QATAR UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

ELEMENTAL COMPOSITION, SOURCE TRACKING, AND AIR QUALITY ASSESSMENT

OF PM2.5 AND PM10 POLLUTION IN QATAR

BY

AHMAD ALI AHMADI

A Thesis Submitted to

the Faculty of the College of Arts and

Sciences

in Partial Fulfillment

of the Requirements

for the Degree of

Masters of Science in

Environmental Sciences

January 2018

© 2018 Ahmad Ali Ahmadi. All Rights Reserved.
COMMITTEE PAGE

The members of the Committee approve the Thesis of Ahmad Ali Ahmadi
defended on 12/12/2017.

____________________
Ipek Goktepe
Thesis/Dissertation Supervisor

____________________
Konstantinos Kakosimos
Committee Member

____________________
Perumal Balakrishnan
Committee Member

____________________
Yousra Soliman
Committee Member

Approved:

____________________
Rashid Al-Kuwari, Dean, College of College of Arts and Sciences
ABSTRACT

AHMADI, AHMAD, ALI., Masters

January: 2018, Environmental Sciences

Title: Elemental Composition, Source Tracking, and Air Quality Assessment of PM2.5 and PM10 Pollution in Qatar

Supervisor of Thesis: Goktepe, Ipek.

Particulate matter (PM) pollution is one of the major environmental pollution issues severely affecting human health and air quality all over the world. Based on the recent World Health Organization (WHO) report, PM levels were considered relatively high in Qatar. This might mainly be attributed to arid climate, but also due to rapid industrialization and urbanization as well as traffic. The literature on PM pollution and its source is limited in Qatar and the region. Therefore, this study was carried out to assess the air quality based on PM2.5 and PM10 levels at different locations in Qatar, determine the elemental composition of PM2.5 and PM10 to trace their sources, and create a map by using Geographical Information System (GIS) to show the air quality based on PM levels in select locations in Qatar.

A total of 100 samples (60 for PM2.5 and 40 for PM10) were collected using SKC Deployable Particulate Sampler (DPS) System for 24-hr during the months of September to December, 2016. The sampling was conducted at five different locations, namely, Qatar University (QU), Education City (EC), Aspire Zone (AZ), Whole Sale Market area (WM), and Al-Wakrah City (AW). The elemental composition of PM samples was determined using an inductively coupled plasma optical emission spectrometry (ICP-OES). The
relationship between the environmental conditions and PM levels were also established.
The health risks associated with different PM levels were calculated using the US EPA Air Quality Index (AQI) tool. The AQI values calculated based on the daily concentrations of PM2.5 and PM10 at each sampling location were computed on maps using GIS modeling system in combination with Google Earth.

The overall mean concentrations of 24-hr PM2.5 ranged from 50 µg/m³ to 64 µg/m³, while PM10 levels were between 127 µg/m³ and 185 µg/m³. The four months mean concentrations of PM2.5 were determined to be 50, 64, 55, 59, and 57 µg/m³ at QU, EC, AZ, WSM, AW, respectively. The average 24-hr PM10 levels were 138 µg/m³ at QU, 156 µg/m³ at EC, 127 µg/m³ at AZ, 185µg/m³ at WM, and 160 µg/m³ at AW. The concentrations of PM2.5 detected at each station exceeded the WHO guideline (20 µg/m³) by 2.5 to 3 fold during the study period.

The presence of high concentrations of Ca, Fe, Al, Fe, Sr, Mn, Na, and Mg indicated the major sources of PM to be soil/crustal. The identification of Ni, Co, Cr, Cd, Ba, Pb, V, and Zn were directly related to anthropogenic sources, specifically due to fossil fuel combustion and vehicular emission and these levels were reported at the highest levels at the wholesale market station. The AQI levels determined at all stations indicated that overall air quality at Qatar University and Aspire Zone area was considered to be “Moderate” for PM10 and “Unhealthy for sensitive group” for PM2.5 levels. While Education City, Whole sale Market, and Al-Wakrah city areas had “unhealthy” and “unhealthy for sensitive group” ratings for PM2.5 and PM10 levels, respectively.

The statistical analysis on determining the effect of sampling date and locations on the concentration of PM2.5 and PM10 showed that there is a significant relationship (p<0.01) between PM levels, sampling stations, and sampling date.
These findings highlight the need for more research on PM pollution 1) to determine seasonal levels since this study only covered four months (September-December), 2) to better understand the source of PM pollution (in addition to elements, the levels of Poly Aromatic Hydrocarbons should also be determined), and 3) to establish more effective control measures to protect public health and preserve the environment in Qatar.
I would like to dedicate my work to the residents of Qatar who need to know more about air quality.
ACKNOWLEDGMENTS

I would first like to thank my thesis advisor Prof. Ipek Goktepe in the Department of Biological and Environmental Sciences at Qatar University (QU) for her support, patience, and guidance during my master’s degree. Thank you Prof. Ipek for your patience with me to finalize this work. You were really diligent in every step of the writing process. I cannot thank you enough and will remember all your hard work and support forever. Special thanks to my committee members who were very helpful, supportive, and encouraging; special thanks and gratitude are for Dr. Konstantinos E. Kakosimos, who I consider as the first person to ask advice on air pollution field in Qatar; Dr. Perumal Balakrishnan who provided all the support and assistance needed to complete the maps and also advised me during my BSc graduation project; and Dr. Yousria Soliman Mohamed Elfaham for her guidance and advice in this master’s thesis. Thanks to Ms. Israa El-Nemr who was the second hidden supervisor during my lab work. Thanks to the department, specifically the heads of the department who encouraged me to enter the bachelor’s degree in Environmental Science, Dr. Hamda Al-Naimi and Dr. Samir Jaoua, who helped obtain the accreditation from CHES, Dr. Fatima Al-Naimi, who supported our batch in bachelor’s degree to have training in Oman, and our new head of the department, Dr. Mohammad Al-Safran, who allowed me to work in the department laboratories to complete my thesis work. I would also like to thank Dr. Mohammed Abu-Dieyeh, the graduate coordinator, for his patience on all our inquiries about master’s degree program and help in securing a Graduate Teaching Assistantship in the department.
Furthermore, this project would not be completed without getting technical help from the Central Laboratory Unit (CLU) at QU, especially Dr. Said Al-Meer, who gave me the opportunity to analyze my samples using their labs, and Ms. Sherin who instructed me during the ICP-OES analysis of my samples. Besides CLU, Environmental Science Center (ESC) also provided me with the opportunity to use their labs to complete extraction of PM samples for elemental analyses. I would like thank specially Ms. Hajer Al-Naimi in ESC, who was carefully following my work during that period, and Ms. Marwa, who worked with me during the extraction procedure. Finally, I would like to thank all my colleagues for their support and friendships during this journey.
# Table of Contents

DEDICATION .................................................................................................................. vi

ACKNOWLEDGEMENTS .............................................................................................. vii

List of Figures ................................................................................................................ xi

List of Tables .................................................................................................................. xii

CHAPTER I: INTRODUCTION .................................................................................... 1

CHAPTER II: LITERATURE REVIEW ......................................................................... 4

1.1. Particulate Matter ................................................................................................ 5

1.2. Size Distribution of Airborne Particulate Matter .............................................. 8

1.3. PM Pollution Sources in Qatar .......................................................................... 10

1.4 Anthropogenic Sources ...................................................................................... 13

1.4.1 Industrial Activities ....................................................................................... 13

1.4.2 Traffic ............................................................................................................ 13

1.6 Meteorology in Qatar ......................................................................................... 15

1.7 Chemical Composition of PM ........................................................................... 17

1.7.1 Elemental Composition of PM ...................................................................... 18

1.8 Health Effects of PMs ....................................................................................... 21

2.1 Justification ......................................................................................................... 23

2.2 Objectives of the Study ...................................................................................... 24

CHAPTER III: MATERIALS AND METHODS ............................................................. 25
List of Figures

Figure 1. Size distribution of PM in ambient air (WHO, 2006) ........................................ 10
Figure 2. TSP source emission by their size distribution (Vega et al., 2001) .................. 18
Figure 3. Map of sampling locations ................................................................. 27
Figure 4. Deployable Particle Sampler ............................................................... 29
Figure 5. Exploded view of IMPACT Sampler .................................................. 30
Figure 6. The comparison of the USEPA standards and the average mean concentrations of PM2.5 and PM10 recorded at different locations during the study period ............. 38
Figure 7. The percentage distribution of different Air Quality Index ratings during the sampling months ................................................................. 43
Figure 8. Land use Illustration at Aspire Zone ..................................................... 45
Figure 9. Land Use Illustration at Qatar University ............................................. 46
Figure 10. Land Use Illustration at Whole Sale Market ....................................... 47
Figure 11. Land Use Illustration at Education City ............................................. 48
Figure 12. PM2.5 based Air Quality Index Values at the sampling stations ............... 50
Figure 13. PM10 based Air Quality Index Values at the sampling stations ............... 51
Figure 14. Illustration of Land use at of Qatar University ..................................... 58
Figure 15. Illustration of Land use at Education City ......................................... 59
Figure 16. Average concentrations of heavy metals in PM2.5 collected from different sampling stations ................................................................. 61
Figure 17. Average concentrations of heavy metals in PM10 samples collected from different sampling stations ................................................................. 61
List of Tables

Table 1  Ambient air pollution limits in Qatari Environment Protection Law 30 (2002) and World Health Organization (WHO, 2005) ................................................................. 7

Table 2  World Health Organization’s report on PM levels in Qatar (WHO, 2016) ........ 8

Table 3  Particulate matter (PM) standards established by USEPA, WHO, Qatar, and several Middle East Countries (Tsiouri et al., 2015) ....................................................... 12

Table 4  Maximum and minimum temperatures measured at Hamad Airport during 2012 (MDPS, 2013) ........................................................................................................ 16

Table 5  Maximum and minimum relative humidity (%) measured at Hamad Airport during 2012 (MDPS, 2013) ........................................................................................................ 17

Table 6  Elemental composition of PM10 samples collected in Iraq and Kuwait (Naimabadi et al., 2016) .................................................................................................................. 19

Table 7  Outdoor elemental composition of PM2.5 and PM10 (Saraga et al., 2017) ....... 21

Table 8  Flow rate measurements of each PM2.5 and PM10 sampling device at the time of calibration ......................................................................................................................... 30

Table 9  Tuning parameters of the ICP-OES .................................................................. 33

Table 10  Air Quality Index categories by Level of Health concern and Colors (AirNow, 2016) ............................................................................................................................ 35

Table 11  The mean concentrations of PM2.5 and PM10 samples collected from different Stations and Meteorological data ................................................................. 37

Table 12  The Air Quality Index Values calculated based on the concentrations* of PM2.5 and PM10 during the study period ................................................................. 42

Table 13  Air Quality Index Values calculated based on the four month averages of PM2.5 xii
and PM10 at different stations ................................................................. 44

Table 14 Elemental composition concentration of PM2.5 samples collected from different locations .............................................................................................................................................. 55

Table 15 Elemental composition concentration of PM10 samples collected from different locations .............................................................................................................................................. 56

Table 16 Enrichment Factor (EF) Values for elements determined in PM2.5 and PM10 samples (µg/m³) .............................................................................................................................................. 64
CHAPTER I: INTRODUCTION

In the last few years, the State of Qatar has been going through many changes and developments in the economy, urban environments, and construction. The population of Qatar is rapidly growing, reaching 2,668,415 according to the latest statistics. This figure is expected to increase to three million by 2026 (MDPS, 2017). The fast population growth caused many environmental changes. Qatar’s National Vision 2030 was developed to address these environmental changes by establishing a balance between economic growth, social development, and environmental protection. The vision emphasizes sustaining the environment for the future generations by balancing between developmental needs and the protection of the natural environment, land, sea, and air (Sillitoe, 2014).

As a result of this initiative, air quality research field has received much needed attention from researchers in Qatar as well as around the world. There is now a substantial body of epidemiological evidence that establishes a link between exposure to air pollution and increased mortality (especially premature death) and morbidity due to a wide range of adverse cardiovascular and respiratory problems (Lee et al., 2014). There are various pollutants in the air, such as nitrogen oxides (NOx), sulfur oxides (SOx), ozone (O₃), particulate matter (PM), CO, CO₂, hazardous air pollutants (e.g., aldehydes, PAHs, etc.).

Particulate matter are fine particles that are suspended in the air and originate from different sources (Laden et al., 2000), including natural and anthropogenic sources (EPA, 2015). Natural sources include wind-blown desert dust, sea spray aerosols, volcanoes, seismic activity, and wild fires (EPA, 2015; Putaud et al., 2004). Examples of
anthropogenic sources include vehicle emissions from fuel combustion, domestic heating, incineration, construction and emissions from thermal power generation (EEA, 2015; Hassan et al., 2016). The major size distribution of PM is between 2.5 and 10 μm (PM2.5 and PM10) (Khan et al., 2010). PM2.5 sources are mainly dust/soil, oil combustion, petrochemical industries, and traffic emissions (Brow et al., 2013). In contrast, PM10 mainly comes from natural sources and transportation (Lenschow et al., 2001).

Many studies have investigated the effects of different sizes of PM and their impact on human health (Davidson et al., 2005). Several health problems result from PM exposure, like respiratory and cardiovascular morbidity, asthma and other respiratory symptoms, and mortality related to lung cancer (Brook et al., 2010; Chen et al., 2016). The sources of PM can be identified based on the chemical and physical properties of these pollutants and their reactions with other chemicals suspended in the air (Ye et al., 2017). The health effects depend on the exposure time and doses (Shaughnessy et al., 2015). The effects also depend on the concentration of PM (PM2.5, PM10; unit mass/m³), the PM’s complex compositions of trace metals and other elements. Therefore, it is important to identify the probable source of PM promptly.

The Middle East is considered one of the most polluted areas in terms of PM pollution (Elbayoumi et al., 2013). Rapid urbanization and construction in this region have created concerns about rising health problems related to PM pollution (Tsiouri et al., 2015). Factors that affect the dispersion and concentration of PM include temperature, humidity, the height of the mixing layer, and pressure (Khan et al., 2010; Marcazzan et al., 2001). Qatar is located in an arid region with desert features similar to other Middle
Eastern countries. The World Health Organization (WHO) has reported high levels of PM2.5 and PM10 in this area (WHO, 2016).

Since Qatar is a fast developing nation, air pollution issues related to PM pollution need urgent attention. Therefore, this study was carried out to monitor the concentrations of PM (PM2.5 and PM10) at different locations in Qatar by integrating emissions within a framework based on a geographic information system (GIS) using different modeling techniques. The study also aimed at investigating the air quality based on PM concentrations and elemental compositions of PM to identify the main source at these sampling sites. The results obtained in this study could be helpful to protect public health and the environment in Qatar.
CHAPTER II: LITERATURE REVIEW

Air pollution problem has become an important public health issue as a result of massive population increases and industrial development (Loupa et al., 2016). Numerous air pollution studies offer indications relating diverse effects and diseases to the toxic substances present in air pollutants (Vallero, 2014). Air pollution in urban areas considered as significant problem, especially in developing countries (Mage et al., 1996). The World Health Organization (WHO) conducted a study on air pollution in 1958 which showed that scientists need to focus deeply on air pollution and its effects on humans, organisms, and earth systems (WHO, 2016). Specific studies carried out during the twentieth century have focused on acid rain in European counties and the United States (Patel et al., 1974; Schindler, 1988). Acid rain is a common type of pollution in many developed countries and can affect people’s lives. However, acid rain is not a global issue, but there are other global air pollution problems that are occurring in tropical and desert countries. In the last part of the twentieth century, scientists started to understand the composition of air pollution, which opened up more opportunities to investigate air pollution in a wider view and to investigate more details by combining sources with other factors (Vallero, 2014).

Air pollution is caused by a mixture of complex components of solids and liquids that vary in size, composition, and origin (natural and anthropogenic) (Dockery et al., 1993; Samet et al., 2002; Brook, et al., 2004). The anthropogenic sources are made by people through automobiles, industry, construction, etc. In contrast, natural sources are mainly from dust, volcanoes, and forest fires, etc. (Kampa & Castanas, 2008). Current
scientific evidence proves the fact that outdoor air pollution causes a variety of diseases, such as respiratory illnesses, cardiovascular illnesses, and death. One of the major air pollutants considered to be the most detrimental to human health is particulate matter (PM).

1.1. Particulate Matter

Particulate matter (PM) are a mixture of solid and liquid particles that are organic and inorganic chemicals (Jang et al., 1997; Laden et al., 2000). Anthropogenic sources that are most dominant in urban areas include industrial fuel combustion, domestic heating in houses, fuel burned by vehicles, road wear, and other sources (EEA, 2015). The elemental composition of PM depends on the source. For example, the elements commonly found in PM generated by power plants are nickel, zinc, sulfate, and mineral aerosol (sodium, magnesium, chloride). Sources including vehicles emit elements such as trace elements, and nitrate, elemental/organic carbon (Rodríguez et al., 2004). Toxic heavy metals like Cd, Pb, Cr, Zn, Ni, and As are usually emitted by the metal industry, and Al, Si, K, Ti, and Fe are distributed by coal combustion. Al and Fe are the main crustal elements that used to be compared with other elements to identify possibility of anthropogenic sources. PM with significant fractions of Si, Cl, and Fe mainly come from burning biomass (Rodríguez et al., 2004). Elements like Na, Cl, and Mg are mainly form sea spray and sea salts (Viana et al., 2008).
There are six criteria air pollutants listed by the United States Environmental Protection Agency (USEPA) under the National Ambient Air Quality Standards (NAAQS) for Clean Air Requirement (USEPA, 2016). These air pollutants are ground-level ozone, PM, CO, lead, sulfur dioxide, and nitrogen dioxide. These pollutants were chosen based on their human health effects and the environmental damage they cause. The Ministry of Environment and Municipality in Qatar uses the same standards as listed by the USEPA with different pollution levels near the surrounding countries’ levels (Tsiouri et al., 2015). The concentration limits of PM10 for 24 hours is 150 µg/m³ and 50 µg/m³ a year, which stays within the limit of other Middle East countries. For PM2.5 limits, the criteria set by the WHO is 50 µg/m³ for 24 hours and 20 µg/m³ annually, but in Qatar, there is no standard limit for PM2.5 (Table 1).
Table 1

Ambient air pollution limits in Qatari Environment Protection Law 30 (2002) and World Health Organization (WHO, 2005)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>Concentration averaged over</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Qatar</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>μg/m³</td>
<td>400</td>
</tr>
<tr>
<td>(NO₂)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>μg/m³</td>
<td>150</td>
</tr>
<tr>
<td>&lt;10 μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>μg/m³</td>
<td>25</td>
</tr>
<tr>
<td>&lt;2.5 μm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>mg/m³</td>
<td>40</td>
</tr>
<tr>
<td>(CO)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Level</td>
<td>μg/m³</td>
<td>235</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>μg/m³</td>
<td>365</td>
</tr>
<tr>
<td>(SO₂)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The most recent report on air pollution published by WHO (WHO, 2016) mentioned Qatar as one of the most polluted countries in terms of PM10 and PM2.5 levels (Table 2).
The reported values were based on the official reported results, satellites data and modelling.

Table 2

*World Health Organization’s report on PM levels in Qatar (WHO, 2016)*

<table>
<thead>
<tr>
<th>Country</th>
<th>PM2.5 [µg/m³], Urban and rural areas</th>
<th>PM2.5 [µg/m³], Urban areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar</td>
<td>Median 103, Lower 67, Upper 160</td>
<td>Median 105, Lower 69, Upper 159</td>
</tr>
</tbody>
</table>

1.2. Size Distribution of Airborne Particulate Matter

Particulate matter are categorized into three sizes relying on their aerodynamic diameter (10, 2.5, and 1 µm). PM10 which is also called inhalable coarse particles (<2.5-<10µm), can be found near roadways and dusty industries and have short lifetime in atmosphere compared to PM2.5. PM10 stays in the air for minutes to days and travel distance of less than one to hundreds Km (Joint & World Health, 2006). Common sources of PM10 are dust resuspension, mining, sea spray, construction, and demolition. PM2.5, which became the most studied pollution in the last ten years, was added to the air quality criteria because of its detrimental health effects on the respiratory system. It is called fine particles, with diameter less than 2.5 micrometer (<2.5). PM2.5 can travel long distances of up to 10⁶ kilometers with ling lifetimes reaching days and weeks, and the main source
of PM2.5 is bringing fossil fuel (organic biomass) and combustion process (Joint & World Health, 2006). It can be found in haze or smoke and is emitted directly from the source. Its size lets PM2.5 be inhaled deeper in the lungs.

Particulate matter that less than 1 μm in diameter are called PM1. It can be travel beyond the lungs disrupts systemic vascular function and causing significant health effects (Rundell et al., 2007). Its atmospheric half-life is minuets to hours and it can travel less than tens of kilometers (Joint & World Health, 2006). Composition and mass of particulate matter could be divided to main two categories which are fine and coarse particles. Particulate matter that are fine and coarse fractions are demonstrated in Figure 1.

Understanding the land use around the sampling station considered important in air pollution studies. Geographical information system software support researchers to build graphical display of geographical information to be presented on maps. That visual tools are used to visualize data in term of numbers to build more clear decision support to the reality on geography map.
1.3. PM Pollution Sources in Qatar

Increased urbanization, industrialization, and construction activities in Qatar have resulted in problems with air pollution (Tsiouri et al., 2015). Additionally, natural conditions such as dust storms often occur in the Arabian Gulf region are also contributing factors that directly impact air quality (Alam et al., 2014). Furthermore, the petroleum industry is the backbone of Arabian Gulf countries. The Qatar General Petroleum Corporation (QGPC) was established in 1974 (Bergendahl, 1985), and ranks as one of

Figure 1. Size distribution of PM in ambient air (WHO, 2006).
the largest petroleum and gas companies in the world. The recent industrial development in this region has led health organizations to establish a link between air pollution issues and petroleum industry activities (Chen et al., 2016). The total emissions of PM are mostly from natural sources, like ocean sprays, suspended dust from terrestrial areas, and burning fossil fuel. In a recent study by Hassan et al. (2016), it was found that the main source of particles size ranged between 0.25-32 µm were from wind erosion of the loose soil, where the study took place near to construction area. The limits of PM in Qatar and the Middle East were reviewed by Tsiouri et al. (2015) who reported that most of the countries in this region have higher PM limits than non-dusty countries due to the concentration levels being naturally high in this region (Table 3).
Table 3

Particulate matter (PM) standards established by USEPA, WHO, Qatar, and several Middle East Countries (Tsiouri et al., 2015)

<table>
<thead>
<tr>
<th>Standards</th>
<th>PM type and averaging time</th>
<th>PM10 (µg/m³)</th>
<th>PM2.5 (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>24-h Annual</td>
<td>24-h Annual</td>
</tr>
<tr>
<td>USEPA (EPA, 2010)</td>
<td></td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>EU (EC, 2010)</td>
<td></td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>WHO (WHO, 2006; WHO, 2011)</td>
<td></td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Jordan (Al-Zubi, 2011)</td>
<td></td>
<td>120</td>
<td>70</td>
</tr>
<tr>
<td>Kuwait (IES, 2011)</td>
<td></td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>Lebanon (LEDO, 2001)</td>
<td></td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Oman (HMR, 2010)</td>
<td></td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Qatar (Abdel-Moati, 2008)</td>
<td></td>
<td>150 (1 h) 50 (3 month)</td>
<td>-</td>
</tr>
<tr>
<td>Saudi Arabia (PME, 2012)</td>
<td></td>
<td>340</td>
<td>80</td>
</tr>
<tr>
<td>Syria (ELARD, 2009)</td>
<td></td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>UAE (EAD, 2014)</td>
<td></td>
<td>150</td>
<td>-</td>
</tr>
</tbody>
</table>
1.4 Anthropogenic Sources

1.4.1 Industrial Activities

Qatar has an area of 11,572.07 Km² and industrial cities are spread out in various locations for petroleum and chemical production. PM2.5 mainly originates from secondary pollutants (which react in the air), followed by primary pollutants (trace metals that could come from industry and transportation systems) which are mainly the sources of PM10 (Heal et al., 2012). Industrial and electrical power plants are recognized as the main stationary air pollution sources in urban cities. These sources are considered as point sources where the type of emission can be easily identified. In Qatar, there are two main power plants for electrical production with total production reaching 8000MW (QEWC, 2011). Elements like Ni, Cr, Cu, Sn, Zn, Mo, Sb, Pb, and Cd in PM could give indications of industrial activities -including power plants- (Das et al., 2015).

Highlighting industrial sources depends on the results of sampling filters collected from sites. Based on official sources, there is no data available on PM sources from industrial activities in Qatar. Since high levels of PM2.5 come from anthropogenic sources such as industry and traffic, several stationary samplers are needed to have continuous readings for longer period near the sources and living areas.

1.4.2 Traffic

Qatar is considered as one of the richest countries in the world when it comes to capital income. Transportation systems in Qatar are mainly based on private cars, and using public transportation is not common in this country. There is no metro system yet, and public bus transportation is not convenient for middle income people since using private cars is faster. Furthermore, trucks are the main method for transporting goods due
to the absence of freight trains. Particles generated by vehicle activities come from several processes, such as the combustion of fossil fuel, resuspension of road/soil dust, tire friction, and brake linings (Laschober et al., 2004). Fine particulate matter is not only from natural sources, it is also come from vehicles (Hassan et al., 2016). PM emitted from or related to traffic varies during periods of high traffic density with poor air movement in urban areas. For example, human exposure to traffic pollutants is higher in street canyons (Vardoulakis et al., 2003) and can be detected if there is a continuous air monitoring during a 24 hour period. There are several elements associated with vehicle activities, such as Fe, Br, Cu, Zn, Ba, and Pb (Huang et al., 1994).

### 1.4.3 Construction

Qatar is considered one of the fastest developing countries with heavy construction activities supported by the strong economy. Since winning the World Cup 2020 bid, construction activities have been sped to build stadiums and infrastructures. A recent study conducted near construction sites in Qatar reported the increased concentrations of PM pollution mainly due to the presence of Calcisols (that resulted from the accumulation of secondary carbonate coming from the construction site) (Hassan et al., 2016). As Qatar characterized by its dry and arid environment (Gopalswami et al., 2015), erosion of the soil and its suspension in the air column during construction activities will increase the particulate matter pollution.
1.5 Natural Sources

In Qatar, dust storms normally occur within specific months of the year. Qatar is a desert country where no fires could increase the pollutants significantly like forest and tropical forest regions. As a result, the elemental composition of PMs will be consisted of the minerals dust like Ca, Fe, Sr, Si, K, and Ti (Weckwerth, 2001) which are mostly available in Qatar and outer regional countries.

