind, will change the region's air mass. One day the air quality may be challenged with high particulates and/or ozone levels and the next day it will be dramatically improved.

Particulate matter (PM) in the air has an effect on human health (Figure 1). The common sizes of particulate measured are those of 10 micrometers and smaller (PM10), also known as thoracic particles but sometimes classified as course particles (Course particles are more commonly known as the sizes between 10 and 2.5 µm). Also, those particles of 2.5 micrometer and smaller (PM2.5), are known as fine particles. When sampling for PM10, all particles less than 10 µm are collected. This includes particulates within the PM2.5 measurement and PM2.5 makes up between 15% and 90% of the PM10 measurement depending on the source (Joe Sutphin, U.S. Army Public Health Command). Particulates are linked to cardiovascular, respiratory, and circulatory diseases. These particulates cause local inflammation and oxidative stress in the vessels, lung and throughout the body by mechanical and physiological reactions. The smaller particulates penetrate deeper into the lungs (small bronchioles) and the smallest particles, ultrafine particulates (less than 0.1 µm and known as UFPs), may be inhaled to the extent of the alveolus and directly transferred from lung space to the circulatory system and to the lung parenchyma through phagocytosis. The extent of the disease created from these particulates varies depending on the amount and components of the particulate and the health status/genetics of the individual.

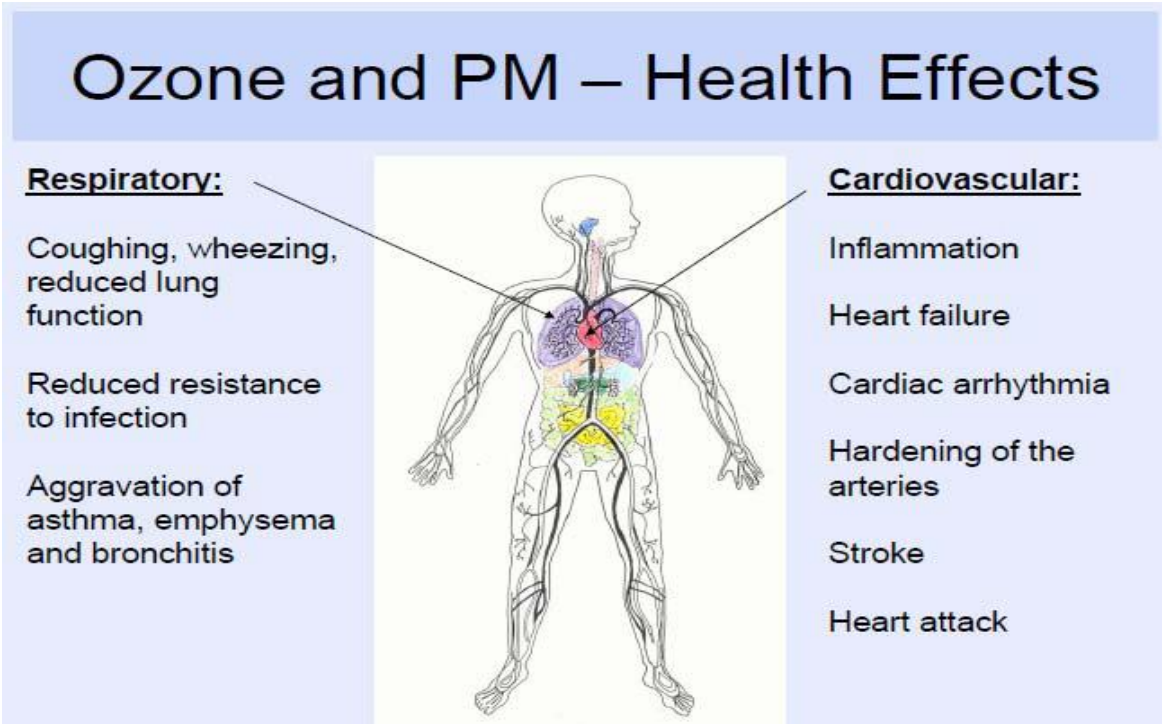


Figure 1, Health effects of Ozone and PM, (KDHE SMP 2010)

This study was established to capture particulate matter data on Fort Riley during the spring pasture burning season. These findings are analyzed from five sampling locations on the fort and compared to the EPA standard for maximum PM10 allowed. Ultimately, the end goal was to quantify the amount of particulate matter during the burning season and make recommendations whether to continue air quality monitoring and the appropriate method of sampling. Both PM10 and PM2.5 were considered in the initial planning and the monitors provided were capable of measuring each depending on the impact sampling head selected. This study sampled for PM10 and thus allows for collecting the maximum particulate matter available. The sampling data is then compared to the Environmental Protection Agency's (EPA) PM10 standard.

Methods

The study involved five recording sites (Figure 2) on Fort Riley utilizing the SKC DPS monitors (SKC Inc., Eighty Four, PA 15330). The monitors are high volume 24 hour particulate monitors. They draw ambient air at 10 Liters per minute (Lpm) and the particulates impact on a 47 mm filter with pore size 0.3 µm (particles of 0.3 µm and larger will impact on the filter). These sites were selected within five major working and residential locations on the Fort. The sites were: #1 Camp Funston, #2 Airfield, #3 Main Post, #4 Custer Hill, #5 Camp Forsyth. Each site had a Deployable Particulate Sampler and Site #5 had two units. These were issued to our organization, the Department of Public Health, Fort Riley, Kansas, by the U.S. Army Public Health Command.

Figure 2, Location of sampling sites on Fort Riley, Kansas (Installation Map 2002)

Seven of the SKC DPS units (Figure 3) were issued for the study. Each unit had been used previously in the United States and overseas. All units were reported as serviced but no records were provided on the service status of the units. Each unit was put through a trial run prior to the background and main study period. The recording periods were two days and 28 days, respectively. Four of the sites had one unit; the fifth site had co-located units to record the variability among the DPS monitors. They sampled 24 hours per day seven days a week during the study period.

Figure 3, SKC Deployable Particulate Sampler

The DPS units were located at the base of wooden utility poles (Figure 4). The ground around the pole was groomed grass. Each filter intake was placed 72 inches above the ground and roughly on the south side of the pole. At Site 5, the #6 Unit was placed adjacent to the #5 Unit and the intake was located roughly on the west side of the pole, approximately 90 degrees from #5 intake on the south side of the pole. The cases were elevated above the ground by the height of one cinder block. Each was locked to restrict access. Four individuals, including myself, tended to the units and the data collection. Each site was located by latitude, longitude, and altitude. Additionally, a picture of each site was recorded. (Figure 4)

Figure 4, Units #1, 2, 3, 4, 5/6 at five sites

The site visits occurred in the same order each day and the trip took roughly 1.5 hours to complete beginning at approximately 8 am. The units were checked each day during the sampling periods. The background sampling occurred February 23 – 24, 2012. There was no sampling for 19 days until the main sampling period started March 15th. Each unit was reviewed for time (minutes of operation), beginning and end of period barometric pressure (mmHg), beginning and end of period Temperature (in degrees Fahrenheit), and the beginning and end intake flow (calibrated liters per minute (Lpm)). A field data sheet (FDS) recorded each 24 hours operation data for each unit. The batteries of each unit were changed at the daily site visit and pertinent comments recorded about the unit's operation, the site environment, and the weather as needed.

These deployable particulate sampling units draw 10 Lpm ambient air via a flexible hose connected to the impact sampling head. The impact sampling head has an option of collecting particulates of PM10 or PM2.5 depending on the intake cone used. Contained within the impact sampling head is the sample filter cassette (contains the sampling filter). The ambient air is pulled through the sampling filter collecting the particulates and exhausted out the pump at the unit's protective case. A rain bell covers the impact sampling head to prevent direct contact with rain and condensation. Each site had two dedicated filter cassettes and each day a new filter was utilized at each site. These filter cassettes were loaded with the appropriately numbered filter in the office and placed in an individually sealable bag prior to the site visit. After recording the previous day's data, the unit was turned off. The exposed filter and cassette was collected and replaced with the next day's sampling cassette. The sampling cassette, with exposed filter, was stored in a sealable bag and returned to the office. A new battery was installed; the unit was calibrated to 10 Lpm and the time and barometric pressure were recorded. Each time the unit had a battery replaced, the daily data was erased. The baseline settings remained unchanged.