1.6 Meteorology in Qatar

Qatar is one of the Gulf Cooperation Council (GCC) countries which is characterized by a desert biome. Qatar has characteristic of dry and arid region conditions (Gopalaswami et al., 2015). This leads to hot temperatures in summer and slightly colder temperatures in winter. However, the peninsula shape results in high relative humidity compared to other GCC countries. The most recent data published by the Ministry of Development Planning and Statistics (MDPS, 2013) on the temperature and relative humanity at the Hamad Airport and other stations is presented in (Table 4). According to the report, the maximum average daily temperature in summer reaches 43.3°C and at least 22.5°C in winter. In summer, the average maximum humidity is 66 to 88%, and minimum is 29 to 60%.
Table 4

*Maximum and minimum temperatures measured at Hamad Airport during 2012 (MDPS, 2013)*

<table>
<thead>
<tr>
<th>Month (2012)</th>
<th>Extreme Temperature Absolute Max (°C)</th>
<th>Extreme Temperature Absolute Min (°C)</th>
<th>Number of days with Max. Temp. and Min. Temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;=25  &gt;=30  &gt;=35  &gt;=40  &gt;=45 &lt;=10</td>
</tr>
<tr>
<td>January</td>
<td>28.0</td>
<td>8.6</td>
<td>5      0      0      0      0      0      2</td>
</tr>
<tr>
<td>February</td>
<td>29.8</td>
<td>11.5</td>
<td>4      0      0      0      0      0      0</td>
</tr>
<tr>
<td>March</td>
<td>37.8</td>
<td>12.8</td>
<td>19     5      2      0      0      0      0</td>
</tr>
<tr>
<td>April</td>
<td>39.8</td>
<td>19.5</td>
<td>30     25     7      0      0      0      0</td>
</tr>
<tr>
<td>May</td>
<td>46.8</td>
<td>27.2</td>
<td>31     31     31     4      1      0      0</td>
</tr>
<tr>
<td>June</td>
<td>47.7</td>
<td>27.6</td>
<td>30     31     30     28     6      0      0</td>
</tr>
<tr>
<td>July</td>
<td>47.6</td>
<td>30.0</td>
<td>31     30     31     31     8      0      0</td>
</tr>
<tr>
<td>August</td>
<td>46.1</td>
<td>29.6</td>
<td>31     31     31     23     2      0      0</td>
</tr>
<tr>
<td>September</td>
<td>43.5</td>
<td>25.5</td>
<td>30     30     30     15     0      0      0</td>
</tr>
<tr>
<td>October</td>
<td>40.5</td>
<td>25.8</td>
<td>31     31     19     2      0      0      0</td>
</tr>
<tr>
<td>November</td>
<td>35.0</td>
<td>18.4</td>
<td>8      17     1      0      0      0      0</td>
</tr>
<tr>
<td>December</td>
<td>31.3</td>
<td>14.3</td>
<td>16     1      0      0      0      0      0</td>
</tr>
<tr>
<td>Annual</td>
<td>47.7</td>
<td>8.6</td>
<td>266    232    182    103    17     2      0</td>
</tr>
</tbody>
</table>
Table 5

*Maximum and minimum relative humidity (%) measured at Hamad Airport during 2012 (MDPS, 2013)*

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>60</td>
<td>59</td>
<td>49</td>
<td>42</td>
<td>34</td>
<td>29</td>
<td>34</td>
<td>43</td>
<td>43</td>
<td>47</td>
<td>55</td>
<td>62</td>
</tr>
<tr>
<td>Max</td>
<td>88</td>
<td>87</td>
<td>82</td>
<td>71</td>
<td>71</td>
<td>66</td>
<td>73</td>
<td>80</td>
<td>77</td>
<td>82</td>
<td>82</td>
<td>88</td>
</tr>
</tbody>
</table>

1.7 Chemical Composition of PM

Particulate matter can differ in physical size and chemical composition (Figure 2). Many different chemical compounds have been detected in PM, but they are mainly sulfates, nitrates, elements, polycyclic hydrocarbons, and other organic chemicals. Vega et al. (2001) indicated that the source of PM2.5 is crude oil combustion, followed by road and soil dust. PM10 originates from road, soil, and construction dust.
Figure 2. TSP source emission by their size distribution (Vega et al., 2001)

1.7.1 Elemental Composition of PM

The elemental composition of PM depends on spatial and temporal factors. The composition reflects the source and activity around the area. Also, at a certain time of the year, there are higher PM concentrations and it contains a great variety of elements attached to the particles. The elemental composition of PM varies between areas and could depend on industrial, transportation, and meteorological factors. Naimabadi et al. (2016) reported on the PM10 concentration and its composition on normal days and during dust storms. It was concluded that there is no significant connection between their elemental compositions, but the study highlighted that elements in PM10 could lead to
cytotoxicity. The study area was similar to Qatar in terms of temperature and near Iraq and Kuwait. The elemental compositions of PM samples determined in this study are shown in Table 6 (Naimabadi et al., 2016).

**Table 6**

*Elemental composition of PM10 samples collected in Iraq and Kuwait (Naimabadi et al., 2016)*

<table>
<thead>
<tr>
<th>Elements</th>
<th>Metal contents of PM10 in dust events day (ng/m³)</th>
<th>Metals contents of PM₁₀ in normal days (ng/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Al</td>
<td>35137.76</td>
<td>20751.96</td>
</tr>
<tr>
<td>Fe</td>
<td>28387.17</td>
<td>26348.50</td>
</tr>
<tr>
<td>Zn</td>
<td>34202.83</td>
<td>44192.53</td>
</tr>
<tr>
<td>Pb</td>
<td>52.06</td>
<td>61.31</td>
</tr>
<tr>
<td>Cr</td>
<td>72.62</td>
<td>81.36</td>
</tr>
<tr>
<td>Cu</td>
<td>83.81</td>
<td>40.74</td>
</tr>
<tr>
<td>Cd</td>
<td>19.50</td>
<td>15.49</td>
</tr>
<tr>
<td>As</td>
<td>6.67</td>
<td>12.06</td>
</tr>
<tr>
<td>V</td>
<td>82.96</td>
<td>93.32</td>
</tr>
<tr>
<td>Ni</td>
<td>74.34</td>
<td>52.77</td>
</tr>
</tbody>
</table>
Das et al. (2016) conducted a study in Baranagar, a crowded city in India with high PM emission from anthropogenic sources, between 2013-2014. It was highlighted in this study that the PM concentration surpassed the normal WHO organization limits and reached 783 µg/m³ (84–783 µg/m³) for PM2.5 and 928 µg/m³ (167–928 µg/m³) for PM10. Many toxic metals were detected in PM2.5, such as Cd, Cu, V, Cr, Ni, Zn, Mo, S, and Sb. Anthropogenic sources, mainly industry, have an enrichment factor for Ni, Cr, and Cu between 100 and 10 ng/m³, while Sn, Zn, Mo, Sb, Pb, and Cd had an enrichment factors between 1000 and 100 ng/m³. The elemental composition of PM2.5 in Kavala, Greece was investigated by Loupa et al. (2016). It was found that the highest concentrations of elemental components in PM2.5 were S (1321.0 µg/m³), followed by Na (657.7 µg/m³), K (374.68 µg/m³), Ca (448.00 µg/m³), Al (360.34 µm/m³), Si (325.50 µg/m³), Fe (147.30 µg/m³), Mg (126.32 µg/m³), Zn (62.19 µg/m³), and Ni (4.87 µg/m³) (Loupa, Zarogianni, Karali, Kosmadakis, & Rapsomanikis, 2016). A recent study focusing on the chemical characteristic of particulate matter monitored indoor and outdoor environments for a duration of two months in Qatar was published by (Saraga et al., 2017). The authors found that there is a positive correlation between indoor and outdoor pollution where pollutants could enter through ventilation system and window/cracks into the building. They concluded that the indoor PM concentrations can be influenced by the outdoor PM concentrations during dusty days. The elemental compositions of outdoor PM 2.5 and PM10 samples collected in Doha as reported in this study is provided in Table 7.
Table 7
*Outdoor elemental composition of PM2.5 and PM10 (Saraga et al., 2017)*

<table>
<thead>
<tr>
<th>Element</th>
<th>PM$_{2.5}$ outdoors</th>
<th>PM$_{10}$ outdoors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>2876</td>
<td>4288</td>
</tr>
<tr>
<td>Fe</td>
<td>3357</td>
<td>5165</td>
</tr>
<tr>
<td>Mn</td>
<td>88.8</td>
<td>138</td>
</tr>
<tr>
<td>Ba</td>
<td>72.2</td>
<td>115</td>
</tr>
<tr>
<td>Sr</td>
<td>111</td>
<td>165</td>
</tr>
<tr>
<td>V</td>
<td>28.6</td>
<td>35.7</td>
</tr>
<tr>
<td>Cr</td>
<td>19.8</td>
<td>39.3</td>
</tr>
<tr>
<td>Rb</td>
<td>3.64</td>
<td>5.41</td>
</tr>
<tr>
<td>Ni</td>
<td>21.1</td>
<td>36.6</td>
</tr>
<tr>
<td>Zn</td>
<td>45.8</td>
<td>63.8</td>
</tr>
<tr>
<td>Cu</td>
<td>31.86</td>
<td>53.7</td>
</tr>
<tr>
<td>Co</td>
<td>2.24</td>
<td>3.59</td>
</tr>
<tr>
<td>Ga</td>
<td>1.22</td>
<td>1.85</td>
</tr>
<tr>
<td>Pb</td>
<td>17.77</td>
<td>20.6</td>
</tr>
<tr>
<td>Cs</td>
<td>0.31</td>
<td>0.45</td>
</tr>
<tr>
<td>As</td>
<td>1.39</td>
<td>2.03</td>
</tr>
<tr>
<td>Cd</td>
<td>0.17</td>
<td>0.27</td>
</tr>
</tbody>
</table>

1.8 Health Effects of PMs

An association has been established between PM pollution and various kinds of health effects (Cascio, 2016). The WHO reported that three million deaths around the world are a result of air pollution (WHO, 2016). In Europe, PM2.5 pollution was related to 432,000 premature deaths in 2012 due to long-term air pollution exposure (EEA, 2015). PM could affect the cardiovascular system and result in sudden heart attacks (Chan et al.,
and irregular heartbeat. Respiratory effects include asthma (Baldacci et al., 2015) and decreased lung function (USEPA, 2016). There were 428 cases of people who contracted chronic obstructive pulmonary disease in Iran in 2009-2013 (21, 111, 94, 102, and 98 in each respective year) due to air pollution issues (Khaefi et al., 2017).

In recent years, studies have also identified a link between PM exposure and cancer (Raaschou-Nielsen et al., 2016; Loomis et al., 2013; Hamra et al., 2014). PM with different size fractions can cause direct damage to DNA, and changes in DNA could cause cancer when there is no DNA repair mechanism (Lynch et al., 2016). Characterization of the components of PM is important to identify potential risks to human health (Bari et al., 2016). PM2.5 can reach deeper parts of the lungs and cause much more serious health effects compared to PM10 (Khan et al., 2010). A study on more than three million people was carried out to correlate the PM components with cancer in different European countries (Raaschou-Nielsen et al., 2016). It was concluded that the elemental composition is a significant cause of cancer. The study focused on eight elements (Cu, Fe, K, Ni, S, Si, V, and Zn), and highlighted the high levels of S and Ni (Raaschou-Nielsen et al., 2016).

Chen et al. (2016) investigated the mortality and lung cancer with long-term exposure (12 years) to PM. They found that with every increase in PM10 concentration of 10 µg/m³, the probability of mortality by lung cancer increases by 3.4–6.0% (Chen et al., 2016). In addition, the concentration of PM is also significant because its individual components can lead to different health effects (Forsberg et al., 2005; Cassee et al., 2013; Peters et al., 2015). Outdoor air pollution, particularly with PM as a major component, is classified as a Group 1 pollutant (carcinogenic to humans) by the International Agency for Research on Cancer (IARC, 2013). Malley et al. (2017) investigated the correlation of
PM2.5 pollution with preterm birth in 183 countries around the world in 2010. The results showed that mothers who are exposed to more PM2.5 pollution have more risk factors that contribute to increasing preterm birth (Malley et al., 2017). In this region, Naimabadi et al.’s study (2016) is the only one which provides a detail information on the link between the composition of PM and negative health effects and cancer. The study did not find a significant correlation ($P > 0.05$) between the composition of PM and its effects on human on normal or dusty days (Naimabadi et al., 2016).

There are several methods and instruments for measuring particulate matter characteristics and concentration. There are two main measurements for PM, which are concentration and size distribution. Concentration measurement of particles has mainly three methods which are Gravimetric (using filters, impactor), optical (Scattering: using Photometer, OPC, and CPC; Extinction: Opacity meter; Absorption: Spotmeter, Aethalometer, PASS, LII) and microbalance. The size distribution measurement has five methods which are the microscopical (using Microscopy), impaction (using Impactor), diffusion (using Diffusion battery), charging (using DMA), and compete systems (using SMPS, CPMA, DMS, FIMS, ELPI, and EDB) (Amaral, de Carvalho, Costa, & Pinheiro, 2015). Most common technique that is used as a reference sampling of PM concentration is the gravimetric method which is also used in this study.

### 2.1 Justification

Air pollution is known to be a major public health and environmental issue (due to decreased visibility effect) all around the world. The assessment of air quality has been carried out in developed nations, such as the USA, Canada, UK, Germany, etc. and
developing nations in Asia, Africa, and the Middle East (e.g. Lebanon, Saudi Arabia, Iraq, Kuwait). A substantial body of epidemiological evidence now exists that establishes a link between exposure to air pollution and increased mortality (especially premature death) and morbidity due to a wide range of adverse cardiovascular and respiratory problems (Lira et al., 2012; Yaacoub et al., 2013; Abdulaziz et al., 2015). The information on the levels of PM and their probable source is very limited in Qatar; hence, there is a need to have a more comprehensive study on the particulate matter in term of its elemental composition and its impact on air quality. Therefore, this study was designed to monitor the levels of PMs (PM2.5 and PM10) at different locations in Qatar by integrating emissions within a framework of geographic information system (GIS) through the use of different mapping techniques depending on the available data. The results obtained from this study will be helpful for decision makers to formulate and implement policies that are feasible and sustainable to protect public health and the environment in Qatar.

2.2 Objectives of the Study

1- Monitor the concentration of particulate matter (PM2.5 and PM10) at different locations in Qatar.

2- Determine the elemental composition of PMs to identify their possible sources.

3- Create a map by using Geographical Information System (GIS) to show the air quality based on PM2.5 and PM10 concentrations at select locations in Qatar.
CHAPTER III: MATERIALS AND METHODS

3.1 Study Site

Five main sampling locations were chosen in this study: Qatar University (QU), (25° 21' 29.8692" N, 51° 29' 34.5984" E), Aspire Zone (25° 16' 2.2332" N, 51° 27' 6.9012" E), Education City (EC) (25° 19' 25.6512" N, 51° 25' 58.3716" E), Wholesale market (WSM) (25° 14' 47.2452" N, 51° 28' 35.1768" E), and Al-Wakrah City (25° 9' 53.1792" N, 51° 35' 38.7456" E) (Figure 3). The main reason for selecting these locations was based on many criteria, such as land use, activities, and traffic density. The selected areas have different forms of land use and have major educational facilities, transportation facilities, industrial buildings, health centers, local schools, and residential buildings.

Qatar University has the largest number of students and faculty members among universities located in Qatar. There are about 14,000 students registered in Qatar University who are not using buses as their main transportation. The majority of students depend on personal transportation to reach the university. In addition to heavy traffic activities, there is a metro being constructed on the northern side of Qatar University, which may affect the concentration of suspended particles in the air.

The Aspire zone is a critical location with common shopping areas, sport facilities, and public parks. At Education city, the activities are similar to those at Qatar University in terms of traffic and construction (metro work) activities, with new building constructions of the Qatar foundation as well. The fourth sampling site is the Wholesale market (WSM), which includes several markets that sell products like fish, animals,
vegetables/fruits, and home accessories. Qatar depends mainly on importing food, animals, and accessories, so big trucks and other vehicles of different sizes are common on this market area.
Figure 3. Map of sampling locations.
The fifth location is Al-Wakrah city, which is one of the fastest growing cities in Qatar in terms of residential and industrial activities. It has the oldest and main desalination/electrical plant in Qatar (Ras Abu Fontas, just 2 km away from the center of Al-Wakrah City). With the new marine port (Hamad Port), there is more construction of commercial offices and buildings that started in parallel with metro activities as well. Since being accepted for holding the world cup 2022, there have been increases in terms of population and construction activities in the state of Qatar.

3.2 Sample Collection and on-site measurements of PM2.5 and PM10

Air samples were collected monthly using Deployable Particle Samplers (DPS; Figure 4; SKC Inc., PA, USA) between September 2016 and December 2016. The DPS is a 24-hour Li-Ion battery-operated system that is easy to operate and portable. Five DPS pumps (3 for PM2.5 and 2 for PM10 measurements) were placed at each sampling location. Each DPS was equipped with a compact internal impactor comprising of a PM2.5 or PM10 inlet and outlet, and a 47-mm filter cassette.
The PTFE filters (SKC Omega Specialty Division, PTFE filters 2.0 µm pore size, 47 mm diameter) were weighed by using a microbalance (METTLER TOLEDO XP2U) and conditioned before each sampling time using the method of California Air Resource Base (SOP MLD 055, 2014) with little modification for temperature and humidity based on the available lab condition in Qatar University. The simultaneous sampling on PTFE filters allowed the subsequent chemical determination of all macro-components of PM. The system was maintained at 10.0 L/min flow rate (Table 8) during 24 hours of sampling period once a month with three PM2.5 and two PM10 pumps located at each station.
**Table 8**

*Flow rate measurements of each PM2.5 and PM10 sampling device at the time of calibration*

<table>
<thead>
<tr>
<th>Device</th>
<th>Flow Rate (L/min)</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device#1 PM2.5</td>
<td>9.76</td>
<td>±0.17</td>
</tr>
<tr>
<td>Device#2 PM2.5</td>
<td>10.07</td>
<td>±0.04</td>
</tr>
<tr>
<td>Device#3 PM2.5</td>
<td>10.13</td>
<td>±0.03</td>
</tr>
<tr>
<td>Device#4 PM10</td>
<td>10.09</td>
<td>±0.03</td>
</tr>
<tr>
<td>Device#5 PM10</td>
<td>10.14</td>
<td>±0.05</td>
</tr>
</tbody>
</table>

Before each sampling period, each pump was calibrated to confirm the 10.0 L/min flow rate. Height of the sampling sites ranged from 3-15 meters for all five stations where pumps were placed.

*Figure 5. Exploded view of IMPACT Sampler*
The formation of ambient PM depends on an interrelated and complex system of emission rates, meteorological processes, and atmospheric chemistry. Thus, data on surface and atmospheric temperatures, dew point, relative humidity, wind speed, wind gust, and sea pressure were obtained from the Qatar Meteorology department. All these data were provided in Appendix A.

3.4 Calculation of PM Mass

The calculation of the concentration of PM was carried out depending on the main equation that is used for PMs in the book of “Code of Federal Regulations Government: 1985-1999” (United States. Office of the Federal, 1994). The average sampling flow of each device was recorded initially and after 24 hrs. Total dust collected on filters were divided by the air volume of 24 hrs of sampling to have the PM2.5 and PM10 levels. The initial and final weight of samples recorded to get collected dust weight. The following formula (Actual PM concentration at field condition) was used to calculate the PM2.5 and PM10 concentrations (Appendix B).

\[ C = \text{PM}_{\text{act}} \left( \frac{P_{\text{std}}}{P_{\text{act}}} \right) \left( \frac{T_{\text{act}}}{T_{\text{std}}} \right)^* \]

(United States. Office of the Federal, 1994)

\( C= \) Actual concentration of PM at field conditions (µg/m³)

\( \text{PM}_{\text{std}} = \) Concentration at standard conditions (µg/m³)

\( P_{\text{act}} = \) Average barometric pressure at the field during sampling (mm Hg)

\( P_{\text{std}} = 760 \text{ mm Hg} \)
\( T_{\text{act}} = \) Average ambient temperature at the field conditions during the sampling period (K)
\( T_{\text{std}} = 298 \text{ K} \)

* Detailed formula sequences is available in Appendix B.

### 3.5 Identification of the elemental composition of PMs

The elemental compositions of all PM samples were determined using the USEPA method 200.7 Revision 4.4 (EPA, 1994). The following elements were targeted based on their known presence in PM samples: Al, Ca, Na, Mg, Fe, K, Cl, Li, P, Ti, V, Cr, Mn, Co, Ni, Zn, As, Se, Rb, Sr, Cd, Sn, Sb, Ba, Pb, and Hg. Calcium, Si, Fe, Al, K, and Ti are crustal elements; Mg, K, and Na come from sea salt; and heavy metals such as Cd, Hg, Pb, etc. are from traffic or industrial pollution. The PTFE filters were collected from different stations and weighed within available lab conditions following the California Air Resource Base (SOP MLD 055, 2014) with some modification for temperature and humidity (using available material at the university). After 24 hrs sampling, the filters were removed from the impactor, placed in a sterile plastic dishes and brought to the acid digestion lab in the Environmental Science Center at Qatar University. Filters were put in PTFE tubes, and \( \text{HNO}_3 \) 70-68\% (12 ml) and HF 40\% (3 ml) were added at different times. Digested samples were transferred to new tubes for analyses by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) Model Optima 7300 DV (Perkin Elmer Inc., Waltham, MA, USA) located in the Central Lab Unit (CLU) at Qatar University. The instrumental characteristics and operating parameters of ICP-OES are summarized in Table 7. A Blank, Duplicate, and CRM (certified Reference Material) were included as quality control. The accuracy of heavy metal measurements was evaluated using the Multi Element standard
solution IV (Ag, Al, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, In, K, Li, Mg, Mn, Na, Ni, Pb, Sr, Tl, Zn Fluka Analytical, Busch, Switzerland). Selection of the elements was based on the main heavy metals and other elements in the air as determined previously (Khan et al., 2010; Segalin et al., 2017). The standards were dissolved in 1% HNO₃ and four major concentrations were prepared to establish a calibration curve of the target elements.

### Table 9

*Tuning parameters of the ICP-OES*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument</td>
<td>Optima 7300 DV</td>
</tr>
<tr>
<td>Nebulizer/Spray chamber</td>
<td>Meinhard/Cyclonic</td>
</tr>
<tr>
<td>Injector</td>
<td>Quartz 2.0 mm ID</td>
</tr>
<tr>
<td>Resolution</td>
<td>Normal</td>
</tr>
<tr>
<td>Read Time</td>
<td>20 sec (min) – 50 sec (max)</td>
</tr>
<tr>
<td>Resolution</td>
<td>Normal</td>
</tr>
<tr>
<td>Plasma Gas</td>
<td>15 L/min</td>
</tr>
<tr>
<td>Auxiliary Gas</td>
<td>0.2 L/min</td>
</tr>
<tr>
<td>Nebulizer Gas</td>
<td>0.6 L/min</td>
</tr>
<tr>
<td>Power</td>
<td>1400 W</td>
</tr>
<tr>
<td>Plasma View</td>
<td>Axial</td>
</tr>
</tbody>
</table>

### 3.6 Determination of PM sources using Enrichment factor (EF)

The enrichment factor was used to highlight the possible source of particulate matter elemental composition. It is based on using a reference crustal element as natural source and comparing it with particulate matter composition. Al and Fe can be used as reference elements as previously reported (Chan et al., 1997).
The EF values were calculated using Al as a reference element that gotten from Rudnick and Gao (Rudnick & Gao, 2003), and applied on the following equation:

\[ EF = \left( \frac{X_a/Refa}{X_c/Refc} \right)_{Crustal} \]  
(Chan et al., 1997).

Where:
- \( X_a \): Target element in air PM samples.
- \( Refa \): Reference element in air PM samples (ex. Al).
- \( X_c \): Reference element from crust like target element.
- \( Refc \): Reference element from crust (ex. Al).

### 3.7 Determination of Air Quality

The air quality based on PM2.5 and PM10 concentrations was determined using the Air Quality Index (AQI) tool. This tool categorizes the health risk based on the following specifications: Good air quality (Index value 0-50), “Moderate” air quality (51-100), “Unhealthy for Sensitive Individuals” (101-150), “Unhealthy’ (151-200), “Very Unhealthy” (201-300), and “Hazardous” air quality (301-500) (Table 10). Calculation of the AQI can be done by the official web site of AQI calculator (www.AirNow.gov) to convert the PM concentration to one of the AQI category. By using AQI, people can take a decision that is related to their living/working locations, and reduction of air pollution.
Table 10

*Air Quality Index categories by Level of Health concern and Colors (AirNow, 2016)*

<table>
<thead>
<tr>
<th>Air Quality Index (AQI) values</th>
<th>Level of Health Concern</th>
<th>Colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 50</td>
<td>Good</td>
<td>Green</td>
</tr>
<tr>
<td>51 to 100</td>
<td>Moderate</td>
<td>Yellow</td>
</tr>
<tr>
<td>101 to 150</td>
<td>Unhealthy for Sensitive Groups</td>
<td>Orange</td>
</tr>
<tr>
<td>151 to 200</td>
<td>Unhealthy</td>
<td>Red</td>
</tr>
<tr>
<td>201 to 300</td>
<td>Very Unhealthy</td>
<td>Purple</td>
</tr>
<tr>
<td>301 to 500</td>
<td>Hazardous</td>
<td>Maroon</td>
</tr>
</tbody>
</table>

3.8 Mapping of AQI values calculated based on PM concentrations and Land use

ArcMap 9.3 software was used to compute Air Quality Index (AQI) values calculated based on the daily concentrations of PM2.5 and PM10 at each sampling location. The AQI tool is available on the USEPA’s website which is used to categorize the health risks associated with different levels of PM2.5 and PM10. Furthermore, land use maps were also included in this study to highlight the main land use activity surrounding sampling stations.
3.9 Statistical Analysis

Different statistical correlation models were used to determine the significant relations between PMs, elemental composition, and meteorological data. The Statistical Analysis System (SAS Institute Inc., Cary, NC, USA) software was used to apply generalized linear model (GLM) using ANOVA to determine the significant differences between PM concentrations and their elemental compositions at different sampling locations and months at $p<0.05$. 
CHAPTER IV: RESULTS AND DISCUSSION

4.1 PM Concentrations by Location and Month

A total of 100 samples (60 of PM2.5 and 40 PM10) were collected for four months starting from September to December 2016. The overall mean concentrations of PM2.5 and PM10 ranged from 50 µg/m³ to 64 µg/m³ and 127 µg/m³ to 185 µg/m³, respectively (Table 11).

Table 11

The mean concentrations of PM2.5 and PM10 samples collected from different Stations and Meteorological data

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Qatar University</th>
<th>Education City</th>
<th>Aspire Zone</th>
<th>Whole Sale Market</th>
<th>Al Wakrah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average PM2.5 Conc. (µg/m³)</td>
<td>50±2.47</td>
<td>65±1.90</td>
<td>55±2.24</td>
<td>59±3.01</td>
<td>57±2.68</td>
</tr>
<tr>
<td>Average PM10 Conc. (µg/m³)</td>
<td>138±3.72</td>
<td>156±3.06</td>
<td>127±3.90</td>
<td>185±3.64</td>
<td>160±2.79</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>26.90±1.16</td>
<td>27.92±1.18</td>
<td>26.97±1.15</td>
<td>28.00±1.26</td>
<td>26.47±1.25</td>
</tr>
<tr>
<td>Wind Speed (m/s)</td>
<td>1.75±0.32</td>
<td>1.80±0.26</td>
<td>1.80±0.35</td>
<td>2.10±0.52</td>
<td>4.15±0.60</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>60.00±1.78</td>
<td>59.25±1.97</td>
<td>61.00±2.02</td>
<td>50.00±1.01</td>
<td>62.00±1.24</td>
</tr>
</tbody>
</table>
The concentrations of both PM2.5 and PM10 were relatively higher than the EPA standards (for PM10= 150 µg/m$^3$ and PM2.5 = 35 µg/m$^3$) and WHO Standards (PM10= 50 µg/m$^3$ 24 hr mean and PM2.5 = 25 µg/m$^3$ for 24 hrs), as well as Qatari Ministry of Environment and Municipality (only 150 µg/m$^3$ for PM10) standards (Figure 6, Tables 1 and 3).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure6.png}
\caption{The comparison of the USEPA standards and the average mean concentrations of PM2.5 and PM10 recorded at different locations during the study period.}
\end{figure}
These results were expected since Qatar is an arid region known for its frequent dust storms and dusty environment. In a recent study, Saraga et al. (2017) reported the indoor and outdoor PM2.5 and PM10 levels being higher than 25 and 50 µg/m³ (WHO standards) on most of the sampling days between April 22, 2015 and June 21, 2015 in Qatar. Similar findings were also recorded in Kuwait, indicating poor air quality based on PM2.5 levels (Brown et al., 2008).

A high concentration of PM10 was recorded at three stations: Wholesale Market, Al Wakrah City, and Education City, with concentrations of 185 µg/m³, 160 µg/m³, and 156 µg/m³, respectively (Table 11). The concentration of PM2.5 reported at all five stations exceeded the EPA daily limit of 35 µg/m³ (Figure 6), indicating relatively poor air quality around these areas. The PM2.5 concentrations at Qatar University, Education City, WSM, Al-Wakrah City, and Aspire Zone were 50, 64, 59, 57, and 55 µg/m³, respectively (Table 11). These high levels could be due to different human activities as observed in these stations.

The Wholesale Market (WSM) is an economic activity site where fish market, animal market, and produce market receive most of Qatar’s food imports. Massive movement of trucks to transport food supplies to the market on unpaved road creates suspended particulate matter. There is an open area on the southern side of WSM and a semi-closed road that uptakes dust particles that come from the open area near the animal market when the wind is blowing from south of WSM which is the area with heavy traffic and logistic activities/industries (Figure 10). This could be one of the contributing factors for PM10 levels reaching considerably high concentrations compared to other sampling sites. Such findings were also supported by Zhu et al. (2015) and Patra et al. (2008) who
mentioned that the concentration of PM10 close to roads is due to resuspended particles. Another factor which might result in high PM10 levels recorded at WSM is large cattle feedlots that supply the local market with cattle meat, which is under category of low to medium impact industries, and there is large logistic area for governmental ministries (Figure 10). The relationship between the cattle areas and high PM10 concentration was previously reported by (Guo et al., 2011).

In April 2017, the fish market and animal market at WSM was partially moved to UmSalal area located in the north of Qatar. As a result of this change, a reduction in PM10 levels is expected, but this hypothesis needs to be tested since this study only covered the period of September to December 2016.

The highest mean concentrations of PM2.5 and PM10 were monitored at concentrations of 64 µg/m³ and 185 µg/m³ at Education City and WSM, respectively (Table 10). Education city is recognized as one of the fastest growing sites in Qatar. The sampling station at EC was in the middle of Education City, which is surrounded by several universities and facilities that are still under construction -which considered as a temporary state-. During sampling, construction work was ongoing near the sampling station at EC, which may have contributed to high concentrations of both PM2.5 and PM10 as recorded at this location. The area is also housing many educational institutions, the largest convention center in Qatar, and many commercial sites. The vehicle movement in this area could also be another important factor contributing to the high concentrations of PMs (Araújo, Costa, & de Moraes, 2014).
4.2 Air Quality Index Values Calculated based on PM2.5 and PM10 Concentrations

Air quality index (AQI) tool is recognized as one of indexes to determine health risks associated with PM levels based on the USEPA guidelines. It categorizes the air quality based on 24 hr PM concentrations using color codes, such as green for Good, yellow for Moderate, orange for Unhealthy for sensitive groups, red for Unhealthy, purple for Very unhealthy, and maroon for Hazardous air quality levels (AirNow, 2016). Air quality is progressively known as a serious issue for human health and is a subject for which comprehensive global emission data are missing. Using AQI, the quality of local air can be determined and a warning system can be created to inform the public, especially sensitive groups to protect their health.

The AQI values calculated based on PM2.5 concentration indicated that the air quality was in “moderate” range in September and December. While, the AQI levels exhibited “Unhealthy” rating during the months of October and November (Table 12). The 24 hrs mean levels of PM10 resulted in relatively better AQI levels which were reported mainly in the “Moderate” category during the entire sampling period, compared to the means of PM2.5 (Table 12) . These differences in AQI during sampling days are important to highlight human activities which were relatively low in September and December due to national holidays and late start of schools in September and winter breaks in December. On the other hand, human activities are at the highest levels in the months of October and November since schools/universities are open and running in full-term. Based on the AQI levels calculated using the concentrations of PM2.5 and PM10, there were 25%, 37.5%, and 37.5% of total days in the category of “Unhealthy”, “Moderate”, and “Unhealthy air quality for Sensitive Groups” during the study period,
respectively (Figure 7). It is noteworthy to mention that there was no single day with “good” air quality during the four months of sampling, demonstrating that air quality associated with PM air pollution could be a significant public health issue in Qatar. Even the PM levels are considered high in Qatar based on the findings obtained in this study and the recent report published by WHO (2016), the number of death and respiratory illness related to PM pollution is surprisingly low. This might create an opportunity for the public agencies to review current standards and establish more reasonable standards considering the arid environment of Qatar since most PM pollution is related to natural sources.

Table 12

The Air Quality Index Values calculated based on the concentrations* of PM2.5 and PM10 during the study period

<table>
<thead>
<tr>
<th>Month</th>
<th>PM2.5</th>
<th>PM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>104 Unhealthy for sensitive group (37 µg/m3)</td>
<td>93 Moderate (140 µg/m3)</td>
</tr>
<tr>
<td>October</td>
<td>156 Unhealthy (66 µg/m3)</td>
<td>100 Moderate (154 µg/m3)</td>
</tr>
<tr>
<td>November</td>
<td>73.01 Unhealthy (66 µg/m3)</td>
<td>111 Unhealthy for sensitive group (176 µg/m3)</td>
</tr>
<tr>
<td>December</td>
<td>142 Unhealthy for sensitive group (52 µg/m3)</td>
<td>95 Moderate (144 µg/m3)</td>
</tr>
</tbody>
</table>

*Values in parentheses are PM2.5 and PM10 concentrations.
Figure 7. The percentage distribution of different Air Quality Index ratings during the sampling months.

At Qatar University and Aspire Zone areas, the AQI levels indicated “Moderate” air quality for PM10 levels and “Unhealthy air quality for sensitive groups” for PM2.5 levels (Table 12). These two locations share similar land use exercises and have many green areas with dense tree population compared to other study sites (Figures 8 and 9). McDonald et al. (2007) investigated the positive changes in particulate matter of urban tree planting on the concentrations and depositions of particulate matter, and found that PM10 levels can be reduced up to 26% if tree density is increased. Trees also can support the air quality by removing 4.7 ton of PM2.5 annually (Nowak et al., 2013). Three of five
stations included in this study had “Unhealthy” air quality rating, which might negatively impact human health (Table 13). However, this correlation needs to be further investigated to establish the link between unhealthy air quality associated with high concentrations of PMs and their health effects on human, especially on sensitive groups by using data on health statistics.

**Table 13**

*Air Quality Index Values calculated based on the four month averages of PM2.5 and PM10 at different stations*

<table>
<thead>
<tr>
<th>Location</th>
<th>PM2.5*</th>
<th>PM10*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar University</td>
<td>136 Unhealthy for sensitive Groups (50 µg/m3)</td>
<td>92 Moderae (138 µg/m3)</td>
</tr>
<tr>
<td>Education City</td>
<td>155 Unhealthy (64µg/m3)</td>
<td>101 Unhealthy for sensitive Group (156 µg/m3)</td>
</tr>
<tr>
<td>ADLQ (Aspire Zone)</td>
<td>150 Unhealthy for sensitive Group (55 µg/m3)</td>
<td>86 Moderate (126.69 µg/m3)</td>
</tr>
<tr>
<td>Whole Sale Market</td>
<td>153 Unhealthy (59 µg/m3)</td>
<td>115 Unhealthy for sensitive Group (185 µg/m3)</td>
</tr>
<tr>
<td>Al Wakrah</td>
<td>152 Unhealthy (57 µg/m3)</td>
<td>103 Unhealthy for sensitive Group (160 µg/m3)</td>
</tr>
</tbody>
</table>

*Values in parentheses are the average concentrations of PM2.5 and PM10 collected for a period of four months.*
Figure 8. Land use Illustration at Aspire Zone
Figure 9. Land Use Illustration at Qatar University
Figure 10. Land Use Illustration at Whole Sale Market
Figure 11. Land Use Illustration at Education City
### 4.2 Mapping of AQI Values Based on PM2.5 and PM10 Concentrations

The AQI values calculated based on PM concentrations at five stations during the months of September-December 2016 were computed using GIS in combination with Google Earth mapping system. Figures 12 and 13 illustrate the AQI category for each site. Orange color was the dominant color in both maps, meaning that the air quality was considered “Unhealthy for sensitive groups” at these locations. This is a concern for part of the society who live in these areas since they can be directly affected by poor air quality. People with respiratory diseases, children and elderly are the groups who are at risk to be affected the most as a result of poor air quality as determined in this study. Such conditions might exacerbate likelihood of respiratory symptoms and aggravation of lung diseases, such as asthma. People who have heart and lung diseases could also be affected by poor air quality -specifically particulate matter pollution- as reported in previous studies (Gauderman et al., 2007; Pope et al., 2006; Zanobetti et al., 2000). Martins et al. (2004) reported that the mortality of elderly people increased from 1.4% to 14.2% in Brazil when the concentration of PM10 increased by 10 µg/m³.

AQI values indicating “unhealthy” air quality (red color) based on the 24 hr mean PM2.5 concentrations were detected for three stations which were Education city, Whole Sale Market, and Al Wakrah city (Figure 12). This condition could lead to adverse health effects even in healthy people and could cause serious health consequences for sensitive groups. A similar pattern was also observed for PM10-based AQI levels at the same sampling station (Figure 13), meaning that there is a positive correlation between high concentrations of PM2.5 and PM10 and dangerous AQI categories (Mohan & Kandya, 2007).
Figure 12. PM2.5 based Air Quality Index Values at the sampling stations
Figure 13. PM10 based Air Quality Index Values at the sampling stations
4.3 Particulate Matter Elemental Composition

The total concentrations of elements detected in PM2.5 and PM10 samples collected from five stations on different days are listed in Tables 16 and 17. The concentrations of elements in PM samples were comparable to previous studies from the Middle East region (Brown et al., 2008; Saraga et al., 2017).

It is important to note that there was a significant correlation between elemental composition of PM2.5 and PM10 and sampling location. The concentration of elements detected in PM10 samples was significantly different ($p<0.001$) at each sampling location. The highest significant differences were observed among crustal and non-crustal elements, such as Al, Ca, Mg, Fe, Li, V, Cr, Mn, Ni, Co, As, Sr, Ba, Pb, while the concentration of Na, Zn, and Cd were not significantly different ($p>0.05$) at different sampling locations. There was also monthly variations in terms of elemental composition of PM10 samples, especially for (Al, Na, Mg, Fe, Li, V, Ba, and Pb) with ($p<0.001$) (Appendix C). (Cheung et al., 2011) also determined a significant correlation between the elemental composition of PM samples and sampling time of the year.

The highest concentrations of elements were detected in PM10 samples collected from WSM. Al, Ca, Na, Mg, Fe, Cr, Ni, Co, Sr, Cd, and Ba had significantly ($p<0.05$) higher levels compared to other stations (Table 17), while the concentrations of the same elements (Al, Ca, Mg, Fe, V, Ni, and Cd) were recorded at the highest level for PM2.5 samples collected from Education City (Table 16).
It is expected that industrial and economic sites like the Wholesale market would normally have higher concentrations of metals such as Cr, Ni, and Ba as the land use illustration indicates (Table 16). It is important to compare the results obtained in this study with others from the same region to be sure that there is no increase of toxic elements in the air column. The highest concentrations of toxic non-crustal elements such as Cr, Ni, V, Pb, and Cd were 26.66, 21.87, 22.78, and 0.65, 4.91 ng/m$^3$ for PM10 and 17.48, 12.06, 14.77, 2.57, and 0.69 ng/m$^3$ for PM2.5, respectively (Tables 16 and 17).

A previous study conducted in Qatar by Saraga et al. (2017) recorded some of these elements: Cr (39.3 ng/m$^3$), V (35.7 ng/m$^3$), Cd (0.27 ng/m$^3$), and Pb (20.6 ng/m$^3$) in PM2.5 samples collected from a site known to have busy traffic. In another study, Naimabadi et al., 2016 reported the presence of similar elements in PM samples collected from a desert in Iran (another Middle East country), which has a similar climate to the Arabian region. The authors recorded high elemental concentrations of heavy metals during the dusty period, which is the most dominant time throughout the year in Qatar. The concentrations of Cr (72.62 ng/m$^3$), Ni (74.34 ng/m$^3$), V (82.96 ng/m$^3$), and Pb (52.06 ng/m$^3$) were three times higher than the values determined in this study (Naimabadi et al., 2016).

Investigation of the relation of the elements was based on grouping them according to their possible source. Determination of Ca, K, Al, and Fe in PM samples usually indicates the source as upper earth crust. Other elements like Cu, Zn, and Pb are mainly considered as indicators of traffic emission elements (Querol et al., 2001; Manoli et al.,
2002; Fang et al., 2003). Elements such Ni and V are recognized as elements coming from burning fossil fuel, and other trace elements such as Cr and Cd result from burning coal. Ni, Cr, Cu, Sn, Zn, Mo, Sb, Pb, and Cd indicate the source as industrially related pollution (Das et al., 2015).

The concentrations of crustal elements such as Al and Fe were relatively high in all samples collected in this study, which is expected since these elements are the normal properties of desert dust. In all stations, the concentrations of non-crustal elements were lower compared to a previously reported study in Qatar (Saraga et al., 2017). This could be due to sampling location and duration. The locations chosen in this study had different activities and sampling was carried out during a warm season. While, Saraga et al. (2017) conducted PM sample collection during the hot season (July) in an area known to be highly crowded part of Doha.
Table 14

*Elemental composition concentration of PM2.5 samples collected from different locations*

<table>
<thead>
<tr>
<th></th>
<th>PM2.5 Mean Elemental Composition Concentration (ng/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>QU</td>
</tr>
<tr>
<td>Al</td>
<td>352.19±28</td>
</tr>
<tr>
<td>Ca</td>
<td>5176.29±529</td>
</tr>
<tr>
<td>Na</td>
<td>620.37±303</td>
</tr>
<tr>
<td>Mg</td>
<td>485.43±89</td>
</tr>
<tr>
<td>Fe</td>
<td>450.20±36</td>
</tr>
<tr>
<td>Li</td>
<td>0.10±0</td>
</tr>
<tr>
<td>V</td>
<td>11.98±1</td>
</tr>
<tr>
<td>Cr</td>
<td>14.72±0</td>
</tr>
<tr>
<td>Mn</td>
<td>6.27±0</td>
</tr>
<tr>
<td>Ni</td>
<td>11.76±1</td>
</tr>
<tr>
<td>Zn</td>
<td>201.79±15</td>
</tr>
<tr>
<td>Sr</td>
<td>10.53±2</td>
</tr>
<tr>
<td>Cd</td>
<td>0.55±0</td>
</tr>
<tr>
<td>Ba</td>
<td>16.32±1</td>
</tr>
<tr>
<td>Pb</td>
<td>2.57±1</td>
</tr>
</tbody>
</table>

* ND. Not detected elements.
Table 15

*Elemental composition concentration of PM10 samples collected from different locations*

<table>
<thead>
<tr>
<th>Element</th>
<th>QU (ng/m³)</th>
<th>EC (ng/m³)</th>
<th>AZ (ng/m³)</th>
<th>WSM (ng/m³)</th>
<th>AW (ng/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>1275.32±191</td>
<td>2701.46±410</td>
<td>2215.90±443</td>
<td>2980.44±685</td>
<td>2106.97±389</td>
</tr>
<tr>
<td>Ca</td>
<td>10238.49±2705</td>
<td>19238.23±309</td>
<td>17681.85±3479</td>
<td>21286.56±2766</td>
<td>20222.25±3078</td>
</tr>
<tr>
<td>Na</td>
<td>1036.78±176</td>
<td>1241.33±162</td>
<td>1165.43±234</td>
<td>1260.99±166</td>
<td>1223.14±166</td>
</tr>
<tr>
<td>Mg</td>
<td>1992.07±550</td>
<td>3814.10±507</td>
<td>3462.83±697</td>
<td>4507.67±650</td>
<td>3768.90±335</td>
</tr>
<tr>
<td>Fe</td>
<td>1645.29±246</td>
<td>2832.27±414</td>
<td>2425.55±385</td>
<td>3359.17±657</td>
<td>2258.90±302</td>
</tr>
<tr>
<td>Li</td>
<td>0.68±0</td>
<td>2.02±0</td>
<td>1.59±0</td>
<td>2.20±0</td>
<td>2.42±0</td>
</tr>
<tr>
<td>V</td>
<td>16.70±2</td>
<td>22.78±1</td>
<td>17.66±1</td>
<td>22.23±2</td>
<td>19.02±1</td>
</tr>
<tr>
<td>Cr</td>
<td>18.98±0</td>
<td>22.28±1</td>
<td>22.66±1</td>
<td>26.66±1</td>
<td>21.97±1</td>
</tr>
<tr>
<td>Mn</td>
<td>19.88±3</td>
<td>30.14±4</td>
<td>31.73±5</td>
<td>33.01±4</td>
<td>27.94±3</td>
</tr>
<tr>
<td>Ni</td>
<td>17.36±1</td>
<td>20.33±0</td>
<td>18.17±1</td>
<td>21.87±1</td>
<td>16.97±1</td>
</tr>
<tr>
<td>Zn</td>
<td>157.71±20</td>
<td>233.43±39</td>
<td>263.03±37</td>
<td>183.33±23</td>
<td>318.35±58</td>
</tr>
<tr>
<td>Sr</td>
<td>36.41±9</td>
<td>61.31±9</td>
<td>47.13±8</td>
<td>74.88±11</td>
<td>49.41±4</td>
</tr>
<tr>
<td>Cd</td>
<td>0.64±0</td>
<td>0.54±0</td>
<td>0.42±0</td>
<td>0.65±0</td>
<td>0.44±0</td>
</tr>
<tr>
<td>Ba</td>
<td>51.17±11</td>
<td>54.84±5</td>
<td>47.92±5</td>
<td>80.57±10</td>
<td>53.34±5</td>
</tr>
<tr>
<td>Pb</td>
<td>2.99±1</td>
<td>0.37±0</td>
<td>2.76±1</td>
<td>3.16±1</td>
<td>4.91±1</td>
</tr>
</tbody>
</table>
PM samples collected from Qatar University had much lower elemental concentrations compared to Education city. For PM10, just two peak values recorded for toxic non-crustal elements (Cr and Ba), while the concentrations of other toxic non-crustal elements like Ni, Cd, and Pb were not significant comparing to other stations (Table 16). For PM2.5, there was a peak recorded for Pb, which is directly related to traffic pollution. Diesel fuel from trucks is the main source of Pb since most cars use lead-free gasoline in Qatar. The sampling location at Qatar University was right next to the main road (Figure 14), while at Education city, the station was not very close to the street (Figure 15).
Figure 14. Illustration of Land use at of Qatar University
Figure 15. Illustration of Land use at Education City
The spatial distribution of the elements varied by location based on the land use activities as illustrated in the study areas. Compared to other studies (Saraga et al., 2017; Hassan et al., 2016), the concentrations of heavy metals in PM2.5 and PM10 samples collected from different locations in Qatar were relatively low. These concentrations can give a general picture of the air quality level in the areas monitored in this study. Figures 16 and 17 show the concentrations of main elements related to the anthropogenic sources (Cr, Pb, Cr, Li, Cd, and V). Cr had the highest level in both PM samples collected from WSM station compared to other stations, exceeding 26 ng/m$^3$ and 17 ng/m$^3$ for PM10 and PM2.5, respectively. The highest concentration of chromium highlights the source as industrial origin.

Pb is recognized as one of the main indication of traffic related PM pollution due burning diesel in vehicle engines (Wang et al., 2003). The concentration of Pb recorded at the highest concentration in QU for PM2.5 and in Al-Wakrah for PM10. The lowest concentration of Pb recorded in EC. Since the sampling location at EC was not very near a roadside, PM pollution source is probably mainly due to construction activities.
**Figure 16.** Average concentrations of heavy metals in PM2.5 collected from different sampling stations.

**Figure 17.** Average concentrations of heavy metals in PM10 samples collected from different sampling stations.
4.4 Possible sources of PMs based on Enrichment Factor Analysis

The enrichment factor (EF) analysis was used based on the concentration of individual elements in the air particulate samples compared with their concentrations in the crust (Rudnick and Gao, 2003). This analysis provides useful information in determining the sources of elements detected in PM samples. In this study, Al was used as a reference element assuming that Al will be present at low concentrations in air samples. Usually, high EF values indicate the origin of elements to be from non-crustal anthropogenic sources, while low EF values are indicative of earth-crust or soil as main source.

In this study, the EF values were categorized into three main classes, for example, Fe and Mg are mainly crustal elements and have small EF values indicating the PM source as natural (Chan et al., 1997). The EF values ranging between 1-9 are indicative of non-anthropogenic sources like Fe, Na, Mg, Sr, Ba, and Li (Table 18). The EF values considered to be in the Moderate category range from 10 to 100. The elements in this category are Ni, Cr, and V which are recognized as anthropogenic sources, where Ni and V come from burning of fossil fuel (Zhang et al., 2009) and Cr is from industrial activity. The EF values higher than 100 are considered as significant anthropogenic sources, such as Zn, Cd, and Pb (Table 18).

The relatively high EF values for Zn, Cd, and Pb may be indication of significant anthropogenic contribution in both PM2.5 and PM10 samples collected in Qatar, even the elemental concentrations are lower than some of previous studies in the Middle East region.
Near to the results of EF were also reported in different areas (Jeddah city and Rabigh city) of Saudi Arabia where EF values of Pb and Cd were more than 1500 for Pb and 8800 for Cd (Khodeir et al., 2012; Nayebare et al., 2016). This reported high EF values for Pb, Cd, and Zn trace the source of PM pollution to mainly traffic and industrial activities. It should be emphasized here that Pb and Cd are known to be highly toxic to humans, especially children. Therefore, a more comprehensive study including the collection of soil and more air samples needs to be carried out to determine the exact source of these two toxic metals in these locations.
Table 16

*Enrichment Factor (EF) Values for elements determined in PM2.5 and PM10 samples

(µg/m³)

<table>
<thead>
<tr>
<th>Element</th>
<th>PM2.5 Concentration (Average) (ng/m³)</th>
<th>EF</th>
<th>PM10 Concentration (Average) (ng/m³)</th>
<th>EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>496.95</td>
<td>R.E*</td>
<td>2256.01</td>
<td>R.E*</td>
</tr>
<tr>
<td>Fe</td>
<td>526.89</td>
<td>2.20</td>
<td>2504.23</td>
<td>2.30</td>
</tr>
<tr>
<td>Na</td>
<td>485.74</td>
<td>2.76</td>
<td>1185.53</td>
<td>1.48</td>
</tr>
<tr>
<td>Mg</td>
<td>574.83</td>
<td>6.30</td>
<td>3509.11</td>
<td>8.47</td>
</tr>
<tr>
<td>Li</td>
<td>0.30</td>
<td>2.40</td>
<td>1.78</td>
<td>3.06</td>
</tr>
<tr>
<td>V</td>
<td>11.82</td>
<td>19.98</td>
<td>19.67</td>
<td>7.32</td>
</tr>
<tr>
<td>Cr</td>
<td>15.33</td>
<td>27.33</td>
<td>22.51</td>
<td>8.83</td>
</tr>
<tr>
<td>Mn</td>
<td>9.04</td>
<td>1.91</td>
<td>28.54</td>
<td>1.33</td>
</tr>
<tr>
<td>Ni</td>
<td>11.58</td>
<td>40.42</td>
<td>18.94</td>
<td>14.55</td>
</tr>
<tr>
<td>Zn</td>
<td>206.34</td>
<td>505.11</td>
<td>231.17</td>
<td>124.65</td>
</tr>
<tr>
<td>Sr</td>
<td>10.79</td>
<td>5.53</td>
<td>53.82</td>
<td>6.07</td>
</tr>
<tr>
<td>Cd</td>
<td>0.58</td>
<td>1072.65</td>
<td>0.53</td>
<td>215.96</td>
</tr>
<tr>
<td>Ba</td>
<td>15.03</td>
<td>5.78</td>
<td>57.56</td>
<td>4.88</td>
</tr>
<tr>
<td>Pb</td>
<td>1.93</td>
<td>933.34</td>
<td>2.83</td>
<td>301.56</td>
</tr>
</tbody>
</table>

*Reference element used in EF calculation.
CHAPTER V: CONCLUSION

The present study aimed at investigating PM pollution, chemical composition and source of PM and its impact on air quality at different locations in Qatar. The gravimetric measurements revealed that the four months average PM concentrations exceed the WHO and USEPA standards in some stations. The concentration of PM2.5 and PM10 in Qatar University, Education city, Aspire Zone, Whole Sale Market, and Al-Wakrah city were 50, 64, 55, 57, 138, 127, 185, and 160 µg/m³, respectively. Overall, the mean concentrations of PM10 and PM2.5 were recorded as peak at Whole Sale Market (185 µg/m³) and Education City (64 µg/m³), respectively. Activities in these two stations were mainly industrial/trading (WSM) and construction in (EC). Having such concentration could be reduced after finishing the construction activities and more efficient of transportation management in industrial/trading areas. The Air Quality Index tool was also used in this study to categorize the health risk associated with different PM levels. The AQI values indicated that 37.5% and 25% days of “Moderate” air quality, “Unhealthy for Sensitive Group” air quality, and “Unhealthy” respectively. The concentrations of elements in PM samples were relatively low compared to previous studies. The enrichment factor analysis showed that high concentrations of Pb, Cd, and Zn were probably due to road traffic emission and activity relates to medium industrial activity near to WSM. The presence of these heavy metals may also influence the degraded air quality in the sampling area as confirmed by AQI values.