The filters were 47 mm Whatman Quartz filters (Whatman, Clifton, NJ). These filters capture 99.95% of particulates to 0.3 µm (Whatman data, 2013). The filters were initially conditioned to a consistent temperature and humidity. The filters were weighed two times and the mean was the recorded initial filter weight. These weights were determined prior to shipment (filters provided by the Air Quality Surveillance Program, Army Institute of Public Health, U.S. Army Public Health Command). Each filter arrived in an individually numbered travel cassette for identification. The study used 186 filters. Two submissions of filters occurred. One submission included filters 1 - 50 and the second included filters 51 – 186. The filters were returned by standard mail to U.S. Army Public Health Command, Building E1675, Room 129, Aberdeen Proving Ground, MD 21010-5403.

The DPS units draw ambient air through the impact sampler head, containing the filter cassette and filter. The filter captures the particulates in the sampled air (those of 0.3 µm and larger) and the intake cone restricts the maximum size to 10 µm. The unit collects particulates for 24 hours. The accumulated particulates increase the weight of the filter. The post exposure filters were conditioned and weighed in the same process as they were when determining the pre-weights.

The loading and unloading the filters from travel cassette to sampling cassette and back to travel cassette occurred consistently. The work space was organized and clean. Cassettes were stored within sealable bags for storage and transportation. Thumb forceps moved the filters between cassettes.

The formula for determining PM Concentration in μg/m³ is the net weight change in filter pre and post exposure (Wn) * 1000 / the volume of air sampled (Va) where Va is equal to the average recorded sampling flows (in liters per minute) at the beginning and at the end of the sampling period (Qact) times the sampling time (in minutes). The formulas are as described:

PM Concentration (μg/m³) = (Wn)(10^3)/Va

Wn (ug) = Post Weight – Pre Weight

Va = Qact (Lpm) x Total Time (min)

Qact (Lpm) = Beginning Sampling Flow Lpm) + End Sampling Flow (Lpm)/2

The populated data was organized on an excel spreadsheet.

Results

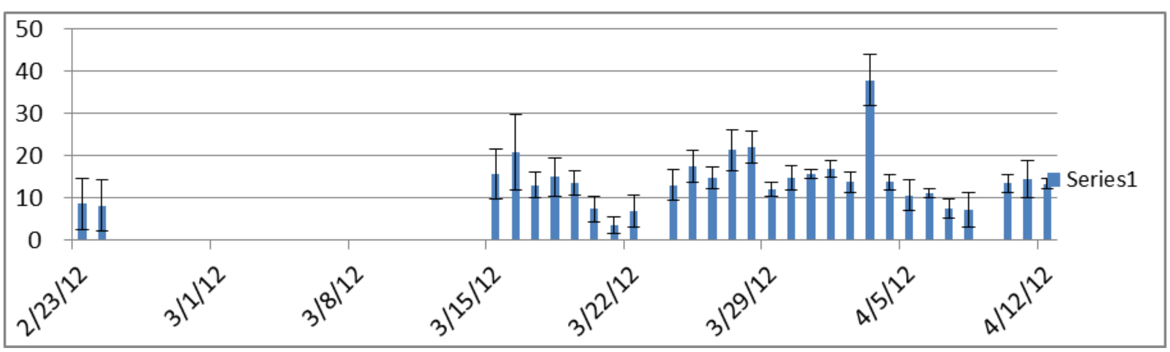
Some filters weights were excluded from the data set. The exclusions of data included one full day (six filters) and four other random filters. The full day exclusion was April 9th and was due to three of the six net weights being negative and one of the three remaining net filter weights was much lower than the remaining two. There were four additional filters and they were on random days. One was the result of zero net weight change of the filter. The second excluded filter occurred as a result of the unit sampling for less than 5 minutes. The third exclusion resulted from the PM10 measure being greater than 10 standard deviations from the day's mean and the fourth filter had a negative weight. ANOVA analysis is based on 27 days of readings (the main sampling period). The p-Values and model adjusted means are reported in Table 1.