This study highlights the urgent need to establish a strategy for continuous monitoring and a reliable and real-time warning system to inform the public about the air
quality in Qatar. It is important to note that this study is considered as a pilot study to
determine air quality based on PM pollution in Qatar. The findings obtained here provide
important data which can be used to assist government agencies to establish air quality
management system. However, this study was limited in terms of sampling and chemical
composition analysis. Hence, future plans should include specific studies in determining
long term effects of exposure to PM pollution in Qatar. Examples of such studies might
be epidemiological studies using health statistics and PM pollution data, inclusion of a
larger sampling area, and measurement of various PM sizes (like PM1) and different
chemical components of PMs, such as PAHs and ions.
REFERENCES


Cascio, W. E. (2016). Proposed pathophysiology framework to explain some excess

Chan, E. A. W., Buckley, B., Farraj, A. K., & Thompson, L. C. (2016). The heart as an extravascular target of endothelin-1 in particulate matter-induced cardiac dysfunction. *Pharmacology & Therapeutics, 165*, 63-78. doi: http://dx.doi.org/10.1016/j.pharmthera.2016.05.006


IARC. (2013). *Outdoor air pollution a leading environmental cause of cancer deaths.* Retrieved from Lyon:


*Aerosol Air Qual Res, 17*(1), 230-237.


in Europe. *Atmospheric environment, 38*(16), 2579-2595.


APPENDICES

Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Temperature degree celsius</th>
<th>Mean Dew Point degree celsius</th>
<th>Mean Relative Humidity percentage</th>
<th>Total Rain Fall millimeters</th>
<th>Mean Wind Speed meters per second</th>
<th>Maximum Wind Gust meters per second</th>
<th>Mean Wind Direction 360 degree rose</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/1/2016</td>
<td>33.1</td>
<td>8.7</td>
<td>26</td>
<td>0</td>
<td>5.3</td>
<td>26.4</td>
<td>320</td>
</tr>
<tr>
<td>6/2/2016</td>
<td>34.6</td>
<td>4.9</td>
<td>18</td>
<td>0</td>
<td>3.8</td>
<td>19.2</td>
<td>300</td>
</tr>
<tr>
<td>6/3/2016</td>
<td>34.4</td>
<td>8</td>
<td>22</td>
<td>0</td>
<td>1.8</td>
<td>15.3</td>
<td>350</td>
</tr>
<tr>
<td>6/4/2016</td>
<td>33.2</td>
<td>14.4</td>
<td>36</td>
<td>0</td>
<td>2.7</td>
<td>13.2</td>
<td>20</td>
</tr>
<tr>
<td>6/5/2016</td>
<td>32.3</td>
<td>12.7</td>
<td>34</td>
<td>0</td>
<td>1.4</td>
<td>10.7</td>
<td>60</td>
</tr>
<tr>
<td>6/6/2016</td>
<td>33.6</td>
<td>16.4</td>
<td>40</td>
<td>0</td>
<td>1.1</td>
<td>7.8</td>
<td>100</td>
</tr>
<tr>
<td>6/7/2016</td>
<td>35.6</td>
<td>11.2</td>
<td>25</td>
<td>0</td>
<td>1.6</td>
<td>44.5</td>
<td>290</td>
</tr>
<tr>
<td>6/8/2016</td>
<td>37.5</td>
<td>9.3</td>
<td>21</td>
<td>0</td>
<td>5.2</td>
<td>25.7</td>
<td>330</td>
</tr>
<tr>
<td>6/9/2016</td>
<td>36.6</td>
<td>8.6</td>
<td>22</td>
<td>0</td>
<td>6.2</td>
<td>31.6</td>
<td>330</td>
</tr>
<tr>
<td>6/10/2016</td>
<td>35.2</td>
<td>15.5</td>
<td>33</td>
<td>0</td>
<td>3.2</td>
<td>30.6</td>
<td>350</td>
</tr>
<tr>
<td>6/11/2016</td>
<td>38.3</td>
<td>10.7</td>
<td>23</td>
<td>0</td>
<td>4.3</td>
<td>29.6</td>
<td>340</td>
</tr>
<tr>
<td>6/12/2016</td>
<td>36.1</td>
<td>8.3</td>
<td>22</td>
<td>0</td>
<td>7</td>
<td>17.5</td>
<td>350</td>
</tr>
<tr>
<td>6/13/2016</td>
<td>34.2</td>
<td>9</td>
<td>24</td>
<td>0</td>
<td>6.5</td>
<td>23.3</td>
<td>320</td>
</tr>
<tr>
<td>6/14/2016</td>
<td>34.4</td>
<td>3.9</td>
<td>20</td>
<td>0</td>
<td>6.5</td>
<td>28</td>
<td>320</td>
</tr>
<tr>
<td>6/15/2016</td>
<td>35</td>
<td>9.1</td>
<td>27</td>
<td>0</td>
<td>4.7</td>
<td>49</td>
<td>330</td>
</tr>
<tr>
<td>6/16/2016</td>
<td>33.7</td>
<td>16.4</td>
<td>41</td>
<td>0</td>
<td>2.4</td>
<td>13.6</td>
<td>20</td>
</tr>
<tr>
<td>6/17/2016</td>
<td>34.6</td>
<td>15.3</td>
<td>35</td>
<td>0</td>
<td>3.5</td>
<td>20.4</td>
<td>0</td>
</tr>
<tr>
<td>6/18/2016</td>
<td>34.9</td>
<td>11.2</td>
<td>27</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>360</td>
</tr>
<tr>
<td>6/19/2016</td>
<td>35.9</td>
<td>13.3</td>
<td>33</td>
<td>0</td>
<td>5</td>
<td>22.7</td>
<td>340</td>
</tr>
<tr>
<td>6/20/2016</td>
<td>37.7</td>
<td>9.3</td>
<td>22</td>
<td>0</td>
<td>5.2</td>
<td>28</td>
<td>340</td>
</tr>
<tr>
<td>6/21/2016</td>
<td>37.3</td>
<td>10.1</td>
<td>24</td>
<td>0</td>
<td>5.2</td>
<td>22.2</td>
<td>340</td>
</tr>
<tr>
<td>6/22/2016</td>
<td>35.2</td>
<td>16.7</td>
<td>35</td>
<td>0</td>
<td>2.7</td>
<td>12.7</td>
<td>20</td>
</tr>
<tr>
<td>6/23/2016</td>
<td>34.6</td>
<td>16.6</td>
<td>36</td>
<td>0</td>
<td>2.4</td>
<td>18.1</td>
<td>30</td>
</tr>
<tr>
<td>6/24/2016</td>
<td>34.9</td>
<td>16.4</td>
<td>37</td>
<td>0</td>
<td>2</td>
<td>19.6</td>
<td>50</td>
</tr>
<tr>
<td>6/25/2016</td>
<td>35.3</td>
<td>16.9</td>
<td>37</td>
<td>0</td>
<td>2</td>
<td>9.8</td>
<td>80</td>
</tr>
<tr>
<td>6/26/2016</td>
<td>35.9</td>
<td>15.4</td>
<td>36</td>
<td>0</td>
<td>1.2</td>
<td>20.4</td>
<td>60</td>
</tr>
<tr>
<td>6/27/2016</td>
<td>39</td>
<td>9.5</td>
<td>21</td>
<td>0</td>
<td>2.5</td>
<td>24.5</td>
<td>330</td>
</tr>
<tr>
<td>6/28/2016</td>
<td>36.6</td>
<td>19.7</td>
<td>41</td>
<td>0</td>
<td>3</td>
<td>25.7</td>
<td>30</td>
</tr>
<tr>
<td>6/29/2016</td>
<td>34.7</td>
<td>22.8</td>
<td>53</td>
<td>0</td>
<td>1.6</td>
<td>15</td>
<td>90</td>
</tr>
<tr>
<td>6/30/2016</td>
<td>36.5</td>
<td>18.9</td>
<td>40</td>
<td>0</td>
<td>1.3</td>
<td>15.8</td>
<td>50</td>
</tr>
<tr>
<td>7/1/2016</td>
<td>39.7</td>
<td>13.2</td>
<td>25</td>
<td>0</td>
<td>4.9</td>
<td>30.6</td>
<td>330</td>
</tr>
<tr>
<td>7/2/2016</td>
<td>38</td>
<td>13.1</td>
<td>26</td>
<td>0</td>
<td>6.5</td>
<td>29.6</td>
<td>330</td>
</tr>
<tr>
<td>7/3/2016</td>
<td>37.6</td>
<td>13</td>
<td>26</td>
<td>0</td>
<td>6.3</td>
<td>28.8</td>
<td>330</td>
</tr>
<tr>
<td>7/4/2016</td>
<td>38.2</td>
<td>10.7</td>
<td>23</td>
<td>0</td>
<td>3.6</td>
<td>22.2</td>
<td>340</td>
</tr>
<tr>
<td>7/5/2016</td>
<td>36.8</td>
<td>18.2</td>
<td>38</td>
<td>0</td>
<td>2.7</td>
<td>18.4</td>
<td>330</td>
</tr>
<tr>
<td>7/6/2016</td>
<td>36.6</td>
<td>14.3</td>
<td>28</td>
<td>0</td>
<td>2.4</td>
<td>36.2</td>
<td>10</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>wind</th>
<th>rain</th>
<th>frost</th>
<th>snow</th>
<th>windchill</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/7/2016</td>
<td>37.2</td>
<td>14.5</td>
<td>29</td>
<td>0</td>
<td>2.6</td>
<td>13</td>
<td>340</td>
</tr>
<tr>
<td>7/8/2016</td>
<td>38.8</td>
<td>14</td>
<td>26</td>
<td>0</td>
<td>3.1</td>
<td>20.8</td>
<td>340</td>
</tr>
<tr>
<td>7/9/2016</td>
<td>39.7</td>
<td>11.7</td>
<td>22</td>
<td>0</td>
<td>4.9</td>
<td>22.7</td>
<td>320</td>
</tr>
<tr>
<td>7/10/2016</td>
<td>39.0</td>
<td>9.6</td>
<td>20</td>
<td>0</td>
<td>6.8</td>
<td>28.8</td>
<td>320</td>
</tr>
<tr>
<td>7/11/2016</td>
<td>39.1</td>
<td>10.7</td>
<td>22</td>
<td>0</td>
<td>5.9</td>
<td>24.5</td>
<td>340</td>
</tr>
<tr>
<td>7/12/2016</td>
<td>37.8</td>
<td>10</td>
<td>23</td>
<td>0</td>
<td>5.7</td>
<td>22.7</td>
<td>320</td>
</tr>
<tr>
<td>7/13/2016</td>
<td>37.9</td>
<td>11.2</td>
<td>24</td>
<td>0</td>
<td>4.3</td>
<td>30.6</td>
<td>320</td>
</tr>
<tr>
<td>7/14/2016</td>
<td>36.1</td>
<td>20</td>
<td>45</td>
<td>0</td>
<td>2.8</td>
<td>9.3</td>
<td>20</td>
</tr>
<tr>
<td>7/15/2016</td>
<td>35.8</td>
<td>22.2</td>
<td>49</td>
<td>0</td>
<td>2.3</td>
<td>19.6</td>
<td>30</td>
</tr>
<tr>
<td>7/16/2016</td>
<td>35.2</td>
<td>23.8</td>
<td>54</td>
<td>0</td>
<td>3</td>
<td>29.6</td>
<td>20</td>
</tr>
<tr>
<td>7/17/2016</td>
<td>36.6</td>
<td>23.4</td>
<td>50</td>
<td>0</td>
<td>2.6</td>
<td>23.9</td>
<td>30</td>
</tr>
<tr>
<td>7/18/2016</td>
<td>35.8</td>
<td>26.5</td>
<td>62</td>
<td>0</td>
<td>2.6</td>
<td>28.8</td>
<td>90</td>
</tr>
<tr>
<td>7/19/2016</td>
<td>38</td>
<td>22.7</td>
<td>43</td>
<td>0</td>
<td>2.4</td>
<td>20.8</td>
<td>110</td>
</tr>
<tr>
<td>7/20/2016</td>
<td>39</td>
<td>21.5</td>
<td>39</td>
<td>0</td>
<td>2</td>
<td>10.2</td>
<td>150</td>
</tr>
<tr>
<td>7/21/2016</td>
<td>36.6</td>
<td>25</td>
<td>52</td>
<td>0</td>
<td>2.5</td>
<td>35</td>
<td>90</td>
</tr>
<tr>
<td>7/22/2016</td>
<td>37.3</td>
<td>25.1</td>
<td>53</td>
<td>0</td>
<td>1.7</td>
<td>15.5</td>
<td>80</td>
</tr>
<tr>
<td>7/23/2016</td>
<td>37.7</td>
<td>23.3</td>
<td>47</td>
<td>0</td>
<td>3.1</td>
<td>31.6</td>
<td>320</td>
</tr>
<tr>
<td>7/24/2016</td>
<td>35.1</td>
<td>27.4</td>
<td>65</td>
<td>0</td>
<td>2.8</td>
<td>26.4</td>
<td>40</td>
</tr>
<tr>
<td>7/25/2016</td>
<td>36.7</td>
<td>28.5</td>
<td>64</td>
<td>0</td>
<td>2.9</td>
<td>11.6</td>
<td>90</td>
</tr>
<tr>
<td>7/26/2016</td>
<td>36.2</td>
<td>28.7</td>
<td>66</td>
<td>0</td>
<td>2.9</td>
<td>28.8</td>
<td>90</td>
</tr>
<tr>
<td>7/27/2016</td>
<td>35.6</td>
<td>27.6</td>
<td>64</td>
<td>0</td>
<td>2.4</td>
<td>11.5</td>
<td>80</td>
</tr>
<tr>
<td>7/28/2016</td>
<td>35.6</td>
<td>27.1</td>
<td>62</td>
<td>0</td>
<td>2.8</td>
<td>28</td>
<td>100</td>
</tr>
<tr>
<td>7/29/2016</td>
<td>35.8</td>
<td>26.9</td>
<td>61</td>
<td>0</td>
<td>2.7</td>
<td>9.1</td>
<td>110</td>
</tr>
<tr>
<td>7/30/2016</td>
<td>35.4</td>
<td>25.8</td>
<td>59</td>
<td>0</td>
<td>1.3</td>
<td>28.8</td>
<td>80</td>
</tr>
<tr>
<td>7/31/2016</td>
<td>35.6</td>
<td>26.2</td>
<td>59</td>
<td>0</td>
<td>1.9</td>
<td>22.2</td>
<td>90</td>
</tr>
<tr>
<td>8/1/2016</td>
<td>36.9</td>
<td>22.7</td>
<td>47</td>
<td>0</td>
<td>1.2</td>
<td>11.8</td>
<td>70</td>
</tr>
<tr>
<td>8/2/2016</td>
<td>38.7</td>
<td>18.8</td>
<td>37</td>
<td>0</td>
<td>1.7</td>
<td>20</td>
<td>300</td>
</tr>
<tr>
<td>8/3/2016</td>
<td>37.8</td>
<td>23.5</td>
<td>49</td>
<td>0</td>
<td>2.6</td>
<td>19.6</td>
<td>70</td>
</tr>
<tr>
<td>8/4/2016</td>
<td>35.8</td>
<td>27.1</td>
<td>62</td>
<td>0</td>
<td>2.4</td>
<td>10.4</td>
<td>70</td>
</tr>
<tr>
<td>8/5/2016</td>
<td>35.7</td>
<td>26.8</td>
<td>61</td>
<td>0</td>
<td>2.5</td>
<td>22.7</td>
<td>40</td>
</tr>
<tr>
<td>8/6/2016</td>
<td>36.3</td>
<td>24.5</td>
<td>54</td>
<td>0</td>
<td>1.5</td>
<td>22.2</td>
<td>50</td>
</tr>
<tr>
<td>8/7/2016</td>
<td>36.7</td>
<td>24.6</td>
<td>53</td>
<td>0</td>
<td>1.9</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td>8/8/2016</td>
<td>36.8</td>
<td>22.9</td>
<td>53</td>
<td>0</td>
<td>1.6</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>8/9/2016</td>
<td>35.8</td>
<td>25.5</td>
<td>58</td>
<td>0</td>
<td>1.4</td>
<td>27.2</td>
<td>40</td>
</tr>
<tr>
<td>8/10/2016</td>
<td>36.5</td>
<td>22.5</td>
<td>49</td>
<td>0</td>
<td>1.8</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>8/11/2016</td>
<td>35.9</td>
<td>26</td>
<td>59</td>
<td>0</td>
<td>1.9</td>
<td>31.6</td>
<td>90</td>
</tr>
<tr>
<td>8/12/2016</td>
<td>35.7</td>
<td>27.8</td>
<td>64</td>
<td>0</td>
<td>2.3</td>
<td>10.8</td>
<td>70</td>
</tr>
<tr>
<td>8/13/2016</td>
<td>36.3</td>
<td>27</td>
<td>64</td>
<td>0</td>
<td>2</td>
<td>17.5</td>
<td>60</td>
</tr>
<tr>
<td>8/14/2016</td>
<td>37.9</td>
<td>23.1</td>
<td>49</td>
<td>0</td>
<td>1.4</td>
<td>17.1</td>
<td>230</td>
</tr>
<tr>
<td>8/15/2016</td>
<td>38.1</td>
<td>22.3</td>
<td>44</td>
<td>0</td>
<td>1.2</td>
<td>12.7</td>
<td>120</td>
</tr>
<tr>
<td>8/16/2016</td>
<td>37</td>
<td>23.8</td>
<td>49</td>
<td>0</td>
<td>1.3</td>
<td>25.1</td>
<td>30</td>
</tr>
</tbody>
</table>
## Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Wind Speed</th>
<th>Precipitation</th>
<th>Visibility</th>
<th>Dew Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/17/2016</td>
<td>37.5</td>
<td>22</td>
<td>45</td>
<td>0</td>
<td>3.3</td>
<td>29.6</td>
</tr>
<tr>
<td>8/18/2016</td>
<td>36.7</td>
<td>22.9</td>
<td>48</td>
<td>0</td>
<td>1.5</td>
<td>9.5</td>
</tr>
<tr>
<td>8/19/2016</td>
<td>35.4</td>
<td>25.9</td>
<td>60</td>
<td>0</td>
<td>2</td>
<td>12.7</td>
</tr>
<tr>
<td>8/20/2016</td>
<td>35.5</td>
<td>25</td>
<td>57</td>
<td>0</td>
<td>1.4</td>
<td>30.6</td>
</tr>
<tr>
<td>8/21/2016</td>
<td>35.4</td>
<td>25.7</td>
<td>60</td>
<td>0</td>
<td>1.2</td>
<td>28.8</td>
</tr>
<tr>
<td>8/22/2016</td>
<td>35.3</td>
<td>27.4</td>
<td>65</td>
<td>0</td>
<td>1.9</td>
<td>19.2</td>
</tr>
<tr>
<td>8/23/2016</td>
<td>35.9</td>
<td>26.1</td>
<td>60</td>
<td>0</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>8/24/2016</td>
<td>36.4</td>
<td>23.5</td>
<td>53</td>
<td>0</td>
<td>2.1</td>
<td>24.5</td>
</tr>
<tr>
<td>8/25/2016</td>
<td>36.3</td>
<td>24.4</td>
<td>54</td>
<td>0</td>
<td>2.4</td>
<td>26.4</td>
</tr>
<tr>
<td>8/26/2016</td>
<td>36.5</td>
<td>23.3</td>
<td>53</td>
<td>0</td>
<td>1.9</td>
<td>12.7</td>
</tr>
<tr>
<td>8/27/2016</td>
<td>36.1</td>
<td>25.1</td>
<td>56</td>
<td>0</td>
<td>1.3</td>
<td>9.8</td>
</tr>
<tr>
<td>8/28/2016</td>
<td>35.5</td>
<td>25.3</td>
<td>58</td>
<td>0</td>
<td>2</td>
<td>32.6</td>
</tr>
<tr>
<td>8/29/2016</td>
<td>35.9</td>
<td>24.5</td>
<td>56</td>
<td>0</td>
<td>2</td>
<td>9.5</td>
</tr>
<tr>
<td>8/30/2016</td>
<td>35.9</td>
<td>24.1</td>
<td>55</td>
<td>0</td>
<td>1.5</td>
<td>20.8</td>
</tr>
<tr>
<td>8/31/2016</td>
<td>36.4</td>
<td>21.5</td>
<td>48</td>
<td>0</td>
<td>1.6</td>
<td>18.1</td>
</tr>
<tr>
<td>9/1/2016</td>
<td>37.7</td>
<td>20.9</td>
<td>43</td>
<td>0</td>
<td>2</td>
<td>31.6</td>
</tr>
<tr>
<td>9/2/2016</td>
<td>37.6</td>
<td>21.3</td>
<td>45</td>
<td>0</td>
<td>2.6</td>
<td>20</td>
</tr>
<tr>
<td>9/3/2016</td>
<td>35</td>
<td>28</td>
<td>68</td>
<td>0</td>
<td>2.4</td>
<td>35</td>
</tr>
<tr>
<td>9/4/2016</td>
<td>35</td>
<td>26.8</td>
<td>63</td>
<td>0</td>
<td>1.9</td>
<td>8.6</td>
</tr>
<tr>
<td>9/5/2016</td>
<td>35.9</td>
<td>26.4</td>
<td>60</td>
<td>0</td>
<td>2.1</td>
<td>14.8</td>
</tr>
<tr>
<td>9/6/2016</td>
<td>36.5</td>
<td>22</td>
<td>45</td>
<td>0</td>
<td>2.7</td>
<td>29.6</td>
</tr>
<tr>
<td>9/7/2016</td>
<td>35.3</td>
<td>21</td>
<td>45</td>
<td>0</td>
<td>3.9</td>
<td>16</td>
</tr>
<tr>
<td>9/8/2016</td>
<td>34.1</td>
<td>21.4</td>
<td>49</td>
<td>0</td>
<td>1.4</td>
<td>25.1</td>
</tr>
<tr>
<td>9/9/2016</td>
<td>33.3</td>
<td>20.4</td>
<td>48</td>
<td>0</td>
<td>1.6</td>
<td>18.4</td>
</tr>
<tr>
<td>9/10/2016</td>
<td>32.9</td>
<td>23.3</td>
<td>58</td>
<td>0</td>
<td>1.5</td>
<td>21.7</td>
</tr>
<tr>
<td>9/11/2016</td>
<td>32.5</td>
<td>23.1</td>
<td>59</td>
<td>0</td>
<td>1.5</td>
<td>29.6</td>
</tr>
<tr>
<td>9/12/2016</td>
<td>33</td>
<td>24</td>
<td>61</td>
<td>0</td>
<td>2</td>
<td>23.3</td>
</tr>
<tr>
<td>9/13/2016</td>
<td>33.1</td>
<td>23.4</td>
<td>59</td>
<td>0</td>
<td>1.5</td>
<td>25.1</td>
</tr>
<tr>
<td>9/14/2016</td>
<td>33.8</td>
<td>26.5</td>
<td>68</td>
<td>0</td>
<td>1.9</td>
<td>9.8</td>
</tr>
<tr>
<td>9/15/2016</td>
<td>33.7</td>
<td>24.9</td>
<td>62</td>
<td>0</td>
<td>1.2</td>
<td>18.1</td>
</tr>
<tr>
<td>9/16/2016</td>
<td>33.4</td>
<td>22.8</td>
<td>56</td>
<td>0</td>
<td>1.5</td>
<td>14</td>
</tr>
<tr>
<td>9/17/2016</td>
<td>34.5</td>
<td>18.8</td>
<td>46</td>
<td>0</td>
<td>1.3</td>
<td>14.4</td>
</tr>
<tr>
<td>9/18/2016</td>
<td>34.3</td>
<td>22.5</td>
<td>56</td>
<td>0</td>
<td>2.2</td>
<td>28.8</td>
</tr>
<tr>
<td>9/19/2016</td>
<td>34.2</td>
<td>22</td>
<td>52</td>
<td>0</td>
<td>2.4</td>
<td>18.4</td>
</tr>
<tr>
<td>9/20/2016</td>
<td>34.1</td>
<td>13.6</td>
<td>33</td>
<td>0</td>
<td>3.6</td>
<td>25.7</td>
</tr>
<tr>
<td>9/21/2016</td>
<td>33.2</td>
<td>18</td>
<td>43</td>
<td>0</td>
<td>3.2</td>
<td>36.2</td>
</tr>
<tr>
<td>9/22/2016</td>
<td>32.4</td>
<td>23</td>
<td>61</td>
<td>0</td>
<td>1.5</td>
<td>21.7</td>
</tr>
<tr>
<td>9/23/2016</td>
<td>33.6</td>
<td>21.6</td>
<td>55</td>
<td>0</td>
<td>2.4</td>
<td>20.8</td>
</tr>
<tr>
<td>9/24/2016</td>
<td>33.7</td>
<td>19.9</td>
<td>47</td>
<td>0</td>
<td>2.8</td>
<td>18.4</td>
</tr>
<tr>
<td>9/25/2016</td>
<td>33.2</td>
<td>17.8</td>
<td>44</td>
<td>0</td>
<td>3.8</td>
<td>25.7</td>
</tr>
<tr>
<td>9/26/2016</td>
<td>31.7</td>
<td>20.7</td>
<td>54</td>
<td>0</td>
<td>1.8</td>
<td>9.3</td>
</tr>
</tbody>
</table>
## Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Wind Speed</th>
<th>Rainfall</th>
<th>Snowfall</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/27/2016</td>
<td>30.7</td>
<td>24.2</td>
<td>69</td>
<td>0</td>
<td>1.3</td>
<td>10.1</td>
</tr>
<tr>
<td>9/28/2016</td>
<td>32.9</td>
<td>19.4</td>
<td>51</td>
<td>0</td>
<td>1.8</td>
<td>28.8</td>
</tr>
<tr>
<td>9/29/2016</td>
<td>33.5</td>
<td>16.2</td>
<td>42</td>
<td>0</td>
<td>4</td>
<td>31.6</td>
</tr>
<tr>
<td>9/30/2016</td>
<td>31</td>
<td>14.8</td>
<td>40</td>
<td>0</td>
<td>5.1</td>
<td>24.5</td>
</tr>
<tr>
<td>10/1/2016</td>
<td>30.2</td>
<td>14.5</td>
<td>41</td>
<td>0</td>
<td>3</td>
<td>14.4</td>
</tr>
<tr>
<td>10/2/2016</td>
<td>29.4</td>
<td>13.4</td>
<td>41</td>
<td>0</td>
<td>1.8</td>
<td>20.8</td>
</tr>
<tr>
<td>10/3/2016</td>
<td>29.5</td>
<td>13.4</td>
<td>41</td>
<td>0</td>
<td>1.8</td>
<td>12.7</td>
</tr>
<tr>
<td>10/4/2016</td>
<td>29.6</td>
<td>16.4</td>
<td>49</td>
<td>0</td>
<td>2.2</td>
<td>14</td>
</tr>
<tr>
<td>10/5/2016</td>
<td>29.4</td>
<td>14.8</td>
<td>47</td>
<td>0</td>
<td>2.1</td>
<td>20.4</td>
</tr>
<tr>
<td>10/6/2016</td>
<td>30</td>
<td>12.2</td>
<td>39</td>
<td>0</td>
<td>2.2</td>
<td>15.8</td>
</tr>
<tr>
<td>10/7/2016</td>
<td>29.4</td>
<td>14.3</td>
<td>48</td>
<td>0</td>
<td>1.4</td>
<td>18.8</td>
</tr>
<tr>
<td>10/8/2016</td>
<td>29.1</td>
<td>18.7</td>
<td>58</td>
<td>0</td>
<td>1.3</td>
<td>10.3</td>
</tr>
<tr>
<td>10/9/2016</td>
<td>30.1</td>
<td>18</td>
<td>56</td>
<td>0</td>
<td>1.4</td>
<td>22.2</td>
</tr>
<tr>
<td>10/10/2016</td>
<td>30.1</td>
<td>17.7</td>
<td>57</td>
<td>0</td>
<td>1.4</td>
<td>13.8</td>
</tr>
<tr>
<td>10/11/2016</td>
<td>30.7</td>
<td>8.7</td>
<td>35</td>
<td>0</td>
<td>2.5</td>
<td>25.7</td>
</tr>
<tr>
<td>10/12/2016</td>
<td>30</td>
<td>14.8</td>
<td>49</td>
<td>0</td>
<td>1.7</td>
<td>28.8</td>
</tr>
<tr>
<td>10/13/2016</td>
<td>30.2</td>
<td>17</td>
<td>50</td>
<td>0</td>
<td>3.2</td>
<td>25.1</td>
</tr>
<tr>
<td>10/14/2016</td>
<td>29.4</td>
<td>20</td>
<td>60</td>
<td>0</td>
<td>1.4</td>
<td>20.8</td>
</tr>
<tr>
<td>10/15/2016</td>
<td>30</td>
<td>13.7</td>
<td>44</td>
<td>0</td>
<td>1.6</td>
<td>15</td>
</tr>
<tr>
<td>10/16/2016</td>
<td>29.8</td>
<td>15.4</td>
<td>50</td>
<td>0</td>
<td>2.5</td>
<td>19.2</td>
</tr>
<tr>
<td>10/17/2016</td>
<td>28.4</td>
<td>18.7</td>
<td>58</td>
<td>0</td>
<td>1.8</td>
<td>10</td>
</tr>
<tr>
<td>10/18/2016</td>
<td>29</td>
<td>19.6</td>
<td>60</td>
<td>0</td>
<td>1.9</td>
<td>18.4</td>
</tr>
<tr>
<td>10/19/2016</td>
<td>29.4</td>
<td>19.3</td>
<td>58</td>
<td>0</td>
<td>0.8</td>
<td>28</td>
</tr>
<tr>
<td>10/20/2016</td>
<td>30</td>
<td>13.7</td>
<td>42</td>
<td>0</td>
<td>2</td>
<td>33.7</td>
</tr>
<tr>
<td>10/21/2016</td>
<td>29.5</td>
<td>15.3</td>
<td>49</td>
<td>0</td>
<td>2.6</td>
<td>12.8</td>
</tr>
<tr>
<td>10/22/2016</td>
<td>28.1</td>
<td>19.4</td>
<td>61</td>
<td>0</td>
<td>1.8</td>
<td>12.7</td>
</tr>
<tr>
<td>10/23/2016</td>
<td>27.9</td>
<td>20</td>
<td>65</td>
<td>0</td>
<td>1.4</td>
<td>16.1</td>
</tr>
<tr>
<td>10/24/2016</td>
<td>27.9</td>
<td>21.2</td>
<td>70</td>
<td>0</td>
<td>1.4</td>
<td>31.6</td>
</tr>
<tr>
<td>10/25/2016</td>
<td>27.9</td>
<td>21.4</td>
<td>72</td>
<td>0</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>10/26/2016</td>
<td>28.7</td>
<td>23.3</td>
<td>73</td>
<td>0</td>
<td>2</td>
<td>30.6</td>
</tr>
<tr>
<td>10/27/2016</td>
<td>28.4</td>
<td>20.9</td>
<td>66</td>
<td>0</td>
<td>1.6</td>
<td>15.3</td>
</tr>
<tr>
<td>10/28/2016</td>
<td>28.5</td>
<td>18.1</td>
<td>58</td>
<td>0</td>
<td>1</td>
<td>11.9</td>
</tr>
<tr>
<td>10/29/2016</td>
<td>28.2</td>
<td>13.6</td>
<td>48</td>
<td>0</td>
<td>1.3</td>
<td>14.6</td>
</tr>
<tr>
<td>10/30/2016</td>
<td>27.6</td>
<td>15.1</td>
<td>50</td>
<td>0</td>
<td>1.5</td>
<td>28</td>
</tr>
<tr>
<td>10/31/2016</td>
<td>27.8</td>
<td>19.4</td>
<td>64</td>
<td>0</td>
<td>0.9</td>
<td>8.9</td>
</tr>
<tr>
<td>11/1/2016</td>
<td>27.6</td>
<td>22</td>
<td>73</td>
<td>0</td>
<td>1.3</td>
<td>18.4</td>
</tr>
<tr>
<td>11/2/2016</td>
<td>28.7</td>
<td>21.2</td>
<td>65</td>
<td>0</td>
<td>2.2</td>
<td>9.8</td>
</tr>
<tr>
<td>11/3/2016</td>
<td>28.6</td>
<td>20.8</td>
<td>64</td>
<td>0</td>
<td>1.7</td>
<td>9.8</td>
</tr>
<tr>
<td>11/4/2016</td>
<td>27.2</td>
<td>17.1</td>
<td>57</td>
<td>0</td>
<td>2.9</td>
<td>7.6</td>
</tr>
<tr>
<td>11/5/2016</td>
<td>27.1</td>
<td>18.2</td>
<td>62</td>
<td>0</td>
<td>2.3</td>
<td>6.9</td>
</tr>
<tr>
<td>11/6/2016</td>
<td>27.8</td>
<td>15.7</td>
<td>58</td>
<td>0</td>
<td>0.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp.</th>
<th>Hum.</th>
<th>Precip.</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Max Gust</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/2016</td>
<td>26.9</td>
<td>17.2</td>
<td>57</td>
<td>0</td>
<td>2.8</td>
<td>10.1</td>
<td>350</td>
</tr>
<tr>
<td>11/8/2016</td>
<td>25.1</td>
<td>10.6</td>
<td>42</td>
<td>0</td>
<td>4</td>
<td>11.9</td>
<td>330</td>
</tr>
<tr>
<td>11/9/2016</td>
<td>25</td>
<td>13.8</td>
<td>51</td>
<td>0</td>
<td>4.1</td>
<td>8.9</td>
<td>330</td>
</tr>
<tr>
<td>11/10/2016</td>
<td>25.3</td>
<td>14.8</td>
<td>54</td>
<td>0</td>
<td>3.3</td>
<td>8.4</td>
<td>330</td>
</tr>
<tr>
<td>11/11/2016</td>
<td>24.6</td>
<td>17.4</td>
<td>66</td>
<td>0</td>
<td>1.5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>11/12/2016</td>
<td>25.1</td>
<td>18.8</td>
<td>70</td>
<td>0</td>
<td>1</td>
<td>5.6</td>
<td>30</td>
</tr>
<tr>
<td>11/13/2016</td>
<td>24.7</td>
<td>18.4</td>
<td>71</td>
<td>0</td>
<td>0.9</td>
<td>4.6</td>
<td>50</td>
</tr>
<tr>
<td>11/14/2016</td>
<td>24.4</td>
<td>18.4</td>
<td>73</td>
<td>0</td>
<td>0.6</td>
<td>3.2</td>
<td>350</td>
</tr>
<tr>
<td>11/15/2016</td>
<td>24.9</td>
<td>17.9</td>
<td>69</td>
<td>0</td>
<td>1.1</td>
<td>4.9</td>
<td>300</td>
</tr>
<tr>
<td>11/16/2016</td>
<td>24.5</td>
<td>15.6</td>
<td>63</td>
<td>0</td>
<td>0.5</td>
<td>3.5</td>
<td>90</td>
</tr>
<tr>
<td>11/17/2016</td>
<td>25</td>
<td>19.2</td>
<td>71</td>
<td>0</td>
<td>1.3</td>
<td>5.3</td>
<td>110</td>
</tr>
<tr>
<td>11/18/2016</td>
<td>24.7</td>
<td>17.5</td>
<td>66</td>
<td>0</td>
<td>0.6</td>
<td>4.3</td>
<td>50</td>
</tr>
<tr>
<td>11/19/2016</td>
<td>24.6</td>
<td>16.1</td>
<td>64</td>
<td>0</td>
<td>2.9</td>
<td>6.9</td>
<td>310</td>
</tr>
<tr>
<td>11/20/2016</td>
<td>24.5</td>
<td>16.3</td>
<td>62</td>
<td>0</td>
<td>3.6</td>
<td>8.2</td>
<td>320</td>
</tr>
<tr>
<td>11/21/2016</td>
<td>24</td>
<td>14.7</td>
<td>58</td>
<td>0</td>
<td>2.1</td>
<td>5.9</td>
<td>330</td>
</tr>
<tr>
<td>11/22/2016</td>
<td>23.8</td>
<td>16.7</td>
<td>65</td>
<td>0</td>
<td>0.9</td>
<td>5.3</td>
<td>30</td>
</tr>
<tr>
<td>11/23/2016</td>
<td>23.9</td>
<td>18.7</td>
<td>74</td>
<td>0</td>
<td>1</td>
<td>6.4</td>
<td>30</td>
</tr>
<tr>
<td>11/24/2016</td>
<td>25.2</td>
<td>17.9</td>
<td>65</td>
<td>0</td>
<td>2.1</td>
<td>7.1</td>
<td>60</td>
</tr>
<tr>
<td>11/25/2016</td>
<td>23.9</td>
<td>17.8</td>
<td>69</td>
<td>4.1</td>
<td>3.4</td>
<td>10.2</td>
<td>70</td>
</tr>
<tr>
<td>11/26/2016</td>
<td>22</td>
<td>18.5</td>
<td>81</td>
<td>3.6</td>
<td>2.7</td>
<td>8.2</td>
<td>40</td>
</tr>
<tr>
<td>11/27/2016</td>
<td>22.8</td>
<td>19.5</td>
<td>82</td>
<td>14.1</td>
<td>2.2</td>
<td>11.5</td>
<td>30</td>
</tr>
<tr>
<td>11/28/2016</td>
<td>23</td>
<td>18.6</td>
<td>77</td>
<td>0.1</td>
<td>2.6</td>
<td>6</td>
<td>330</td>
</tr>
<tr>
<td>11/29/2016</td>
<td>22.9</td>
<td>16.8</td>
<td>70</td>
<td>0</td>
<td>2.9</td>
<td>8.2</td>
<td>320</td>
</tr>
<tr>
<td>11/30/2016</td>
<td>23.3</td>
<td>16.5</td>
<td>67</td>
<td>0</td>
<td>1.8</td>
<td>4.7</td>
<td>340</td>
</tr>
<tr>
<td>12/1/2016</td>
<td>24.8</td>
<td>18.1</td>
<td>68</td>
<td>0</td>
<td>1.8</td>
<td>5.2</td>
<td>100</td>
</tr>
<tr>
<td>12/2/2016</td>
<td>25.6</td>
<td>20.5</td>
<td>76</td>
<td>0</td>
<td>2.5</td>
<td>6.6</td>
<td>120</td>
</tr>
<tr>
<td>12/3/2016</td>
<td>25.9</td>
<td>19.9</td>
<td>72</td>
<td>0</td>
<td>2.2</td>
<td>5.6</td>
<td>320</td>
</tr>
<tr>
<td>12/4/2016</td>
<td>24.7</td>
<td>18.7</td>
<td>71</td>
<td>0</td>
<td>4.2</td>
<td>9.5</td>
<td>330</td>
</tr>
<tr>
<td>12/5/2016</td>
<td>24</td>
<td>18.4</td>
<td>73</td>
<td>0</td>
<td>3.2</td>
<td>7.7</td>
<td>330</td>
</tr>
<tr>
<td>12/6/2016</td>
<td>23.7</td>
<td>20.3</td>
<td>82</td>
<td>0</td>
<td>1.5</td>
<td>3.9</td>
<td>350</td>
</tr>
<tr>
<td>12/7/2016</td>
<td>23.3</td>
<td>16.8</td>
<td>68</td>
<td>0</td>
<td>3.2</td>
<td>8.2</td>
<td>330</td>
</tr>
<tr>
<td>12/8/2016</td>
<td>21</td>
<td>13.2</td>
<td>63</td>
<td>0</td>
<td>4</td>
<td>8.3</td>
<td>310</td>
</tr>
<tr>
<td>12/9/2016</td>
<td>20.2</td>
<td>11</td>
<td>57</td>
<td>0</td>
<td>3.8</td>
<td>9.4</td>
<td>320</td>
</tr>
<tr>
<td>12/10/2016</td>
<td>17.3</td>
<td>5.4</td>
<td>49</td>
<td>0</td>
<td>4.5</td>
<td>10.8</td>
<td>310</td>
</tr>
<tr>
<td>12/11/2016</td>
<td>16.8</td>
<td>4.6</td>
<td>45</td>
<td>0</td>
<td>4.4</td>
<td>8.5</td>
<td>310</td>
</tr>
<tr>
<td>12/12/2016</td>
<td>17.6</td>
<td>6.4</td>
<td>48</td>
<td>0</td>
<td>4.6</td>
<td>9.6</td>
<td>310</td>
</tr>
<tr>
<td>12/13/2016</td>
<td>17.9</td>
<td>8.2</td>
<td>54</td>
<td>0</td>
<td>1.9</td>
<td>7.4</td>
<td>310</td>
</tr>
<tr>
<td>12/14/2016</td>
<td>19.8</td>
<td>11.7</td>
<td>61</td>
<td>0</td>
<td>1.8</td>
<td>6.2</td>
<td>130</td>
</tr>
<tr>
<td>12/15/2016</td>
<td>22.1</td>
<td>12.3</td>
<td>57</td>
<td>0</td>
<td>3.3</td>
<td>7.8</td>
<td>170</td>
</tr>
<tr>
<td>12/16/2016</td>
<td>18.4</td>
<td>9.6</td>
<td>58</td>
<td>0</td>
<td>3.8</td>
<td>9</td>
<td>330</td>
</tr>
<tr>
<td>12/17/2016</td>
<td>18.2</td>
<td>10.5</td>
<td>63</td>
<td>0</td>
<td>3.8</td>
<td>8.2</td>
<td>320</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Wind</th>
<th>Pressure</th>
<th>Precipitation</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/18/2016</td>
<td>18.7</td>
<td>11.5</td>
<td>64</td>
<td>0</td>
<td>3.7</td>
<td>9.3</td>
</tr>
<tr>
<td>12/19/2016</td>
<td>19.2</td>
<td>12.0</td>
<td>65</td>
<td>0</td>
<td>2.6</td>
<td>6.4</td>
</tr>
<tr>
<td>12/20/2016</td>
<td>20.2</td>
<td>12.4</td>
<td>63</td>
<td>0</td>
<td>1.6</td>
<td>4.7</td>
</tr>
<tr>
<td>12/21/2016</td>
<td>19.7</td>
<td>13.3</td>
<td>66</td>
<td>0</td>
<td>3.1</td>
<td>7.8</td>
</tr>
<tr>
<td>12/22/2016</td>
<td>20.2</td>
<td>13.3</td>
<td>66</td>
<td>0</td>
<td>2.2</td>
<td>6.4</td>
</tr>
<tr>
<td>12/23/2016</td>
<td>21.4</td>
<td>14.3</td>
<td>66</td>
<td>0</td>
<td>2.9</td>
<td>9.8</td>
</tr>
<tr>
<td>12/24/2016</td>
<td>21.1</td>
<td>16.0</td>
<td>74</td>
<td>0</td>
<td>2.1</td>
<td>5.6</td>
</tr>
<tr>
<td>12/25/2016</td>
<td>21.2</td>
<td>18.1</td>
<td>84</td>
<td>0</td>
<td>1.3</td>
<td>5.2</td>
</tr>
<tr>
<td>12/26/2016</td>
<td>20.3</td>
<td>17.9</td>
<td>87</td>
<td>0</td>
<td>1.3</td>
<td>3.9</td>
</tr>
<tr>
<td>12/27/2016</td>
<td>19.7</td>
<td>17.5</td>
<td>88</td>
<td>0</td>
<td>1.3</td>
<td>3.2</td>
</tr>
<tr>
<td>12/28/2016</td>
<td>21.8</td>
<td>14.6</td>
<td>68</td>
<td>0</td>
<td>1.7</td>
<td>4.9</td>
</tr>
<tr>
<td>12/29/2016</td>
<td>21.0</td>
<td>16.3</td>
<td>76</td>
<td>0</td>
<td>2.8</td>
<td>7.5</td>
</tr>
<tr>
<td>12/30/2016</td>
<td>21.7</td>
<td>15.6</td>
<td>72</td>
<td>0</td>
<td>1.9</td>
<td>4.7</td>
</tr>
<tr>
<td>12/31/2016</td>
<td>21.8</td>
<td>12.5</td>
<td>60</td>
<td>0</td>
<td>1.6</td>
<td>4.6</td>
</tr>
<tr>
<td>1/1/2017</td>
<td>23.0</td>
<td>11.4</td>
<td>55</td>
<td>0</td>
<td>2.4</td>
<td>5.2</td>
</tr>
<tr>
<td>1/2/2017</td>
<td>21.2</td>
<td>14.7</td>
<td>70</td>
<td>0</td>
<td>1.8</td>
<td>5.1</td>
</tr>
<tr>
<td>1/3/2017</td>
<td>20.2</td>
<td>14.1</td>
<td>71</td>
<td>0</td>
<td>1.8</td>
<td>4.1</td>
</tr>
<tr>
<td>1/4/2017</td>
<td>20.2</td>
<td>12.0</td>
<td>61</td>
<td>0</td>
<td>3.1</td>
<td>7.1</td>
</tr>
<tr>
<td>1/5/2017</td>
<td>18.4</td>
<td>9.6</td>
<td>58</td>
<td>0</td>
<td>5</td>
<td>10.8</td>
</tr>
<tr>
<td>1/6/2017</td>
<td>17.2</td>
<td>9.7</td>
<td>62</td>
<td>0</td>
<td>4.4</td>
<td>10.5</td>
</tr>
<tr>
<td>1/7/2017</td>
<td>18.9</td>
<td>11.8</td>
<td>69</td>
<td>0</td>
<td>1.8</td>
<td>4.7</td>
</tr>
<tr>
<td>1/8/2017</td>
<td>19.1</td>
<td>9.4</td>
<td>60</td>
<td>0</td>
<td>1.3</td>
<td>4.1</td>
</tr>
<tr>
<td>1/9/2017</td>
<td>20.8</td>
<td>13.4</td>
<td>66</td>
<td>0</td>
<td>2.2</td>
<td>5.9</td>
</tr>
<tr>
<td>1/10/2017</td>
<td>20.4</td>
<td>16.1</td>
<td>78</td>
<td>0</td>
<td>1.5</td>
<td>4.2</td>
</tr>
<tr>
<td>1/11/2017</td>
<td>19.4</td>
<td>14.3</td>
<td>75</td>
<td>0</td>
<td>1.6</td>
<td>4.6</td>
</tr>
<tr>
<td>1/12/2017</td>
<td>20.1</td>
<td>11.7</td>
<td>62</td>
<td>0</td>
<td>3.3</td>
<td>8.1</td>
</tr>
<tr>
<td>1/13/2017</td>
<td>18.5</td>
<td>9.0</td>
<td>56</td>
<td>0</td>
<td>3.7</td>
<td>8.3</td>
</tr>
<tr>
<td>1/14/2017</td>
<td>17.5</td>
<td>6.0</td>
<td>49</td>
<td>0</td>
<td>3.9</td>
<td>10.8</td>
</tr>
<tr>
<td>1/15/2017</td>
<td>17.6</td>
<td>9.6</td>
<td>61</td>
<td>0</td>
<td>1.8</td>
<td>4.5</td>
</tr>
<tr>
<td>1/16/2017</td>
<td>18.2</td>
<td>13.0</td>
<td>73</td>
<td>0</td>
<td>1.9</td>
<td>4.7</td>
</tr>
<tr>
<td>1/17/2017</td>
<td>18.4</td>
<td>10.7</td>
<td>62</td>
<td>0</td>
<td>3.2</td>
<td>7.5</td>
</tr>
<tr>
<td>1/18/2017</td>
<td>17.7</td>
<td>10.8</td>
<td>65</td>
<td>0</td>
<td>1.9</td>
<td>5.6</td>
</tr>
<tr>
<td>1/19/2017</td>
<td>19.1</td>
<td>13.7</td>
<td>71</td>
<td>0</td>
<td>2.2</td>
<td>5.9</td>
</tr>
<tr>
<td>1/20/2017</td>
<td>21.3</td>
<td>13.3</td>
<td>63</td>
<td>0</td>
<td>2.4</td>
<td>6.9</td>
</tr>
<tr>
<td>1/21/2017</td>
<td>19.5</td>
<td>15.1</td>
<td>77</td>
<td>0</td>
<td>1.5</td>
<td>5.6</td>
</tr>
<tr>
<td>1/22/2017</td>
<td>20.7</td>
<td>17.0</td>
<td>80</td>
<td>0</td>
<td>2</td>
<td>5.8</td>
</tr>
<tr>
<td>1/23/2017</td>
<td>19.3</td>
<td>9.6</td>
<td>55</td>
<td>0</td>
<td>4.2</td>
<td>9.1</td>
</tr>
<tr>
<td>1/24/2017</td>
<td>16.2</td>
<td>5.2</td>
<td>49</td>
<td>0</td>
<td>4.2</td>
<td>10.1</td>
</tr>
<tr>
<td>1/25/2017</td>
<td>17.1</td>
<td>8.4</td>
<td>58</td>
<td>0</td>
<td>2.6</td>
<td>7.3</td>
</tr>
<tr>
<td>1/26/2017</td>
<td>18.3</td>
<td>11.7</td>
<td>67</td>
<td>0</td>
<td>1.6</td>
<td>5.6</td>
</tr>
<tr>
<td>1/27/2017</td>
<td>20.2</td>
<td>12.1</td>
<td>62</td>
<td>0</td>
<td>3.3</td>
<td>9.9</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Wind Speed</th>
<th>Humidity</th>
<th>Barometer</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/28/2017</td>
<td>22.1</td>
<td>14.3</td>
<td>63</td>
<td>0</td>
<td>3.3</td>
</tr>
<tr>
<td>1/29/2017</td>
<td>20.5</td>
<td>12.8</td>
<td>62</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>1/30/2017</td>
<td>16.8</td>
<td>6.2</td>
<td>51</td>
<td>0</td>
<td>3.9</td>
</tr>
<tr>
<td>1/31/2017</td>
<td>17.2</td>
<td>10.8</td>
<td>67</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>2/1/2017</td>
<td>20.2</td>
<td>13.3</td>
<td>65</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>2/2/2017</td>
<td>15.2</td>
<td>3.2</td>
<td>45</td>
<td>0</td>
<td>5.8</td>
</tr>
<tr>
<td>2/3/2017</td>
<td>10.8</td>
<td>-2.4</td>
<td>42</td>
<td>0</td>
<td>6.2</td>
</tr>
<tr>
<td>2/4/2017</td>
<td>13</td>
<td>3.1</td>
<td>52</td>
<td>0</td>
<td>3.9</td>
</tr>
<tr>
<td>2/5/2017</td>
<td>13.5</td>
<td>2.9</td>
<td>50</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>2/6/2017</td>
<td>14.8</td>
<td>5.5</td>
<td>58</td>
<td>0.6</td>
<td>2.9</td>
</tr>
<tr>
<td>2/7/2017</td>
<td>15.6</td>
<td>5.9</td>
<td>54</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>2/8/2017</td>
<td>16.8</td>
<td>9.1</td>
<td>63</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>2/9/2017</td>
<td>18.2</td>
<td>13.4</td>
<td>74</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>2/10/2017</td>
<td>20</td>
<td>15</td>
<td>74</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>2/11/2017</td>
<td>19.6</td>
<td>14.6</td>
<td>74</td>
<td>0.3</td>
<td>3.1</td>
</tr>
<tr>
<td>2/12/2017</td>
<td>21.2</td>
<td>15.6</td>
<td>71</td>
<td>0.1</td>
<td>5.9</td>
</tr>
<tr>
<td>2/13/2017</td>
<td>21.1</td>
<td>16.9</td>
<td>77</td>
<td>4.2</td>
<td>3.3</td>
</tr>
<tr>
<td>2/14/2017</td>
<td>18.4</td>
<td>16.5</td>
<td>89</td>
<td>19.2</td>
<td>2.9</td>
</tr>
<tr>
<td>2/15/2017</td>
<td>20.4</td>
<td>18</td>
<td>86</td>
<td>7.4</td>
<td>4.2</td>
</tr>
<tr>
<td>2/16/2017</td>
<td>20.5</td>
<td>17.8</td>
<td>83</td>
<td>14.2</td>
<td>3.6</td>
</tr>
<tr>
<td>2/17/2017</td>
<td>19.5</td>
<td>16.2</td>
<td>81</td>
<td>11.7</td>
<td>3.8</td>
</tr>
<tr>
<td>2/18/2017</td>
<td>14.5</td>
<td>6.5</td>
<td>59</td>
<td>0</td>
<td>4.3</td>
</tr>
<tr>
<td>2/19/2017</td>
<td>12.6</td>
<td>4.7</td>
<td>59</td>
<td>0</td>
<td>4.3</td>
</tr>
<tr>
<td>2/20/2017</td>
<td>13.6</td>
<td>7</td>
<td>65</td>
<td>2.3</td>
<td>3.1</td>
</tr>
<tr>
<td>2/21/2017</td>
<td>14.9</td>
<td>7.7</td>
<td>63</td>
<td>0.6</td>
<td>2.4</td>
</tr>
<tr>
<td>2/22/2017</td>
<td>17.3</td>
<td>11.5</td>
<td>71</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>2/23/2017</td>
<td>18.5</td>
<td>14.2</td>
<td>77</td>
<td>0.2</td>
<td>2.3</td>
</tr>
<tr>
<td>2/24/2017</td>
<td>19.6</td>
<td>14.2</td>
<td>73</td>
<td>0.1</td>
<td>3.5</td>
</tr>
<tr>
<td>2/25/2017</td>
<td>19.6</td>
<td>12.9</td>
<td>67</td>
<td>0.8</td>
<td>2.1</td>
</tr>
<tr>
<td>2/26/2017</td>
<td>17.8</td>
<td>6.6</td>
<td>52</td>
<td>0.7</td>
<td>2.1</td>
</tr>
<tr>
<td>2/27/2017</td>
<td>18.3</td>
<td>6.2</td>
<td>51</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2/28/2017</td>
<td>18</td>
<td>8</td>
<td>56</td>
<td>0</td>
<td>1.4</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