P-value and Model Adjusted Mean by Sampling Unit

Unit[1] [3]	1 *vs.*	2 *vs.*	3 *vs.*	4 *vs.*	5 *vs.*	6 *vs.*	Mean[2]
1							12.50
2	**0.002**						15.52
3	**0.003**	0.996					15.51
4	**0.004**	0.899	0.904				15.39
5	**0.028**	0.427	0.435	0.503			14.72
6	0.513	**0.018**	**0.019**	**0.024**	0.121		13.15

Bold cells reflect statistical difference between specified unit and contrasted unit (P<0.05)
[1] One unit was located at each of sites #1-4; two units were located at site #5
[2] ANOVA Model adjusted mean
[3] ANOVA analysis, units #5 and #6 analyzed as separate locations in this chart yet are co-located units
Table 1, PM10 P-value and model adjusted means by unit

The highest recorded individual PM10 reading for this study was on April 04, 2012 at site #4. This was 44.05 µg/m³. The lowest individual reading was 1.93 µg/m³ on February 23, 2012 (Day 1 of the two day background sampling period). The main sampling period covered 29 days of time (30 days planned, units recovered one day early). For a period of 19 days, no sampling occurred in between the background sampling period and the main sampling period. The PM10 mean across all locations, was 14.04 µg/m³ and does not include the exclusions. March 21st had the lowest mean PM10 at 3.66 µg/m³ across the six units. April 3rd had the highest mean PM10 at 37.93 µg/m³ (Graph 1 /Table 2). None of the individual PM10 measures exceeded the EPA maximum of 150 µg/m³.