#### Daily Average of Some Meteorological Data At Alwakrah

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Temperature degree celsius</th>
<th>Mean Dew Point degree celsius</th>
<th>Mean Relative Humidity percentage</th>
<th>Total Rain Fall millimetres</th>
<th>Mean Wind Speed meters per second</th>
<th>Maximum Wind Gust meters per second</th>
<th>Mean Wind Direction 360 degree rose</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/1/2016</td>
<td>33.2</td>
<td>7.8</td>
<td>23</td>
<td>0</td>
<td>6.2</td>
<td>13.7</td>
<td>320</td>
</tr>
<tr>
<td>6/2/2016</td>
<td>34.1</td>
<td>4.3</td>
<td>18</td>
<td>0</td>
<td>5.4</td>
<td>12</td>
<td>300</td>
</tr>
<tr>
<td>6/3/2016</td>
<td>32.6</td>
<td>14.9</td>
<td>39</td>
<td>0</td>
<td>2.5</td>
<td>8</td>
<td>130</td>
</tr>
<tr>
<td>6/4/2016</td>
<td>31.9</td>
<td>16.7</td>
<td>44</td>
<td>0</td>
<td>4.6</td>
<td>10.1</td>
<td>10</td>
</tr>
<tr>
<td>6/5/2016</td>
<td>31.1</td>
<td>17.2</td>
<td>45</td>
<td>0</td>
<td>2.3</td>
<td>6.5</td>
<td>50</td>
</tr>
<tr>
<td>6/6/2016</td>
<td>31.1</td>
<td>20.9</td>
<td>55</td>
<td>0</td>
<td>2.6</td>
<td>5.7</td>
<td>120</td>
</tr>
<tr>
<td>6/7/2016</td>
<td>32.5</td>
<td>18.1</td>
<td>46</td>
<td>0</td>
<td>2.5</td>
<td>6.2</td>
<td>160</td>
</tr>
<tr>
<td>6/8/2016</td>
<td>36.8</td>
<td>10.9</td>
<td>22</td>
<td>0</td>
<td>6.6</td>
<td>12.8</td>
<td>330</td>
</tr>
<tr>
<td>6/9/2016</td>
<td>37.7</td>
<td>5.9</td>
<td>16</td>
<td>0</td>
<td>7.5</td>
<td>13.4</td>
<td>330</td>
</tr>
<tr>
<td>6/10/2016</td>
<td>35.2</td>
<td>15.6</td>
<td>35</td>
<td>0</td>
<td>5.1</td>
<td>11.2</td>
<td>350</td>
</tr>
<tr>
<td>6/11/2016</td>
<td>36.5</td>
<td>13.9</td>
<td>29</td>
<td>0</td>
<td>5.9</td>
<td>12.3</td>
<td>340</td>
</tr>
<tr>
<td>6/12/2016</td>
<td>35.9</td>
<td>9.8</td>
<td>21</td>
<td>0</td>
<td>8.2</td>
<td>15.7</td>
<td>350</td>
</tr>
<tr>
<td>6/13/2016</td>
<td>34.8</td>
<td>5.9</td>
<td>18</td>
<td>0</td>
<td>7.3</td>
<td>13</td>
<td>320</td>
</tr>
<tr>
<td>6/14/2016</td>
<td>34.4</td>
<td>1.4</td>
<td>16</td>
<td>0</td>
<td>7.2</td>
<td>13.6</td>
<td>310</td>
</tr>
<tr>
<td>6/15/2016</td>
<td>33</td>
<td>14.7</td>
<td>40</td>
<td>0</td>
<td>6</td>
<td>12</td>
<td>340</td>
</tr>
<tr>
<td>6/16/2016</td>
<td>31.9</td>
<td>22.1</td>
<td>58</td>
<td>0</td>
<td>3.4</td>
<td>6.4</td>
<td>20</td>
</tr>
<tr>
<td>6/17/2016</td>
<td>32.8</td>
<td>19.3</td>
<td>46</td>
<td>0</td>
<td>5.8</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>6/18/2016</td>
<td>33.9</td>
<td>13.8</td>
<td>31</td>
<td>0</td>
<td>6.5</td>
<td>10.8</td>
<td>360</td>
</tr>
<tr>
<td>6/19/2016</td>
<td>34.1</td>
<td>17.8</td>
<td>40</td>
<td>0</td>
<td>6.1</td>
<td>10.5</td>
<td>360</td>
</tr>
<tr>
<td>6/20/2016</td>
<td>36.3</td>
<td>14.5</td>
<td>29</td>
<td>0</td>
<td>7</td>
<td>12.4</td>
<td>360</td>
</tr>
<tr>
<td>6/21/2016</td>
<td>34.9</td>
<td>16.3</td>
<td>35</td>
<td>0</td>
<td>6.5</td>
<td>14.5</td>
<td>360</td>
</tr>
<tr>
<td>6/22/2016</td>
<td>33.8</td>
<td>19.3</td>
<td>45</td>
<td>0</td>
<td>4.8</td>
<td>8.7</td>
<td>10</td>
</tr>
<tr>
<td>6/23/2016</td>
<td>33</td>
<td>20</td>
<td>49</td>
<td>0</td>
<td>3</td>
<td>7.1</td>
<td>20</td>
</tr>
<tr>
<td>6/24/2016</td>
<td>32.7</td>
<td>21.9</td>
<td>54</td>
<td>0</td>
<td>2.9</td>
<td>6.4</td>
<td>70</td>
</tr>
<tr>
<td>6/25/2016</td>
<td>32.9</td>
<td>21.6</td>
<td>53</td>
<td>0</td>
<td>2.9</td>
<td>6.8</td>
<td>50</td>
</tr>
<tr>
<td>6/26/2016</td>
<td>33.5</td>
<td>23.5</td>
<td>57</td>
<td>0</td>
<td>2.2</td>
<td>6.2</td>
<td>100</td>
</tr>
<tr>
<td>6/27/2016</td>
<td>36.4</td>
<td>16.8</td>
<td>35</td>
<td>0</td>
<td>3.2</td>
<td>8.7</td>
<td>350</td>
</tr>
<tr>
<td>6/28/2016</td>
<td>34.4</td>
<td>22.4</td>
<td>52</td>
<td>0</td>
<td>3.7</td>
<td>8.7</td>
<td>20</td>
</tr>
<tr>
<td>6/29/2016</td>
<td>32.8</td>
<td>25.5</td>
<td>66</td>
<td>0</td>
<td>2.8</td>
<td>6.4</td>
<td>90</td>
</tr>
<tr>
<td>6/30/2016</td>
<td>33.5</td>
<td>24.1</td>
<td>59</td>
<td>0</td>
<td>2.2</td>
<td>5.8</td>
<td>110</td>
</tr>
<tr>
<td>7/1/2016</td>
<td>39.2</td>
<td>14.4</td>
<td>25</td>
<td>0</td>
<td>6.4</td>
<td>13.7</td>
<td>330</td>
</tr>
<tr>
<td>7/2/2016</td>
<td>38.4</td>
<td>11.7</td>
<td>22</td>
<td>0</td>
<td>7</td>
<td>13.4</td>
<td>320</td>
</tr>
<tr>
<td>7/3/2016</td>
<td>37.1</td>
<td>13.3</td>
<td>25</td>
<td>0</td>
<td>7.4</td>
<td>15.5</td>
<td>340</td>
</tr>
<tr>
<td>7/4/2016</td>
<td>34.8</td>
<td>20.9</td>
<td>47</td>
<td>0</td>
<td>4.6</td>
<td>10.7</td>
<td>0</td>
</tr>
<tr>
<td>7/5/2016</td>
<td>34.6</td>
<td>21.6</td>
<td>52</td>
<td>0</td>
<td>3.5</td>
<td>8.7</td>
<td>340</td>
</tr>
<tr>
<td>7/6/2016</td>
<td>33.6</td>
<td>20.4</td>
<td>48</td>
<td>0</td>
<td>3.4</td>
<td>7</td>
<td>90</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Min.</th>
<th>Max.</th>
<th>Change</th>
<th>Precip.</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/7/2016</td>
<td>34.7</td>
<td>19.7</td>
<td>46</td>
<td>0</td>
<td>3.5</td>
<td>8.4</td>
</tr>
<tr>
<td>7/8/2016</td>
<td>35.9</td>
<td>17.3</td>
<td>36</td>
<td>0</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>7/9/2016</td>
<td>39.4</td>
<td>9.9</td>
<td>19</td>
<td>0</td>
<td>5.6</td>
<td>12.3</td>
</tr>
<tr>
<td>7/10/2016</td>
<td>40</td>
<td>7.5</td>
<td>17</td>
<td>0</td>
<td>6.5</td>
<td>15.3</td>
</tr>
<tr>
<td>7/11/2016</td>
<td>39</td>
<td>10.3</td>
<td>19</td>
<td>0</td>
<td>7.3</td>
<td>14.7</td>
</tr>
<tr>
<td>7/12/2016</td>
<td>38.2</td>
<td>6.9</td>
<td>18</td>
<td>0</td>
<td>6.4</td>
<td>17</td>
</tr>
<tr>
<td>7/13/2016</td>
<td>37.4</td>
<td>11.4</td>
<td>23</td>
<td>0</td>
<td>5.4</td>
<td>11.6</td>
</tr>
<tr>
<td>7/14/2016</td>
<td>34.2</td>
<td>23</td>
<td>56</td>
<td>0</td>
<td>3.8</td>
<td>6.4</td>
</tr>
<tr>
<td>7/15/2016</td>
<td>33.9</td>
<td>26.6</td>
<td>67</td>
<td>0</td>
<td>3.6</td>
<td>8.1</td>
</tr>
<tr>
<td>7/16/2016</td>
<td>34.1</td>
<td>25.8</td>
<td>64</td>
<td>0</td>
<td>4.2</td>
<td>9.7</td>
</tr>
<tr>
<td>7/17/2016</td>
<td>34.6</td>
<td>25.5</td>
<td>62</td>
<td>0</td>
<td>3</td>
<td>9.5</td>
</tr>
<tr>
<td>7/18/2016</td>
<td>34.5</td>
<td>28.3</td>
<td>71</td>
<td>0</td>
<td>3.7</td>
<td>7.5</td>
</tr>
<tr>
<td>7/19/2016</td>
<td>35.6</td>
<td>28.5</td>
<td>67</td>
<td>0</td>
<td>3.8</td>
<td>6.3</td>
</tr>
<tr>
<td>7/20/2016</td>
<td>35.9</td>
<td>27.8</td>
<td>64</td>
<td>0</td>
<td>3.7</td>
<td>7.5</td>
</tr>
<tr>
<td>7/21/2016</td>
<td>35</td>
<td>27.7</td>
<td>67</td>
<td>0</td>
<td>4.6</td>
<td>8.9</td>
</tr>
<tr>
<td>7/22/2016</td>
<td>34.8</td>
<td>28.1</td>
<td>69</td>
<td>0</td>
<td>3.1</td>
<td>6.1</td>
</tr>
<tr>
<td>7/23/2016</td>
<td>35.6</td>
<td>26.7</td>
<td>63</td>
<td>0</td>
<td>4.7</td>
<td>8.9</td>
</tr>
<tr>
<td>7/24/2016</td>
<td>34.2</td>
<td>28.4</td>
<td>72</td>
<td>0</td>
<td>4.8</td>
<td>7.9</td>
</tr>
<tr>
<td>7/25/2016</td>
<td>35.4</td>
<td>28.8</td>
<td>69</td>
<td>0</td>
<td>4.1</td>
<td>9.2</td>
</tr>
<tr>
<td>7/26/2016</td>
<td>35</td>
<td>29.9</td>
<td>75</td>
<td>0</td>
<td>4.5</td>
<td>9.1</td>
</tr>
<tr>
<td>7/27/2016</td>
<td>34.6</td>
<td>28.8</td>
<td>72</td>
<td>0</td>
<td>4.3</td>
<td>7.1</td>
</tr>
<tr>
<td>7/28/2016</td>
<td>34.7</td>
<td>27.2</td>
<td>65</td>
<td>0</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>7/29/2016</td>
<td>34.9</td>
<td>26.9</td>
<td>64</td>
<td>0</td>
<td>4.4</td>
<td>7.6</td>
</tr>
<tr>
<td>7/30/2016</td>
<td>34.5</td>
<td>26.5</td>
<td>63</td>
<td>0</td>
<td>3</td>
<td>7.4</td>
</tr>
<tr>
<td>7/31/2016</td>
<td>34.7</td>
<td>27</td>
<td>65</td>
<td>0</td>
<td>3.6</td>
<td>6.2</td>
</tr>
<tr>
<td>8/1/2016</td>
<td>34.5</td>
<td>27.1</td>
<td>56</td>
<td>0</td>
<td>3.2</td>
<td>6.2</td>
</tr>
<tr>
<td>8/2/2016</td>
<td>36.2</td>
<td>24.2</td>
<td>53</td>
<td>0</td>
<td>3.4</td>
<td>6.7</td>
</tr>
<tr>
<td>8/3/2016</td>
<td>36.4</td>
<td>24.9</td>
<td>56</td>
<td>0</td>
<td>4.1</td>
<td>6.9</td>
</tr>
<tr>
<td>8/4/2016</td>
<td>35.4</td>
<td>27.8</td>
<td>65</td>
<td>0</td>
<td>4.3</td>
<td>8.7</td>
</tr>
<tr>
<td>8/5/2016</td>
<td>35</td>
<td>29.1</td>
<td>72</td>
<td>0</td>
<td>4.5</td>
<td>7.7</td>
</tr>
<tr>
<td>8/6/2016</td>
<td>35.3</td>
<td>26.1</td>
<td>60</td>
<td>0</td>
<td>3.2</td>
<td>9.2</td>
</tr>
<tr>
<td>8/7/2016</td>
<td>35.3</td>
<td>26.7</td>
<td>63</td>
<td>0</td>
<td>3.5</td>
<td>7.8</td>
</tr>
<tr>
<td>8/8/2016</td>
<td>35.1</td>
<td>27.1</td>
<td>65</td>
<td>0</td>
<td>3.6</td>
<td>6.4</td>
</tr>
<tr>
<td>8/9/2016</td>
<td>35</td>
<td>26.4</td>
<td>63</td>
<td>0</td>
<td>3.1</td>
<td>6</td>
</tr>
<tr>
<td>8/10/2016</td>
<td>35.2</td>
<td>24.7</td>
<td>58</td>
<td>0</td>
<td>3.9</td>
<td>7.5</td>
</tr>
<tr>
<td>8/11/2016</td>
<td>34.9</td>
<td>26.6</td>
<td>64</td>
<td>0</td>
<td>4.1</td>
<td>7.5</td>
</tr>
<tr>
<td>8/12/2016</td>
<td>35.2</td>
<td>28.9</td>
<td>70</td>
<td>0</td>
<td>3.8</td>
<td>9.7</td>
</tr>
<tr>
<td>8/13/2016</td>
<td>34.9</td>
<td>29.9</td>
<td>76</td>
<td>0</td>
<td>3.7</td>
<td>7.9</td>
</tr>
<tr>
<td>8/14/2016</td>
<td>35.8</td>
<td>27.3</td>
<td>63</td>
<td>0</td>
<td>3.3</td>
<td>5.6</td>
</tr>
<tr>
<td>8/15/2016</td>
<td>35.9</td>
<td>25</td>
<td>55</td>
<td>0</td>
<td>2.9</td>
<td>6.4</td>
</tr>
<tr>
<td>8/16/2016</td>
<td>35.7</td>
<td>25</td>
<td>55</td>
<td>0</td>
<td>3.1</td>
<td>7.9</td>
</tr>
</tbody>
</table>