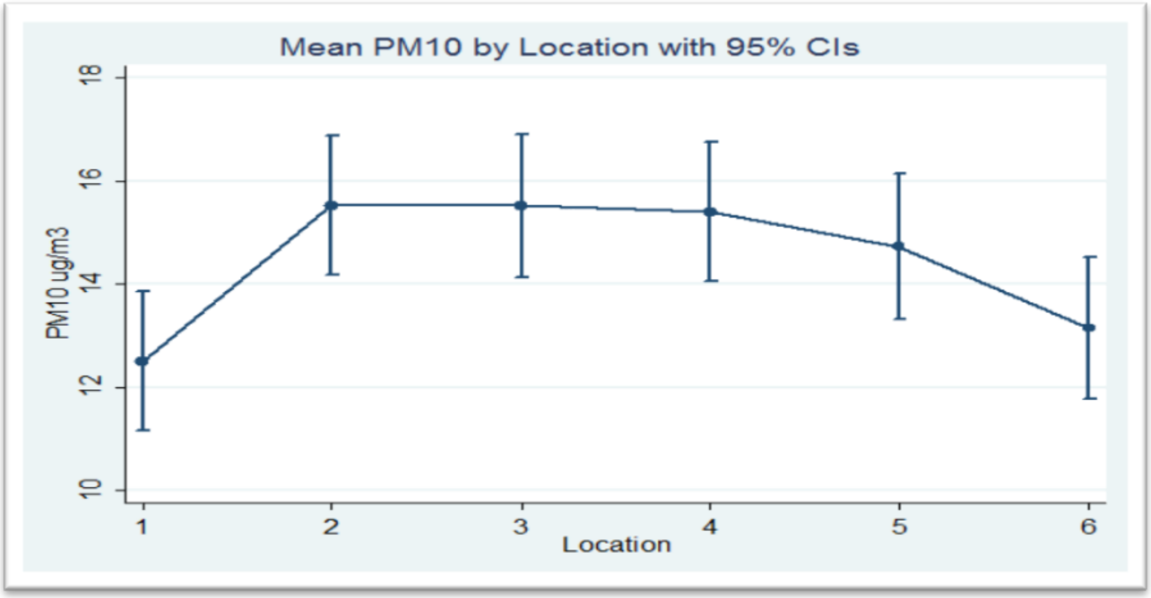


Graph 1, Daily means and standard deviations across all 5 sites

DATE	MEAN	STD
2/23/12	8.62	6.01
2/24/12	8.28	5.96
3/15/12	15.71	5.91
3/16/12	20.89	8.96
3/17/12	13.11	2.91
3/18/12	14.97	4.60
3/19/12	13.53	2.81
3/20/12	7.39	3.14
3/21/12	3.66	1.95
3/22/12	6.96	3.76
3/24/12	13.11	3.58
3/25/12	17.58	3.69
3/26/12	14.93	2.58
3/27/12	21.34	4.94
3/28/12	22.11	3.69
3/29/12	12.16	1.66
3/30/12	14.83	2.96
3/31/12	15.81	1.04
4/1/12	16.96	1.96
4/2/12	13.81	2.42
4/3/12	37.93	6.02
4/4/12	13.77	1.88
4/5/12	10.59	3.64
4/6/12	11.10	1.02
4/7/12	7.50	2.27
4/8/12	7.17	4.01
4/10/12	13.50	2.09
4/11/12	14.59	4.40
4/12/12	13.39	1.16

Table 2, Daily means and SD across location

By location, the mean PM10 readings (in µg/m³) were 12.5, 15.52, 15.51, and 15.39 for sites #1 – 4, respectively. Site #5 had two units co-located (Units #5 and #6). The mean PM10 for these two units were 14.72 and 13.13 respectively (Graph 2). The units were contrasted separately between sites as Units #1, 2, 3, 4, 5, or 6 vs. all others. There were statistical differences between Unit #1 and those units numbering 2 through 5 ($p<0.05$). However there was no difference between Units #1 and #6 ($p=0.51$). When comparing Unit #5 vs. all others, there was a statistical difference between Units #5 and #1 and no difference between Unit #5 and Unit #6 (co-located units). Contrasting Unit #6 vs. all others, there was a statistical difference between Units #2, 3, and 4 and no difference observed with Unit #1 or Unit #5. Table 1 is an abbreviated report of the ANOVA analysis containing the daily means across locations and corresponding standard deviations. The analysis considers the main sampling period minus the excluded days. The analysis is of 27 days of sampling data. Additionally, the analysis does not include the four random filters described earlier. Graph 1 and Table 2 are based on Excel formulas and include the two day back ground sampling period.



Graph 2, **Model adjusted daily mean PM10 by location**

The temperatures during the sampling period ranged from 33 to 88 degrees Fahrenheit. Frost was observed at all locations during one day of the sampling periods. There were four days classified as overcast and 16 days classified as clear. The remaining days were some degree of partly cloudy / sunny (scale from 0 to 8 with 0 being sunny and 8 being overcast). Measurable precipitation occurred on 11 days of the study and the mean daily wind speeds ranged from 2 mph to 25 mph. The weather data report was produced by the 14th Weather Squadron, USAF and was recorded at Marshall Airfield, Fort Riley, Kansas.

Discussion

The study included two background days in February (the 23rd and 24th). The second background day went longer than the planned 24 hour sampling period yet it had similar results to the first 24 hour sampling. The background days helped establish a baseline particulate matter measure prior to any widespread burning in the Central Kansas region. It established the procedures required to run the DPS units and record the data in the field. Prior to this time, they had been operated indoors for 24 hours to test battery life and DPS function. The study was originally designed for a continuous 30 day main sampling period. The 30 day main sampling period was based off of the estimated peak burning period of March 15 – April 15. Additionally, the sampling period length was affected by the number of filters available for the study. Two hundred filters were the maximum number that would be provided for the study. One day of sampling did not occur do to extensive rain on March 23rd. At the end of the study, the units were pulled from the field one day early due to wet weather, limited burning in the area for the prior week, and consistent DPS issues (failing batteries and dysfunctional units). As a result, the main study period included 27 days of sampling.

There were issues with the DPS units. The most consistent issues were the battery life and the variability of calibrated flow rates. The batteries were tested for longevity prior to the study and during the background sampling period. As the units operated 24 hours a day for days at a time, it became evident that extensive use caused nearly 50% of the batteries to fail (no specific records were kept). By the end of the study, there were not enough batteries to run the six units. Replacement batteries were requested and received two times during the study. The calibrated flow rate issues stemmed from the connectors: hose-to-barbed fittings and quick connectors at the DPS external case. Various attempts were made to mitigate the problems. There were no consistent fixes for the problems. As a result, on any given day, any of the units could have suction leaks. These leaks may have affected the data (PM10 measures) by allowing ambient air to bypass the impact sampling head containing the filter (sampling less than 10 Lpm). The maximum mean observed volume was 10.5 Lpm considering all units. The minimum was 8.4 Lpm. The EPA guidance for flow rate is 10 Lpm plus or minus 10%. The minimum was exceeded one time and the maximum was not exceeded. Daily flow adjustments occurred randomly and no particular unit consistently needed adjustment. Additional issues with the DPS units were screen and keyboard malfunctions though these issues had a negligible impact on the study data.

The 2012 pasture burning season had the least number of acres burned in the past 5 years considering the 14 county area of the Flint Hills. It was estimated at 285,715 acres (provided by Doug Watson, KDHE). In 2009, an estimated 1.2 million acres were burned (KDHE data). The EPA 24 hour maximum for PM10 measured during the main study period was never exceeded. The 24 hours limit for PM10 established by the EPA is 150 $\mu g/m^3$. The highest individual recorded 24 hour PM10 measure in this study was 44.05 $\mu g/m^3$. This is less than a third of the maximum allowed. The point to consider is that this is a 24 hour limit and does not describe the peaks and valleys during the 24 hours. The results in this study do not capture the highest momentary PM10 measurement during the 24 hours. It is plausible that during some portions of the day, PM10 values were significantly higher and that is a consideration lacking in the EPA 24 hour PM10 limit. Additionally, the limited burning that occurred in the 2012 season may skew the results to lower values when considering there were years that heavier burning occurred and periods that Kansas City and Wichita recorded values exceeding the EPA standard.

The DPS units used in this study are high volume continuous flow monitors and the capabilities are limited to collecting total particulates during an extended period. In this study, the period was 24 hours which is the EPA standard for PM10 monitoring. The limitation is the time it takes to evaluate the filters. The filters shipped from this study were to a distant laboratory for evaluation (weight changes). An additional shortcoming of this type of monitor is they do not capture the fluctuations within the daily ambient particulate matter. Pastures are generally burned individually but weather and other factors collectively affect the process when considering all pastures in a region. There is no region wide plan for burning so many pastures in an area, region, or local may burn the same day. As a result of the working relationships among area land owners and livestock producers, the weather and wind direction, societal work habits (five day work week), legacy trends, and the input from the KDHE Smoke Management Plan (SMP) and the Extension Agencies (climatic data websites, State air regulatory input, and pasture burning clinics), burns are not randomly distributed across days. The result is very intense periods of burning and potentially abrupt changes in air quality. The dissipation of the smoke cloud, the reactions in the atmosphere affecting ozone formation, and overall downrange affects have some predictability but remain largely an unknown. The SMP works to push burning to days when the smoke dispersal is best to mitigate changes in air quality. If the goal is to monitor and chart a source of particulate matter emissions that comes from a continuous emissions producer (point source) throughout the day and night, then a DPS type or similar monitor is adequate. They are useful monitors in the strategic planning for a small geographic/metropolitan area. If the goal is to monitor a source of particulate matter emissions that fluctuate in a much shorter period, then the monitor needs to be capable of measures that produce data in nearly real time (e.g. a TEOM monitor which stands for tapered element oscillating microbalance monitor). These monitors sample ambient air for particulate matter by drawing air across an oscillating filter. The particulate matter measurement is calculated from the rate of change in mass on the filter and the flow rate.

Fort Riley is considering air monitoring, both PM and ozone sampling, and the Fort is considering whether to do sampling on-site or request the KDHE place one nearby. In this study we did not sample Ozone. The study had five sampling sites for PM10. These were located along the south end of the Fort and placed in locals representing training and residential areas. The elevations ranged from 1188 – 1453 feet above sea level and included some terrain features such as hillsides and bottom land. The sampling sites with the lowest elevations were #1 and #5. Each of these had the two lowest mean PM10 results. Site #4 had the highest elevation and had the highest mean PM10 results among the five sites. Statistically, there was a difference between sites but the observed differences were not biologically significant.