86
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp</th>
<th>Humidity</th>
<th>Precip</th>
<th>Wind</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/17/2016</td>
<td>36</td>
<td>25.1</td>
<td>55</td>
<td>0</td>
<td>6.3</td>
</tr>
<tr>
<td>8/18/2016</td>
<td>35.7</td>
<td>25.4</td>
<td>56</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>8/19/2016</td>
<td>35.3</td>
<td>27.3</td>
<td>64</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>8/20/2016</td>
<td>35</td>
<td>26.5</td>
<td>62</td>
<td>0</td>
<td>3.3</td>
</tr>
<tr>
<td>8/21/2016</td>
<td>34.2</td>
<td>26.8</td>
<td>66</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>8/22/2016</td>
<td>34.7</td>
<td>28</td>
<td>69</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>8/23/2016</td>
<td>35.2</td>
<td>27.7</td>
<td>66</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>8/24/2016</td>
<td>35.9</td>
<td>25.8</td>
<td>58</td>
<td>0</td>
<td>4.6</td>
</tr>
<tr>
<td>8/25/2016</td>
<td>35.1</td>
<td>26.7</td>
<td>63</td>
<td>0</td>
<td>4.4</td>
</tr>
<tr>
<td>8/26/2016</td>
<td>35.3</td>
<td>26.8</td>
<td>62</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>8/27/2016</td>
<td>34.7</td>
<td>27.9</td>
<td>68</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>8/28/2016</td>
<td>34.7</td>
<td>26.4</td>
<td>63</td>
<td>0</td>
<td>4.0</td>
</tr>
<tr>
<td>8/29/2016</td>
<td>35.1</td>
<td>26.6</td>
<td>62</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>8/30/2016</td>
<td>35.3</td>
<td>26.2</td>
<td>60</td>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>8/31/2016</td>
<td>34.9</td>
<td>25.2</td>
<td>59</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>9/1/2016</td>
<td>35.6</td>
<td>24.3</td>
<td>57</td>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>9/2/2016</td>
<td>35.4</td>
<td>26.3</td>
<td>61</td>
<td>0</td>
<td>4.0</td>
</tr>
<tr>
<td>9/3/2016</td>
<td>34.8</td>
<td>28.3</td>
<td>69</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>9/4/2016</td>
<td>34.5</td>
<td>27.1</td>
<td>66</td>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>9/5/2016</td>
<td>35.3</td>
<td>26.5</td>
<td>61</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>9/6/2016</td>
<td>35.7</td>
<td>23.7</td>
<td>51</td>
<td>0</td>
<td>5.5</td>
</tr>
<tr>
<td>9/7/2016</td>
<td>34.8</td>
<td>22.9</td>
<td>51</td>
<td>0</td>
<td>7.1</td>
</tr>
<tr>
<td>9/8/2016</td>
<td>33.7</td>
<td>22.8</td>
<td>53</td>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>9/9/2016</td>
<td>32.8</td>
<td>21.6</td>
<td>52</td>
<td>0</td>
<td>3.3</td>
</tr>
<tr>
<td>9/10/2016</td>
<td>33.1</td>
<td>24.1</td>
<td>60</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>9/11/2016</td>
<td>32.2</td>
<td>24.1</td>
<td>63</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>9/12/2016</td>
<td>31.7</td>
<td>24.7</td>
<td>67</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>9/13/2016</td>
<td>32.4</td>
<td>24.7</td>
<td>65</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>9/14/2016</td>
<td>33.5</td>
<td>27.6</td>
<td>72</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>9/15/2016</td>
<td>33.3</td>
<td>26.3</td>
<td>67</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>9/16/2016</td>
<td>33.1</td>
<td>22.7</td>
<td>55</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>9/17/2016</td>
<td>33</td>
<td>22.8</td>
<td>57</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>9/18/2016</td>
<td>33.3</td>
<td>24.6</td>
<td>62</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>9/19/2016</td>
<td>33.9</td>
<td>23.4</td>
<td>55</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>9/20/2016</td>
<td>34</td>
<td>15.2</td>
<td>34</td>
<td>0</td>
<td>6.0</td>
</tr>
<tr>
<td>9/21/2016</td>
<td>32.4</td>
<td>21</td>
<td>51</td>
<td>0</td>
<td>5.9</td>
</tr>
<tr>
<td>9/22/2016</td>
<td>31.7</td>
<td>24.1</td>
<td>64</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>9/23/2016</td>
<td>32.6</td>
<td>22.7</td>
<td>58</td>
<td>0</td>
<td>4.3</td>
</tr>
<tr>
<td>9/24/2016</td>
<td>33.1</td>
<td>19.4</td>
<td>45</td>
<td>0</td>
<td>5.1</td>
</tr>
<tr>
<td>9/25/2016</td>
<td>33.7</td>
<td>15.9</td>
<td>37</td>
<td>0</td>
<td>6.0</td>
</tr>
<tr>
<td>9/26/2016</td>
<td>31.2</td>
<td>21.4</td>
<td>57</td>
<td>0</td>
<td>3.8</td>
</tr>
</tbody>
</table>
## Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>MAX</th>
<th>AVG</th>
<th>MIN</th>
<th>Wind</th>
<th>Rain</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/27/2016</td>
<td>30.5</td>
<td>24.6</td>
<td>71</td>
<td>0</td>
<td>2.6</td>
<td>6.3</td>
</tr>
<tr>
<td>9/28/2016</td>
<td>31.8</td>
<td>20.9</td>
<td>54</td>
<td>0</td>
<td>2.8</td>
<td>7</td>
</tr>
<tr>
<td>9/29/2016</td>
<td>32.9</td>
<td>17.6</td>
<td>43</td>
<td>0</td>
<td>6.2</td>
<td>12.9</td>
</tr>
<tr>
<td>9/30/2016</td>
<td>31</td>
<td>14</td>
<td>38</td>
<td>0</td>
<td>6.6</td>
<td>13</td>
</tr>
<tr>
<td>10/1/2016</td>
<td>29.8</td>
<td>16.6</td>
<td>46</td>
<td>0</td>
<td>5.7</td>
<td>10.1</td>
</tr>
<tr>
<td>10/2/2016</td>
<td>29</td>
<td>17</td>
<td>49</td>
<td>0</td>
<td>4.4</td>
<td>10.6</td>
</tr>
<tr>
<td>10/3/2016</td>
<td>28.7</td>
<td>16.3</td>
<td>48</td>
<td>0</td>
<td>4.8</td>
<td>9.3</td>
</tr>
<tr>
<td>10/4/2016</td>
<td>28.6</td>
<td>17.7</td>
<td>53</td>
<td>0</td>
<td>3.8</td>
<td>8.6</td>
</tr>
<tr>
<td>10/5/2016</td>
<td>28.1</td>
<td>16.5</td>
<td>52</td>
<td>0</td>
<td>2.8</td>
<td>6.7</td>
</tr>
<tr>
<td>10/6/2016</td>
<td>28.2</td>
<td>16.6</td>
<td>51</td>
<td>0</td>
<td>3.1</td>
<td>5.7</td>
</tr>
<tr>
<td>10/7/2016</td>
<td>29.5</td>
<td>16.9</td>
<td>50</td>
<td>0</td>
<td>3.8</td>
<td>6.5</td>
</tr>
<tr>
<td>10/8/2016</td>
<td>28.3</td>
<td>20</td>
<td>62</td>
<td>0</td>
<td>3</td>
<td>6.7</td>
</tr>
<tr>
<td>10/9/2016</td>
<td>29.2</td>
<td>20.7</td>
<td>62</td>
<td>0</td>
<td>2.6</td>
<td>5.8</td>
</tr>
<tr>
<td>10/10/2016</td>
<td>29</td>
<td>21.1</td>
<td>65</td>
<td>0</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>10/11/2016</td>
<td>29.8</td>
<td>12.7</td>
<td>42</td>
<td>0</td>
<td>3.3</td>
<td>9.7</td>
</tr>
<tr>
<td>10/12/2016</td>
<td>29</td>
<td>18.3</td>
<td>55</td>
<td>0</td>
<td>2.7</td>
<td>7.3</td>
</tr>
<tr>
<td>10/13/2016</td>
<td>29.6</td>
<td>18.8</td>
<td>54</td>
<td>0</td>
<td>4.5</td>
<td>9.8</td>
</tr>
<tr>
<td>10/14/2016</td>
<td>29</td>
<td>20.7</td>
<td>62</td>
<td>0</td>
<td>3.7</td>
<td>7.9</td>
</tr>
<tr>
<td>10/15/2016</td>
<td>28.8</td>
<td>17.9</td>
<td>56</td>
<td>0</td>
<td>2.6</td>
<td>6.7</td>
</tr>
<tr>
<td>10/16/2016</td>
<td>29.3</td>
<td>18.5</td>
<td>55</td>
<td>0</td>
<td>4.9</td>
<td>10.3</td>
</tr>
<tr>
<td>10/17/2016</td>
<td>28.8</td>
<td>19.7</td>
<td>59</td>
<td>0</td>
<td>3</td>
<td>5.8</td>
</tr>
<tr>
<td>10/18/2016</td>
<td>29.3</td>
<td>22.3</td>
<td>66</td>
<td>0</td>
<td>3.4</td>
<td>5.7</td>
</tr>
<tr>
<td>10/19/2016</td>
<td>29.7</td>
<td>21.4</td>
<td>62</td>
<td>0</td>
<td>2.4</td>
<td>4.9</td>
</tr>
<tr>
<td>10/20/2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/21/2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/22/2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/23/2016</td>
<td>27.9</td>
<td>21.1</td>
<td>67</td>
<td>0</td>
<td>3</td>
<td>6.2</td>
</tr>
<tr>
<td>10/24/2016</td>
<td>27.7</td>
<td>21.8</td>
<td>71</td>
<td>0</td>
<td>3.2</td>
<td>5.2</td>
</tr>
<tr>
<td>10/25/2016</td>
<td>27.8</td>
<td>22.7</td>
<td>74</td>
<td>0</td>
<td>2.9</td>
<td>5.4</td>
</tr>
<tr>
<td>10/26/2016</td>
<td>29.2</td>
<td>23.7</td>
<td>72</td>
<td>0</td>
<td>3.7</td>
<td>6.3</td>
</tr>
<tr>
<td>10/27/2016</td>
<td>29.4</td>
<td>22.8</td>
<td>68</td>
<td>0</td>
<td>4.4</td>
<td>6.8</td>
</tr>
<tr>
<td>10/28/2016</td>
<td>28.8</td>
<td>20.9</td>
<td>63</td>
<td>0</td>
<td>3.3</td>
<td>5.9</td>
</tr>
<tr>
<td>10/29/2016</td>
<td>27.5</td>
<td>15.1</td>
<td>50</td>
<td>0</td>
<td>2.9</td>
<td>6.9</td>
</tr>
<tr>
<td>10/30/2016</td>
<td>27.5</td>
<td>16.2</td>
<td>54</td>
<td>0</td>
<td>3</td>
<td>7.2</td>
</tr>
<tr>
<td>10/31/2016</td>
<td>27.7</td>
<td>20.5</td>
<td>67</td>
<td>0</td>
<td>3.4</td>
<td>6.5</td>
</tr>
<tr>
<td>11/1/2016</td>
<td>28.7</td>
<td>21.9</td>
<td>67</td>
<td>0</td>
<td>3.1</td>
<td>5.9</td>
</tr>
<tr>
<td>11/2/2016</td>
<td>29.1</td>
<td>21.5</td>
<td>64</td>
<td>0</td>
<td>4.1</td>
<td>6.9</td>
</tr>
<tr>
<td>11/3/2016</td>
<td>28.5</td>
<td>21.7</td>
<td>67</td>
<td>0</td>
<td>4.2</td>
<td>9.2</td>
</tr>
<tr>
<td>11/4/2016</td>
<td>27</td>
<td>17.8</td>
<td>58</td>
<td>0</td>
<td>6</td>
<td>9.3</td>
</tr>
<tr>
<td>11/5/2016</td>
<td>27.2</td>
<td>16.6</td>
<td>57</td>
<td>0</td>
<td>4.2</td>
<td>8.5</td>
</tr>
<tr>
<td>11/6/2016</td>
<td>27.4</td>
<td>19.6</td>
<td>64</td>
<td>0</td>
<td>2.5</td>
<td>4.9</td>
</tr>
</tbody>
</table>
# Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Precipitation</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Humidity</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/2016</td>
<td>26.6</td>
<td>18</td>
<td>60</td>
<td>0</td>
<td>5.4</td>
<td>12.8</td>
</tr>
<tr>
<td>11/8/2016</td>
<td>25.4</td>
<td>10.1</td>
<td>39</td>
<td>0</td>
<td>6.5</td>
<td>13.1</td>
</tr>
<tr>
<td>11/9/2016</td>
<td>25</td>
<td>12.7</td>
<td>48</td>
<td>0</td>
<td>5.7</td>
<td>9.9</td>
</tr>
<tr>
<td>11/10/2016</td>
<td>24.9</td>
<td>15.6</td>
<td>57</td>
<td>0</td>
<td>5.8</td>
<td>11.2</td>
</tr>
<tr>
<td>11/11/2016</td>
<td>25</td>
<td>17.9</td>
<td>65</td>
<td>0</td>
<td>4</td>
<td>7.5</td>
</tr>
<tr>
<td>11/12/2016</td>
<td>25.3</td>
<td>19.2</td>
<td>70</td>
<td>0</td>
<td>3.1</td>
<td>5.7</td>
</tr>
<tr>
<td>11/13/2016</td>
<td>24.7</td>
<td>18.8</td>
<td>70</td>
<td>0</td>
<td>2.5</td>
<td>5.3</td>
</tr>
<tr>
<td>11/14/2016</td>
<td>23.7</td>
<td>17.4</td>
<td>70</td>
<td>0</td>
<td>2.4</td>
<td>5</td>
</tr>
<tr>
<td>11/15/2016</td>
<td>23.7</td>
<td>19</td>
<td>76</td>
<td>0</td>
<td>2.4</td>
<td>5.5</td>
</tr>
<tr>
<td>11/16/2016</td>
<td>24.1</td>
<td>18.2</td>
<td>70</td>
<td>0</td>
<td>2.3</td>
<td>4.3</td>
</tr>
<tr>
<td>11/17/2016</td>
<td>26.1</td>
<td>19.1</td>
<td>65</td>
<td>0</td>
<td>3.5</td>
<td>4.9</td>
</tr>
<tr>
<td>11/18/2016</td>
<td>24.8</td>
<td>17.3</td>
<td>63</td>
<td>0</td>
<td>2.3</td>
<td>5.6</td>
</tr>
<tr>
<td>11/19/2016</td>
<td>24.1</td>
<td>14.7</td>
<td>60</td>
<td>0</td>
<td>5.7</td>
<td>8.9</td>
</tr>
<tr>
<td>11/20/2016</td>
<td>24.5</td>
<td>15.3</td>
<td>59</td>
<td>0</td>
<td>5.7</td>
<td>10</td>
</tr>
<tr>
<td>11/21/2016</td>
<td>24.1</td>
<td>15.9</td>
<td>61</td>
<td>0</td>
<td>4.5</td>
<td>8.1</td>
</tr>
<tr>
<td>11/22/2016</td>
<td>24.4</td>
<td>17.8</td>
<td>67</td>
<td>0</td>
<td>4</td>
<td>8.9</td>
</tr>
<tr>
<td>11/23/2016</td>
<td>25</td>
<td>19.2</td>
<td>70</td>
<td>0</td>
<td>3.1</td>
<td>7</td>
</tr>
<tr>
<td>11/24/2016</td>
<td>25.6</td>
<td>18.8</td>
<td>66</td>
<td>0.1</td>
<td>5.1</td>
<td>11.2</td>
</tr>
<tr>
<td>11/25/2016</td>
<td>24.2</td>
<td>18.3</td>
<td>70</td>
<td>0.5</td>
<td>7.1</td>
<td>12.8</td>
</tr>
<tr>
<td>11/26/2016</td>
<td>23.7</td>
<td>19.3</td>
<td>77</td>
<td>18</td>
<td>6.5</td>
<td>11.2</td>
</tr>
<tr>
<td>11/27/2016</td>
<td>24.2</td>
<td>19.2</td>
<td>74</td>
<td>11.6</td>
<td>3.4</td>
<td>15.3</td>
</tr>
<tr>
<td>11/28/2016</td>
<td>23.1</td>
<td>17.7</td>
<td>72</td>
<td>0</td>
<td>4.6</td>
<td>8.5</td>
</tr>
<tr>
<td>11/29/2016</td>
<td>22.8</td>
<td>15.5</td>
<td>64</td>
<td>0</td>
<td>5.2</td>
<td>9.8</td>
</tr>
<tr>
<td>11/30/2016</td>
<td>23.1</td>
<td>16.4</td>
<td>66</td>
<td>0</td>
<td>3.6</td>
<td>7.3</td>
</tr>
<tr>
<td>12/1/2016</td>
<td>24.1</td>
<td>18.6</td>
<td>72</td>
<td>0</td>
<td>3.2</td>
<td>5.8</td>
</tr>
<tr>
<td>12/2/2016</td>
<td>25</td>
<td>22.2</td>
<td>84</td>
<td>0</td>
<td>3.1</td>
<td>5.3</td>
</tr>
<tr>
<td>12/3/2016</td>
<td>25</td>
<td>20.9</td>
<td>79</td>
<td>0</td>
<td>3.6</td>
<td>8.7</td>
</tr>
<tr>
<td>12/4/2016</td>
<td>24.8</td>
<td>18</td>
<td>67</td>
<td>0</td>
<td>6</td>
<td>10.9</td>
</tr>
<tr>
<td>12/5/2016</td>
<td>24.2</td>
<td>17.9</td>
<td>69</td>
<td>0</td>
<td>4.9</td>
<td>10</td>
</tr>
<tr>
<td>12/6/2016</td>
<td>23.5</td>
<td>19.9</td>
<td>80</td>
<td>0</td>
<td>2.1</td>
<td>5.3</td>
</tr>
<tr>
<td>12/7/2016</td>
<td>22.8</td>
<td>16.9</td>
<td>70</td>
<td>0</td>
<td>5.5</td>
<td>9.7</td>
</tr>
<tr>
<td>12/8/2016</td>
<td>20.8</td>
<td>12.5</td>
<td>61</td>
<td>0</td>
<td>5.6</td>
<td>10</td>
</tr>
<tr>
<td>12/9/2016</td>
<td>20.7</td>
<td>10.4</td>
<td>53</td>
<td>0</td>
<td>5.6</td>
<td>10.3</td>
</tr>
<tr>
<td>12/10/2016</td>
<td>17.3</td>
<td>3.7</td>
<td>44</td>
<td>0</td>
<td>6.8</td>
<td>12.1</td>
</tr>
<tr>
<td>12/11/2016</td>
<td>16.5</td>
<td>3.5</td>
<td>43</td>
<td>0</td>
<td>5.9</td>
<td>11.2</td>
</tr>
<tr>
<td>12/12/2016</td>
<td>17.2</td>
<td>5.7</td>
<td>47</td>
<td>0</td>
<td>5.9</td>
<td>11</td>
</tr>
<tr>
<td>12/13/2016</td>
<td>17.4</td>
<td>8.1</td>
<td>55</td>
<td>0</td>
<td>2.9</td>
<td>6.6</td>
</tr>
<tr>
<td>12/14/2016</td>
<td>19.5</td>
<td>13.3</td>
<td>68</td>
<td>0</td>
<td>3.6</td>
<td>7.4</td>
</tr>
<tr>
<td>12/15/2016</td>
<td>21.1</td>
<td>14.6</td>
<td>67</td>
<td>0</td>
<td>5.3</td>
<td>9.8</td>
</tr>
<tr>
<td>12/16/2016</td>
<td>18.5</td>
<td>9.3</td>
<td>56</td>
<td>0</td>
<td>6</td>
<td>10.7</td>
</tr>
<tr>
<td>12/17/2016</td>
<td>18</td>
<td>9.9</td>
<td>60</td>
<td>0</td>
<td>5.8</td>
<td>9.3</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp</th>
<th>Wind</th>
<th>Precip</th>
<th>UV</th>
<th>Humidity</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/18/2016</td>
<td>18.6</td>
<td>10.7</td>
<td>61</td>
<td>0</td>
<td>5.8</td>
<td>10.5</td>
</tr>
<tr>
<td>12/19/2016</td>
<td>18.9</td>
<td>11.8</td>
<td>64</td>
<td>0</td>
<td>4.1</td>
<td>8.1</td>
</tr>
<tr>
<td>12/20/2016</td>
<td>19.1</td>
<td>13.4</td>
<td>70</td>
<td>0</td>
<td>2.2</td>
<td>5.6</td>
</tr>
<tr>
<td>12/21/2016</td>
<td>19.3</td>
<td>13.2</td>
<td>68</td>
<td>0</td>
<td>6.1</td>
<td>11.4</td>
</tr>
<tr>
<td>12/22/2016</td>
<td>19.4</td>
<td>13.3</td>
<td>68</td>
<td>0</td>
<td>4.1</td>
<td>8.9</td>
</tr>
<tr>
<td>12/23/2016</td>
<td>20.6</td>
<td>14.7</td>
<td>69</td>
<td>0</td>
<td>5</td>
<td>9.9</td>
</tr>
<tr>
<td>12/24/2016</td>
<td>20.9</td>
<td>16.3</td>
<td>76</td>
<td>0</td>
<td>3.8</td>
<td>8</td>
</tr>
<tr>
<td>12/25/2016</td>
<td>19.2</td>
<td>17.5</td>
<td>90</td>
<td>0</td>
<td>1.4</td>
<td>3.6</td>
</tr>
<tr>
<td>12/26/2016</td>
<td>18.4</td>
<td>17.3</td>
<td>94</td>
<td>0</td>
<td>1.6</td>
<td>4.5</td>
</tr>
<tr>
<td>12/27/2016</td>
<td>17.7</td>
<td>8.4</td>
<td>55</td>
<td>0</td>
<td>1.4</td>
<td>3.1</td>
</tr>
<tr>
<td>12/28/2016</td>
<td>19.1</td>
<td>12.8</td>
<td>56</td>
<td>0</td>
<td>2.9</td>
<td>6.8</td>
</tr>
<tr>
<td>12/29/2016</td>
<td>20.6</td>
<td>16.1</td>
<td>76</td>
<td>0</td>
<td>4.5</td>
<td>8.7</td>
</tr>
<tr>
<td>12/30/2016</td>
<td>21.4</td>
<td>14.8</td>
<td>68</td>
<td>0</td>
<td>3.3</td>
<td>6.6</td>
</tr>
<tr>
<td>12/31/2016</td>
<td>21.4</td>
<td>12.6</td>
<td>61</td>
<td>0</td>
<td>2.9</td>
<td>6</td>
</tr>
<tr>
<td>1/1/2017</td>
<td>21.5</td>
<td>12</td>
<td>59</td>
<td>0</td>
<td>3.2</td>
<td>6.9</td>
</tr>
<tr>
<td>1/2/2017</td>
<td>20.3</td>
<td>16.1</td>
<td>77</td>
<td>0</td>
<td>2.5</td>
<td>6.3</td>
</tr>
<tr>
<td>1/3/2017</td>
<td>19.8</td>
<td>15.2</td>
<td>76</td>
<td>0</td>
<td>2.9</td>
<td>6.9</td>
</tr>
<tr>
<td>1/4/2017</td>
<td>19.6</td>
<td>12.1</td>
<td>62</td>
<td>0</td>
<td>5.2</td>
<td>9</td>
</tr>
<tr>
<td>1/5/2017</td>
<td>18.1</td>
<td>8.8</td>
<td>56</td>
<td>0</td>
<td>6.7</td>
<td>11.8</td>
</tr>
<tr>
<td>1/6/2017</td>
<td>16.8</td>
<td>8.9</td>
<td>60</td>
<td>0</td>
<td>6.5</td>
<td>11.1</td>
</tr>
<tr>
<td>1/7/2017</td>
<td>17.8</td>
<td>11.6</td>
<td>68</td>
<td>0</td>
<td>3.6</td>
<td>6.1</td>
</tr>
<tr>
<td>1/8/2017</td>
<td>19</td>
<td>11.6</td>
<td>63</td>
<td>0</td>
<td>2.6</td>
<td>4.8</td>
</tr>
<tr>
<td>1/9/2017</td>
<td>20.1</td>
<td>15.8</td>
<td>77</td>
<td>0</td>
<td>3.1</td>
<td>5.1</td>
</tr>
<tr>
<td>1/10/2017</td>
<td>19.8</td>
<td>17.2</td>
<td>85</td>
<td>0</td>
<td>2.4</td>
<td>4.2</td>
</tr>
<tr>
<td>1/11/2017</td>
<td>19.3</td>
<td>14.5</td>
<td>74</td>
<td>0</td>
<td>2.6</td>
<td>6.2</td>
</tr>
<tr>
<td>1/12/2017</td>
<td>19.9</td>
<td>10.4</td>
<td>57</td>
<td>0</td>
<td>5.7</td>
<td>9.5</td>
</tr>
<tr>
<td>1/13/2017</td>
<td>18.6</td>
<td>8.4</td>
<td>53</td>
<td>0</td>
<td>5.5</td>
<td>8.7</td>
</tr>
<tr>
<td>1/14/2017</td>
<td>17.6</td>
<td>5.4</td>
<td>46</td>
<td>0</td>
<td>5.8</td>
<td>12</td>
</tr>
<tr>
<td>1/15/2017</td>
<td>17.2</td>
<td>9.8</td>
<td>62</td>
<td>0</td>
<td>3.4</td>
<td>6.4</td>
</tr>
<tr>
<td>1/16/2017</td>
<td>18.5</td>
<td>13.5</td>
<td>73</td>
<td>0</td>
<td>2.8</td>
<td>5.2</td>
</tr>
<tr>
<td>1/17/2017</td>
<td>18.2</td>
<td>10.9</td>
<td>63</td>
<td>0</td>
<td>5.3</td>
<td>9.9</td>
</tr>
<tr>
<td>1/18/2017</td>
<td>17.6</td>
<td>10.9</td>
<td>66</td>
<td>0</td>
<td>3.6</td>
<td>8.4</td>
</tr>
<tr>
<td>1/19/2017</td>
<td>18.9</td>
<td>14</td>
<td>73</td>
<td>0</td>
<td>3.3</td>
<td>7</td>
</tr>
<tr>
<td>1/20/2017</td>
<td>19.9</td>
<td>14.7</td>
<td>73</td>
<td>0</td>
<td>3.6</td>
<td>7.4</td>
</tr>
<tr>
<td>1/21/2017</td>
<td>19.5</td>
<td>14.8</td>
<td>75</td>
<td>0</td>
<td>2.9</td>
<td>6.1</td>
</tr>
<tr>
<td>1/22/2017</td>
<td>20.6</td>
<td>17.5</td>
<td>82</td>
<td>0</td>
<td>3.5</td>
<td>7.1</td>
</tr>
<tr>
<td>1/23/2017</td>
<td>19.2</td>
<td>9.8</td>
<td>55</td>
<td>0</td>
<td>6.5</td>
<td>12.3</td>
</tr>
<tr>
<td>1/24/2017</td>
<td>15.9</td>
<td>4.3</td>
<td>47</td>
<td>0</td>
<td>6.6</td>
<td>11.3</td>
</tr>
<tr>
<td>1/25/2017</td>
<td>16.7</td>
<td>8.3</td>
<td>59</td>
<td>0</td>
<td>4.5</td>
<td>8.5</td>
</tr>
<tr>
<td>1/26/2017</td>
<td>18.3</td>
<td>12.2</td>
<td>68</td>
<td>0</td>
<td>3.1</td>
<td>6.2</td>
</tr>
<tr>
<td>1/27/2017</td>
<td>19.7</td>
<td>13.9</td>
<td>69</td>
<td>0</td>
<td>6.3</td>
<td>8.7</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Pressure</th>
<th>Rainfall</th>
<th>Wind Speed</th>
<th>Hourly Sunlight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/28/2017</td>
<td>20.6</td>
<td>16.1</td>
<td>76</td>
<td>0</td>
<td>5</td>
<td>8.1</td>
</tr>
<tr>
<td>1/29/2017</td>
<td>20</td>
<td>13.4</td>
<td>67</td>
<td>0</td>
<td>4.6</td>
<td>12</td>
</tr>
<tr>
<td>1/30/2017</td>
<td>16.6</td>
<td>6.2</td>
<td>91</td>
<td>0</td>
<td>4.6</td>
<td>12.7</td>
</tr>
<tr>
<td>1/31/2017</td>
<td>16.9</td>
<td>11.9</td>
<td>72</td>
<td>0</td>
<td>3.6</td>
<td>5.9</td>
</tr>
<tr>
<td>2/1/2017</td>
<td>19.6</td>
<td>14.7</td>
<td>74</td>
<td>0</td>
<td>4.3</td>
<td>10.9</td>
</tr>
<tr>
<td>2/2/2017</td>
<td>15.3</td>
<td>3.4</td>
<td>51</td>
<td>0</td>
<td>3.1</td>
<td>15.9</td>
</tr>
<tr>
<td>2/3/2017</td>
<td>10.8</td>
<td>-3.7</td>
<td>39</td>
<td>0</td>
<td>8.8</td>
<td>18.5</td>
</tr>
<tr>
<td>2/4/2017</td>
<td>13.1</td>
<td>2.5</td>
<td>49</td>
<td>0</td>
<td>3.3</td>
<td>10.9</td>
</tr>
<tr>
<td>2/5/2017</td>
<td>13.4</td>
<td>2.6</td>
<td>49</td>
<td>0</td>
<td>3.3</td>
<td>7.5</td>
</tr>
<tr>
<td>2/6/2017</td>
<td>14.3</td>
<td>5.8</td>
<td>58</td>
<td>0.3</td>
<td>4.9</td>
<td>9.5</td>
</tr>
<tr>
<td>2/7/2017</td>
<td>15.6</td>
<td>4.6</td>
<td>61</td>
<td>0</td>
<td>6.1</td>
<td>10.3</td>
</tr>
<tr>
<td>2/8/2017</td>
<td>17.3</td>
<td>11.1</td>
<td>58</td>
<td>0</td>
<td>3.5</td>
<td>10.3</td>
</tr>
<tr>
<td>2/9/2017</td>
<td>18.2</td>
<td>14.8</td>
<td>81</td>
<td>0</td>
<td>2.7</td>
<td>7.1</td>
</tr>
<tr>
<td>2/10/2017</td>
<td>18.7</td>
<td>16</td>
<td>84</td>
<td>0.1</td>
<td>2.4</td>
<td>4.1</td>
</tr>
<tr>
<td>2/11/2017</td>
<td>19.2</td>
<td>15.3</td>
<td>78</td>
<td>0.4</td>
<td>5.1</td>
<td>10</td>
</tr>
<tr>
<td>2/12/2017</td>
<td>20.1</td>
<td>16.5</td>
<td>80</td>
<td>0.2</td>
<td>7.5</td>
<td>15.4</td>
</tr>
<tr>
<td>2/13/2017</td>
<td>20.5</td>
<td>16.6</td>
<td>79</td>
<td>0</td>
<td>5</td>
<td>12.3</td>
</tr>
<tr>
<td>2/14/2017</td>
<td>18.7</td>
<td>16.3</td>
<td>86</td>
<td>7.1</td>
<td>5.8</td>
<td>11.1</td>
</tr>
<tr>
<td>2/15/2017</td>
<td>19.7</td>
<td>17.4</td>
<td>87</td>
<td>3.7</td>
<td>5.3</td>
<td>9.8</td>
</tr>
<tr>
<td>2/16/2017</td>
<td>19.9</td>
<td>17.3</td>
<td>85</td>
<td>8.9</td>
<td>5.4</td>
<td>13.3</td>
</tr>
<tr>
<td>2/17/2017</td>
<td>19.3</td>
<td>15.4</td>
<td>78</td>
<td>5</td>
<td>5.6</td>
<td>13.7</td>
</tr>
<tr>
<td>2/18/2017</td>
<td>14.6</td>
<td>5.3</td>
<td>54</td>
<td>0</td>
<td>6.2</td>
<td>12.5</td>
</tr>
<tr>
<td>2/19/2017</td>
<td>12.8</td>
<td>3.5</td>
<td>54</td>
<td>0</td>
<td>6.7</td>
<td>10.7</td>
</tr>
<tr>
<td>2/20/2017</td>
<td>13.5</td>
<td>5.7</td>
<td>60</td>
<td>1.9</td>
<td>5.3</td>
<td>9.8</td>
</tr>
<tr>
<td>2/21/2017</td>
<td>14.5</td>
<td>6.6</td>
<td>61</td>
<td>1.4</td>
<td>3.5</td>
<td>7</td>
</tr>
<tr>
<td>2/22/2017</td>
<td>16.7</td>
<td>12.1</td>
<td>74</td>
<td>0</td>
<td>2.6</td>
<td>6.1</td>
</tr>
<tr>
<td>2/23/2017</td>
<td>18.4</td>
<td>14.9</td>
<td>80</td>
<td>1.2</td>
<td>3.7</td>
<td>6.7</td>
</tr>
<tr>
<td>2/24/2017</td>
<td>19.1</td>
<td>14.2</td>
<td>74</td>
<td>0</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>2/25/2017</td>
<td>18.8</td>
<td>13.2</td>
<td>70</td>
<td>1.6</td>
<td>3.7</td>
<td>10.3</td>
</tr>
<tr>
<td>2/26/2017</td>
<td>17.4</td>
<td>6.9</td>
<td>52</td>
<td>0.1</td>
<td>2.8</td>
<td>9.8</td>
</tr>
<tr>
<td>2/27/2017</td>
<td>18.3</td>
<td>6.5</td>
<td>50</td>
<td>0</td>
<td>3.5</td>
<td>7.7</td>
</tr>
<tr>
<td>2/28/2017</td>
<td>17.5</td>
<td>10.4</td>
<td>64</td>
<td>0</td>
<td>3.3</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Temperature (degree celsius)</th>
<th>Mean Dew Point (degree celsius)</th>
<th>Mean Relative Humidity (percentage)</th>
<th>Total Rain Fall (millimeters)</th>
<th>Mean Wind Speed meters per second</th>
<th>Mean Wind Direction 360 degree rose</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/1/2016</td>
<td>33.9</td>
<td>5.5</td>
<td>20</td>
<td>0</td>
<td>3.9</td>
<td>320</td>
</tr>
<tr>
<td>6/2/2016</td>
<td>35.6</td>
<td>0.4</td>
<td>14</td>
<td>0</td>
<td>3</td>
<td>300</td>
</tr>
<tr>
<td>6/3/2016</td>
<td>35.9</td>
<td>3.3</td>
<td>14</td>
<td>0</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>6/4/2016</td>
<td>34.9</td>
<td>9.2</td>
<td>22</td>
<td>0</td>
<td>2.8</td>
<td>10</td>
</tr>
<tr>
<td>6/5/2016</td>
<td>34.6</td>
<td>7.6</td>
<td>22</td>
<td>0</td>
<td>1.6</td>
<td>40</td>
</tr>
<tr>
<td>6/6/2016</td>
<td>35.5</td>
<td>10.1</td>
<td>25</td>
<td>0</td>
<td>1.5</td>
<td>120</td>
</tr>
<tr>
<td>6/7/2016</td>
<td>36</td>
<td>9.6</td>
<td>24</td>
<td>0</td>
<td>1.9</td>
<td>160</td>
</tr>
<tr>
<td>6/8/2016</td>
<td>38.4</td>
<td>5</td>
<td>16</td>
<td>0</td>
<td>4</td>
<td>330</td>
</tr>
<tr>
<td>6/9/2016</td>
<td>37.5</td>
<td>4.1</td>
<td>16</td>
<td>0</td>
<td>4.8</td>
<td>320</td>
</tr>
<tr>
<td>6/10/2016</td>
<td>37.7</td>
<td>10.8</td>
<td>22</td>
<td>0</td>
<td>3.2</td>
<td>350</td>
</tr>
<tr>
<td>6/11/2016</td>
<td>39.3</td>
<td>8</td>
<td>17</td>
<td>0</td>
<td>4</td>
<td>340</td>
</tr>
<tr>
<td>6/12/2016</td>
<td>36.9</td>
<td>5.4</td>
<td>17</td>
<td>0</td>
<td>5.1</td>
<td>340</td>
</tr>
<tr>
<td>6/13/2016</td>
<td>35</td>
<td>5.1</td>
<td>18</td>
<td>0</td>
<td>4.7</td>
<td>320</td>
</tr>
<tr>
<td>6/14/2016</td>
<td>35.2</td>
<td>-1.2</td>
<td>14</td>
<td>0</td>
<td>4.6</td>
<td>310</td>
</tr>
<tr>
<td>6/15/2016</td>
<td>35.9</td>
<td>7.7</td>
<td>21</td>
<td>0</td>
<td>3.5</td>
<td>330</td>
</tr>
<tr>
<td>6/16/2016</td>
<td>35.6</td>
<td>12.4</td>
<td>28</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>6/17/2016</td>
<td>35.8</td>
<td>11.6</td>
<td>26</td>
<td>0</td>
<td>3.7</td>
<td>350</td>
</tr>
<tr>
<td>6/18/2016</td>
<td>36.1</td>
<td>7.7</td>
<td>20</td>
<td>0</td>
<td>3.8</td>
<td>350</td>
</tr>
<tr>
<td>6/19/2016</td>
<td>36.4</td>
<td>13.1</td>
<td>28</td>
<td>0</td>
<td>3.9</td>
<td>350</td>
</tr>
<tr>
<td>6/20/2016</td>
<td>38.4</td>
<td>7.7</td>
<td>18</td>
<td>0</td>
<td>4</td>
<td>340</td>
</tr>
<tr>
<td>6/21/2016</td>
<td>38.2</td>
<td>8</td>
<td>19</td>
<td>0</td>
<td>3.9</td>
<td>340</td>
</tr>
<tr>
<td>6/22/2016</td>
<td>36.9</td>
<td>12.6</td>
<td>24</td>
<td>0</td>
<td>3.1</td>
<td>10</td>
</tr>
<tr>
<td>6/23/2016</td>
<td>36.5</td>
<td>12.4</td>
<td>25</td>
<td>0</td>
<td>2.3</td>
<td>360</td>
</tr>
<tr>
<td>6/24/2016</td>
<td>36.8</td>
<td>12.5</td>
<td>25</td>
<td>0</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>6/25/2016</td>
<td>36.5</td>
<td>12.8</td>
<td>28</td>
<td>0</td>
<td>1.8</td>
<td>60</td>
</tr>
<tr>
<td>6/26/2016</td>
<td>37</td>
<td>12.5</td>
<td>27</td>
<td>0</td>
<td>1.3</td>
<td>70</td>
</tr>
<tr>
<td>6/27/2016</td>
<td>40.5</td>
<td>4.7</td>
<td>16</td>
<td>0</td>
<td>2.2</td>
<td>330</td>
</tr>
<tr>
<td>6/28/2016</td>
<td>37.9</td>
<td>15.7</td>
<td>30</td>
<td>0</td>
<td>2.6</td>
<td>20</td>
</tr>
<tr>
<td>6/29/2016</td>
<td>35.8</td>
<td>20.1</td>
<td>42</td>
<td>0</td>
<td>1.5</td>
<td>70</td>
</tr>
</tbody>
</table>
## Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
<th>Humidity (%)</th>
<th>Wind Speed (km/h)</th>
<th>Visibility (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/30/2016</td>