This study captured PM10 data. In the future, PM2.5 data should be captured. Particulate matter of this size is considered more relevant to acute illness than PM10 and is more specifically relevant to cardiovascular events and mortality. If considering respiratory illness, acute or chronic, then ozone monitoring is important.

Fort Riley considers the safety of their Soldiers, their families and the civilian work force a high priority. Many of them work outdoors each day. During the spring, Fort Riley experiences smoky days as does much of the entire region. This study is the first outdoor air quality monitoring for PM at Fort Riley. There are currently no policies in place providing commanders and civilian personnel managers guidance to react to air quality events. Once policies are developed, they will be added to current outdoor environmental work policies (e.g., heat categories policies) as a way to improve health and decrease illness trends among the Fort's population.

PM monitors that produce only 24 hour data, such as used in this study, are not capable of providing immediate data for real time decision-making on Fort Riley. One monitor type that would measure in short periods is a TEOM monitor. It was described by Tom Gross from the Kansas Department of Health and Environment as an appropriate monitor for real time PM measurements. It takes samples, measures, and purges within minutes, thus providing rolling and long term averages. These monitors may be mobile or stationary and accessed remotely for data. Kansas uses these monitors in several locations throughout the State. The approximate cost for this type of unit, on a trailer and remotely accessible by computer, is $45,000 to 50,000. Costs associated to train personnel to use the equipment are additional. As Fort Riley considers the costs associated with air quality monitoring, another consideration is to establish an agreement to use a KDHE monitor for specific periods each spring or ask to have a unit placed adjacent to Fort Riley and utilize the data. That may ease some of the capital investment by Fort Riley and all the related storage and maintenance costs associated with owning expensive equipment.

Conclusion

Fort Riley occupies nearly 101,000 acres (Wikipedia, 2013). It burns 20,000 acres annually. Most of the burning occurs during the spring but residual acres may burn periodically through the year. The impact of Fort Riley managing/burning their property has a minimal impact on the main working and living areas because most burning occurs on the outskirts of populated areas.

These areas are burned in accordance to an approved burn plan. This plan directs burning to occur during periods that the wind and weather moves the smoke away from the populated areas.

Fort Riley has an approximate daytime population of 36,000 people. Like many military posts, the daytime and night time populations fluctuate as civilians and Soldiers migrate in and out for work. The Fort has a residential population of approximately half the daytime number. The Fort is considering what effects pasture burning has on the residents, civilians and military workforce. The season of concern is relatively short (45-60 days and the majority of burning occurs in a 30 day window). This season may also overlap the beginning of the spring allergies. Together they may affect the health of individuals.

Fort Riley is utilizing the data presented in this paper and comparing it to other variables, such as medical encounters coded for asthma and cardiac visits and to assess whether there is a plausible link among these variables. Additionally, elevated ozone levels should be considered a significant variable regarding respiratory health. This study did not assess the relationships of elevated particulate matter and ozone levels and human health. A study specific to this region of Kansas, with relevant PM and Ozone data, and compared to emergency visits, hospitalizations and routine respiratory/cardiac encounters, may help describe the effects of smoke on Kansas residents. Additionally, an elemental/chemical evaluation of the smoke would explain the composition of the smoke. There appears to be no published data on the chemical makeup of the smoke produced from tallgrass prairies. PM2.5 sampling should replace PM10 sampling because of its relevance to acute episodes of cardiovascular mortality.

Fort Riley has a significant population. It is understandable that further consideration is needed to understand its air quality and how it can affects their residents, Soldiers and the civilian workers during the spring pasture burning season. The need is for more sensitive data and thus more sensitive equipment to determine the changes of particulate matter during the spring. A TEOM monitor should be considered to accomplish this. Fort Riley has a good working relationship with the Kansas Department of Health and Environment and they can be a valuable resource. Together, both parties can work through the issues. This includes decisions of purchase versus leasing versus borrowing, the training and data analysis, and policy development that Commanders and civilian mangers can utilize. As a result, a more informed community is a healthier community and that benefits everyone who calls Fort Riley, Kansas home.

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