<td>36.8</td>
<td>19.4</td>
<td>40</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>7/1/2016</td>
<td>40.8</td>
<td>9.3</td>
<td>18</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>7/2/2016</td>
<td>38.7</td>
<td>9.7</td>
<td>20</td>
<td>0</td>
<td>4.9</td>
</tr>
<tr>
<td>7/3/2016</td>
<td>38.4</td>
<td>9.5</td>
<td>20</td>
<td>0</td>
<td>4.6</td>
</tr>
<tr>
<td>7/4/2016</td>
<td>39.2</td>
<td>8.8</td>
<td>18</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>7/5/2016</td>
<td>37.5</td>
<td>15.2</td>
<td>33</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>7/6/2016</td>
<td>37.5</td>
<td>11.3</td>
<td>24</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>7/7/2016</td>
<td>37.9</td>
<td>12.4</td>
<td>26</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>7/8/2016</td>
<td>39.5</td>
<td>10.4</td>
<td>21</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>7/9/2016</td>
<td>40.8</td>
<td>7.3</td>
<td>16</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>7/10/2016</td>
<td>40.4</td>
<td>4.9</td>
<td>15</td>
<td>0</td>
<td>4.4</td>
</tr>
<tr>
<td>7/11/2016</td>
<td>40</td>
<td>6.9</td>
<td>16</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>7/12/2016</td>
<td>38.6</td>
<td>5.2</td>
<td>16</td>
<td>0</td>
<td>4.4</td>
</tr>
<tr>
<td>7/13/2016</td>
<td>38.9</td>
<td>6.6</td>
<td>17</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>7/14/2016</td>
<td>37.7</td>
<td>15.9</td>
<td>33</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>7/15/2016</td>
<td>37.4</td>
<td>19.1</td>
<td>37</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7/16/2016</td>
<td>36.7</td>
<td>21.8</td>
<td>44</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>7/17/2016</td>
<td>38.1</td>
<td>19.4</td>
<td>38</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>7/18/2016</td>
<td>37.3</td>
<td>23.8</td>
<td>49</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>7/19/2016</td>
<td>38.9</td>
<td>21.7</td>
<td>40</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>7/20/2016</td>
<td>39.8</td>
<td>18.9</td>
<td>34</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>7/21/2016</td>
<td>37.7</td>
<td>22.4</td>
<td>43</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>7/22/2016</td>
<td>38</td>
<td>23.6</td>
<td>47</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>7/23/2016</td>
<td>38.5</td>
<td>22</td>
<td>42</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>7/24/2016</td>
<td>36.3</td>
<td>25.4</td>
<td>55</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>7/25/2016</td>
<td>37.5</td>
<td>26.4</td>
<td>55</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>7/26/2016</td>
<td>37.2</td>
<td>26.7</td>
<td>56</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>7/27/2016</td>
<td>36.3</td>
<td>26</td>
<td>57</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>7/28/2016</td>
<td>35.9</td>
<td>25.5</td>
<td>55</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>7/29/2016</td>
<td>36.4</td>
<td>25.1</td>
<td>53</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>7/30/2016</td>
<td>36</td>
<td>24.4</td>
<td>52</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7/31/2016</td>
<td>36.3</td>
<td>24.1</td>
<td>51</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>8/1/2016</td>
<td>37.3</td>
<td>22</td>
<td>45</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>8/2/2016</td>
<td>39</td>
<td>17.5</td>
<td>35</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>8/3/2016</td>
<td>38.7</td>
<td>20.2</td>
<td>40</td>
<td>0</td>
<td>2.5</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp</th>
<th>RH</th>
<th>Temp Min</th>
<th>Temp Max</th>
<th>Wind</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/4/2016</td>
<td>37.1</td>
<td></td>
<td>25</td>
<td>51</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>8/5/2016</td>
<td>36.9</td>
<td></td>
<td>26.2</td>
<td>56</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>8/6/2016</td>
<td>37.4</td>
<td></td>
<td>22.2</td>
<td>45</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>8/7/2016</td>
<td>37.3</td>
<td></td>
<td>22.7</td>
<td>47</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>8/8/2016</td>
<td>37.6</td>
<td></td>
<td>21</td>
<td>46</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>8/9/2016</td>
<td>37.3</td>
<td></td>
<td>23.2</td>
<td>47</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>8/10/2016</td>
<td>37.4</td>
<td></td>
<td>21</td>
<td>44</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>8/11/2016</td>
<td>36.7</td>
<td></td>
<td>24.1</td>
<td>52</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>8/12/2016</td>
<td>36.7</td>
<td></td>
<td>26.8</td>
<td>58</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>8/13/2016</td>
<td>37.4</td>
<td></td>
<td>25.9</td>
<td>56</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>8/14/2016</td>
<td>38.1</td>
<td></td>
<td>22.5</td>
<td>47</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>8/15/2016</td>
<td>39</td>
<td></td>
<td>19.9</td>
<td>37</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>8/16/2016</td>
<td>38.7</td>
<td></td>
<td>21</td>
<td>39</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>8/17/2016</td>
<td>38.3</td>
<td></td>
<td>20.9</td>
<td>39</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>8/18/2016</td>
<td>37.9</td>
<td></td>
<td>19.7</td>
<td>38</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>8/19/2016</td>
<td>37</td>
<td></td>
<td>23.8</td>
<td>49</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>8/20/2016</td>
<td>37.1</td>
<td></td>
<td>23.7</td>
<td>49</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>8/21/2016</td>
<td>36.2</td>
<td></td>
<td>24.3</td>
<td>52</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>8/22/2016</td>
<td>36.1</td>
<td></td>
<td>25.8</td>
<td>57</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>8/23/2016</td>
<td>36.7</td>
<td></td>
<td>23.5</td>
<td>52</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>8/24/2016</td>
<td>37.9</td>
<td></td>
<td>20.3</td>
<td>43</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>8/25/2016</td>
<td>37</td>
<td></td>
<td>22.1</td>
<td>48</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>8/26/2016</td>
<td>37.8</td>
<td></td>
<td>21.3</td>
<td>45</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>8/27/2016</td>
<td>37.1</td>
<td></td>
<td>23.7</td>
<td>49</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>8/28/2016</td>
<td>36.4</td>
<td></td>
<td>23.6</td>
<td>51</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>8/29/2016</td>
<td>37.1</td>
<td></td>
<td>21.6</td>
<td>45</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>8/30/2016</td>
<td>37.7</td>
<td></td>
<td>20.8</td>
<td>42</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>8/31/2016</td>
<td>36.9</td>
<td></td>
<td>20.4</td>
<td>44</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>9/1/2016</td>
<td>37.4</td>
<td></td>
<td>18.9</td>
<td>44</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>9/2/2016</td>
<td>37.7</td>
<td></td>
<td>20.5</td>
<td>42</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>9/3/2016</td>
<td>36</td>
<td></td>
<td>26.8</td>
<td>60</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>9/4/2016</td>
<td>36.4</td>
<td></td>
<td>24.7</td>
<td>52</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>9/5/2016</td>
<td>37.6</td>
<td></td>
<td>23</td>
<td>46</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>9/6/2016</td>
<td>37.5</td>
<td></td>
<td>20.8</td>
<td>40</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9/7/2016</td>
<td>36.1</td>
<td></td>
<td>20.8</td>
<td>42</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
## Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Pressure</th>
<th>Precipitation</th>
<th>Street Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/8/2016</td>
<td>35.4</td>
<td>19.6</td>
<td>41</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>9/9/2016</td>
<td>34.4</td>
<td>18.2</td>
<td>41</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>9/10/2016</td>
<td>34.2</td>
<td>22.5</td>
<td>51</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>9/11/2016</td>
<td>33.7</td>
<td>22.2</td>
<td>52</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>9/12/2016</td>
<td>33.4</td>
<td>23.2</td>
<td>57</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>9/13/2016</td>
<td>34</td>
<td>22.5</td>
<td>53</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>9/14/2016</td>
<td>35.2</td>
<td>25</td>
<td>58</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>9/15/2016</td>
<td>35</td>
<td>23.7</td>
<td>54</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>9/16/2016</td>
<td>34.7</td>
<td>20.1</td>
<td>45</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>9/17/2016</td>
<td>35</td>
<td>18.7</td>
<td>43</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>9/18/2016</td>
<td>35.6</td>
<td>20.4</td>
<td>48</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>9/19/2016</td>
<td>35.6</td>
<td>19.6</td>
<td>42</td>
<td>0</td>
<td>2.8</td>
</tr>
<tr>
<td>9/20/2016</td>
<td>35.2</td>
<td>11.7</td>
<td>28</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>9/21/2016</td>
<td>33.9</td>
<td>17.3</td>
<td>39</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>9/22/2016</td>
<td>33.4</td>
<td>21.6</td>
<td>53</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>9/23/2016</td>
<td>34.6</td>
<td>19.5</td>
<td>48</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>9/24/2016</td>
<td>34.8</td>
<td>17.2</td>
<td>38</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>9/25/2016</td>
<td>34.3</td>
<td>15.2</td>
<td>36</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>9/26/2016</td>
<td>33</td>
<td>19.4</td>
<td>46</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>9/27/2016</td>
<td>32.2</td>
<td>22.9</td>
<td>59</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>9/28/2016</td>
<td>34.6</td>
<td>16.7</td>
<td>38</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>9/29/2016</td>
<td>34.3</td>
<td>14.6</td>
<td>36</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>9/30/2016</td>
<td>31.5</td>
<td>13.6</td>
<td>36</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>10/1/2016</td>
<td>31.1</td>
<td>13.9</td>
<td>37</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>10/2/2016</td>
<td>30.7</td>
<td>12.7</td>
<td>35</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>10/3/2016</td>
<td>29.7</td>
<td>13.1</td>
<td>38</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>10/4/2016</td>
<td>30.4</td>
<td>15</td>
<td>42</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>10/5/2016</td>
<td>29.9</td>
<td>11.2</td>
<td>39</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>10/6/2016</td>
<td>30.8</td>
<td>8.9</td>
<td>32</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>10/7/2016</td>
<td>31.2</td>
<td>9.5</td>
<td>35</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>10/8/2016</td>
<td>30.6</td>
<td>15.4</td>
<td>44</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>10/9/2016</td>
<td>31.5</td>
<td>13.2</td>
<td>44</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>10/10/2016</td>
<td>31.4</td>
<td>13.6</td>
<td>45</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>10/11/2016</td>
<td>32.5</td>
<td>2.4</td>
<td>25</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>10/12/2016</td>
<td>32</td>
<td>9.7</td>
<td>34</td>
<td>0</td>
<td>1.9</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp</th>
<th>Prec</th>
<th>Dewp</th>
<th>Wind</th>
<th>Humid</th>
<th>AtmP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/13/2016</td>
<td>31.2</td>
<td>14.5</td>
<td>41</td>
<td>0</td>
<td>2.7</td>
<td>320</td>
</tr>
<tr>
<td>10/14/2016</td>
<td>30.5</td>
<td>17.4</td>
<td>48</td>
<td>0</td>
<td>2.3</td>
<td>10</td>
</tr>
<tr>
<td>10/15/2016</td>
<td>31.3</td>
<td>9.8</td>
<td>35</td>
<td>0</td>
<td>1.6</td>
<td>300</td>
</tr>
<tr>
<td>10/16/2016</td>
<td>31.1</td>
<td>13</td>
<td>41</td>
<td>0</td>
<td>2.8</td>
<td>320</td>
</tr>
<tr>
<td>10/17/2016</td>
<td>29.6</td>
<td>17.5</td>
<td>50</td>
<td>0</td>
<td>1.8</td>
<td>60</td>
</tr>
<tr>
<td>10/18/2016</td>
<td>30.7</td>
<td>17.4</td>
<td>48</td>
<td>0</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>10/19/2016</td>
<td>30.7</td>
<td>16.4</td>
<td>48</td>
<td>0</td>
<td>1.1</td>
<td>100</td>
</tr>
<tr>
<td>10/20/2016</td>
<td>31.3</td>
<td>11</td>
<td>33</td>
<td>0</td>
<td>1.8</td>
<td>310</td>
</tr>
<tr>
<td>10/21/2016</td>
<td>30.3</td>
<td>14.3</td>
<td>43</td>
<td>0</td>
<td>2.7</td>
<td>330</td>
</tr>
<tr>
<td>10/22/2016</td>
<td>29.6</td>
<td>17.7</td>
<td>50</td>
<td>0</td>
<td>2.1</td>
<td>360</td>
</tr>
<tr>
<td>10/23/2016</td>
<td>28.8</td>
<td>18.5</td>
<td>56</td>
<td>0</td>
<td>1.6</td>
<td>340</td>
</tr>
<tr>
<td>10/24/2016</td>
<td>29.3</td>
<td>19.8</td>
<td>60</td>
<td>0</td>
<td>1.9</td>
<td>20</td>
</tr>
<tr>
<td>10/25/2016</td>
<td>29</td>
<td>20.5</td>
<td>63</td>
<td>0</td>
<td>1.5</td>
<td>110</td>
</tr>
<tr>
<td>10/26/2016</td>
<td>29.9</td>
<td>22.3</td>
<td>65</td>
<td>0</td>
<td>2.2</td>
<td>90</td>
</tr>
<tr>
<td>10/27/2016</td>
<td>30.8</td>
<td>19</td>
<td>52</td>
<td>0</td>
<td>2.3</td>
<td>40</td>
</tr>
<tr>
<td>10/28/2016</td>
<td>30.5</td>
<td>15</td>
<td>45</td>
<td>0</td>
<td>1.9</td>
<td>10</td>
</tr>
<tr>
<td>10/29/2016</td>
<td>29.5</td>
<td>12</td>
<td>41</td>
<td>0</td>
<td>1.7</td>
<td>300</td>
</tr>
<tr>
<td>10/30/2016</td>
<td>29</td>
<td>13.9</td>
<td>43</td>
<td>0</td>
<td>1.5</td>
<td>330</td>
</tr>
<tr>
<td>10/31/2016</td>
<td>29.1</td>
<td>18.7</td>
<td>58</td>
<td>0</td>
<td>1.4</td>
<td>40</td>
</tr>
<tr>
<td>11/1/2016</td>
<td>29</td>
<td>21.4</td>
<td>64</td>
<td>0</td>
<td>1.3</td>
<td>90</td>
</tr>
<tr>
<td>11/2/2016</td>
<td>29.4</td>
<td>20.5</td>
<td>59</td>
<td>0</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td>11/3/2016</td>
<td>29.6</td>
<td>20</td>
<td>58</td>
<td>0</td>
<td>2.2</td>
<td>20</td>
</tr>
<tr>
<td>11/4/2016</td>
<td>28.1</td>
<td>16.4</td>
<td>52</td>
<td>0</td>
<td>2.7</td>
<td>330</td>
</tr>
<tr>
<td>11/5/2016</td>
<td>28.1</td>
<td>17.1</td>
<td>56</td>
<td>0</td>
<td>2.5</td>
<td>320</td>
</tr>
<tr>
<td>11/6/2016</td>
<td>28.7</td>
<td>15</td>
<td>52</td>
<td>0</td>
<td>1.3</td>
<td>340</td>
</tr>
<tr>
<td>11/7/2016</td>
<td>27.3</td>
<td>16.7</td>
<td>54</td>
<td>0</td>
<td>3.1</td>
<td>340</td>
</tr>
<tr>
<td>11/8/2016</td>
<td>25.7</td>
<td>10</td>
<td>38</td>
<td>0</td>
<td>4.1</td>
<td>320</td>
</tr>
<tr>
<td>11/9/2016</td>
<td>25.6</td>
<td>13</td>
<td>47</td>
<td>0</td>
<td>3</td>
<td>320</td>
</tr>
<tr>
<td>11/10/2016</td>
<td>26.2</td>
<td>14.1</td>
<td>49</td>
<td>0</td>
<td>3</td>
<td>330</td>
</tr>
<tr>
<td>11/11/2016</td>
<td>26.3</td>
<td>16.7</td>
<td>57</td>
<td>0</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>11/12/2016</td>
<td>26.9</td>
<td>16.9</td>
<td>58</td>
<td>0</td>
<td>1.8</td>
<td>0</td>
</tr>
<tr>
<td>11/13/2016</td>
<td>25.7</td>
<td>17.6</td>
<td>64</td>
<td>0</td>
<td>1.4</td>
<td>360</td>
</tr>
<tr>
<td>11/14/2016</td>
<td>25.3</td>
<td>16.6</td>
<td>63</td>
<td>0</td>
<td>1.3</td>
<td>310</td>
</tr>
<tr>
<td>11/15/2016</td>
<td>25.7</td>
<td>17.6</td>
<td>64</td>
<td>0</td>
<td>1.2</td>
<td>300</td>
</tr>
<tr>
<td>11/16/2016</td>
<td>25.3</td>
<td>16.2</td>
<td>61</td>
<td>0</td>
<td>1</td>
<td>80</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Precipitation</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/17/2016</td>
<td>25.8</td>
<td>18.2</td>
<td>65</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>11/18/2016</td>
<td>25.8</td>
<td>16.4</td>
<td>58</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>11/19/2016</td>
<td>25.1</td>
<td>14.7</td>
<td>58</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>11/20/2016</td>
<td>24.9</td>
<td>15.8</td>
<td>59</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>11/21/2016</td>
<td>25</td>
<td>14.5</td>
<td>54</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>11/22/2016</td>
<td>25</td>
<td>17.1</td>
<td>62</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>11/23/2016</td>
<td>25.6</td>
<td>18.9</td>
<td>67</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>11/24/2016</td>
<td>25.7</td>
<td>17.7</td>
<td>63</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>11/25/2016</td>
<td>24.6</td>
<td>17.4</td>
<td>64</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>11/26/2016</td>
<td>23</td>
<td>18.8</td>
<td>78</td>
<td>36.3</td>
<td>2.9</td>
</tr>
<tr>
<td>11/27/2016</td>
<td>23.9</td>
<td>19.3</td>
<td>76</td>
<td>3.9</td>
<td>1.7</td>
</tr>
<tr>
<td>11/28/2016</td>
<td>23.8</td>
<td>17.9</td>
<td>70</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>11/29/2016</td>
<td>23.6</td>
<td>16.4</td>
<td>65</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>11/30/2016</td>
<td>24.1</td>
<td>16.1</td>
<td>62</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>12/1/2016</td>
<td>25.1</td>
<td>17.8</td>
<td>66</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>12/2/2016</td>
<td>26</td>
<td>20.8</td>
<td>76</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>12/3/2016</td>
<td>26</td>
<td>20.4</td>
<td>74</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>12/4/2016</td>
<td>25.1</td>
<td>18.6</td>
<td>68</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>12/5/2016</td>
<td>24.7</td>
<td>18.2</td>
<td>70</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>12/6/2016</td>
<td>24.7</td>
<td>20.3</td>
<td>78</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>12/7/2016</td>
<td>25</td>
<td>18.1</td>
<td>67</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>12/8/2016</td>
<td>21.7</td>
<td>12.4</td>
<td>57</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>12/9/2016</td>
<td>21</td>
<td>10.5</td>
<td>53</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>12/10/2016</td>
<td>17.7</td>
<td>4.2</td>
<td>44</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>12/11/2016</td>
<td>17.2</td>
<td>3</td>
<td>40</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>12/12/2016</td>
<td>18</td>
<td>5.3</td>
<td>44</td>
<td>0</td>
<td>3.6</td>
</tr>
<tr>
<td>12/13/2016</td>
<td>18.7</td>
<td>7.2</td>
<td>48</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>12/14/2016</td>
<td>20.2</td>
<td>11.9</td>
<td>60</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>12/15/2016</td>
<td>22.1</td>
<td>12.2</td>
<td>56</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>12/16/2016</td>
<td>18.8</td>
<td>9.3</td>
<td>55</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>12/17/2016</td>
<td>18.6</td>
<td>10.2</td>
<td>59</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>12/18/2016</td>
<td>18.9</td>
<td>11.2</td>
<td>62</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>12/19/2016</td>
<td>19.8</td>
<td>11.6</td>
<td>60</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>12/20/2016</td>
<td>20.4</td>
<td>11.7</td>
<td>60</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>12/21/2016</td>
<td>20.3</td>
<td>12.9</td>
<td>63</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
### Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp</th>
<th>Wind Speed</th>
<th>humidity</th>
<th>Dew Point</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/22/2016</td>
<td>20.6</td>
<td>12.9</td>
<td>63</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>12/23/2016</td>
<td>21.9</td>
<td>13.7</td>
<td>63</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>12/24/2016</td>
<td>22.1</td>
<td>15.8</td>
<td>69</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>12/25/2016</td>
<td>21.6</td>
<td>18</td>
<td>81</td>
<td>0</td>
<td>1.2</td>
</tr>
<tr>
<td>12/26/2016</td>
<td>20.6</td>
<td>17.5</td>
<td>84</td>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>12/27/2016</td>
<td>19.7</td>
<td>17</td>
<td>86</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>12/28/2016</td>
<td>21.6</td>
<td>14.5</td>
<td>69</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>12/29/2016</td>
<td>22</td>
<td>16.2</td>
<td>71</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>12/30/2016</td>
<td>22.8</td>
<td>14.8</td>
<td>65</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>12/31/2016</td>
<td>23.2</td>
<td>11.3</td>
<td>53</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>1/1/2017</td>
<td>23.9</td>
<td>9.9</td>
<td>48</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>1/2/2017</td>
<td>22.1</td>
<td>14.5</td>
<td>65</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>1/3/2017</td>
<td>21.3</td>
<td>13.7</td>
<td>66</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>1/4/2017</td>
<td>20.3</td>
<td>11.6</td>
<td>59</td>
<td>0</td>
<td>2.8</td>
</tr>
<tr>
<td>1/5/2017</td>
<td>18.7</td>
<td>9.2</td>
<td>55</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>1/6/2017</td>
<td>17.5</td>
<td>9</td>
<td>58</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>1/7/2017</td>
<td>19.1</td>
<td>11.4</td>
<td>62</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>1/8/2017</td>
<td>19.6</td>
<td>8.7</td>
<td>55</td>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>1/9/2017</td>
<td>20.9</td>
<td>12.6</td>
<td>64</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>1/10/2017</td>
<td>21.1</td>
<td>16.6</td>
<td>78</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>1/11/2017</td>
<td>20.7</td>
<td>13.4</td>
<td>65</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>1/12/2017</td>
<td>20.5</td>
<td>10.8</td>
<td>57</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1/13/2017</td>
<td>19.1</td>
<td>8.5</td>
<td>52</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>1/14/2017</td>
<td>18</td>
<td>5.6</td>
<td>46</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1/15/2017</td>
<td>17.9</td>
<td>8.9</td>
<td>57</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>1/16/2017</td>
<td>19.6</td>
<td>12.8</td>
<td>66</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>1/17/2017</td>
<td>19.2</td>
<td>10.5</td>
<td>59</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>1/18/2017</td>
<td>18.6</td>
<td>10.8</td>
<td>62</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>1/19/2017</td>
<td>19.4</td>
<td>13.3</td>
<td>68</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>1/20/2017</td>
<td>21.7</td>
<td>12.6</td>
<td>59</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>1/21/2017</td>
<td>20.4</td>
<td>14.8</td>
<td>71</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>1/22/2017</td>
<td>21.6</td>
<td>16.6</td>
<td>73</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>1/23/2017</td>
<td>19.8</td>
<td>9.3</td>
<td>53</td>
<td>0</td>
<td>3.9</td>
</tr>
<tr>
<td>1/24/2017</td>
<td>16.6</td>
<td>4.6</td>
<td>46</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>1/25/2017</td>
<td>17.7</td>
<td>8.3</td>
<td>55</td>
<td>0</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Appendix A: Meteorological Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Precipitation</th>
<th>Snow</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Temperature</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/26/2017</td>
<td>18.9</td>
<td>11.2</td>
<td>63</td>
<td>0</td>
<td>1.7</td>
<td>120</td>
</tr>
<tr>
<td>1/27/2017</td>
<td>20.3</td>
<td>11.9</td>
<td>61</td>
<td>0</td>
<td>2.8</td>
<td>140</td>
</tr>
<tr>
<td>1/28/2017</td>
<td>22.1</td>
<td>14.1</td>
<td>63</td>
<td>0</td>
<td>2.8</td>
<td>120</td>
</tr>
<tr>
<td>1/29/2017</td>
<td>21.4</td>
<td>12.8</td>
<td>59</td>
<td>0</td>
<td>3</td>
<td>340</td>
</tr>
<tr>
<td>1/30/2017</td>
<td>17.4</td>
<td>5.6</td>
<td>48</td>
<td>0</td>
<td>3.1</td>
<td>330</td>
</tr>
<tr>
<td>1/31/2017</td>
<td>17.8</td>
<td>10.6</td>
<td>64</td>
<td>0</td>
<td>1.6</td>
<td>90</td>
</tr>
<tr>
<td>2/1/2017</td>
<td>21</td>
<td>12.6</td>
<td>61</td>
<td>0</td>
<td>2.9</td>
<td>20</td>
</tr>
<tr>
<td>2/2/2017</td>
<td>15.6</td>
<td>2.7</td>
<td>42</td>
<td>0</td>
<td>5.3</td>
<td>330</td>
</tr>
<tr>
<td>2/3/2017</td>
<td>11.1</td>
<td>-3.9</td>
<td>38</td>
<td>0</td>
<td>5.4</td>
<td>310</td>
</tr>
<tr>
<td>2/4/2017</td>
<td>13.4</td>
<td>2.7</td>
<td>49</td>
<td>0</td>
<td>3.3</td>
<td>310</td>
</tr>
<tr>
<td>2/5/2017</td>
<td>14.5</td>
<td>1.9</td>
<td>44</td>
<td>0</td>
<td>2</td>
<td>310</td>
</tr>
<tr>
<td>2/6/2017</td>
<td>15.1</td>
<td>4.1</td>
<td>53</td>
<td>0.7</td>
<td>2.6</td>
<td>320</td>
</tr>
<tr>
<td>2/7/2017</td>
<td>16.3</td>
<td>4.8</td>
<td>49</td>
<td>0</td>
<td>3</td>
<td>320</td>
</tr>
<tr>
<td>2/8/2017</td>
<td>18.1</td>
<td>7.7</td>
<td>54</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>2/9/2017</td>
<td>19.2</td>
<td>13.3</td>
<td>70</td>
<td>0</td>
<td>1.6</td>
<td>90</td>
</tr>
<tr>
<td>2/10/2017</td>
<td>20.8</td>
<td>14.9</td>
<td>71</td>
<td>0</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td>2/11/2017</td>
<td>20.4</td>
<td>14.5</td>
<td>69</td>
<td>0.3</td>
<td>3.2</td>
<td>40</td>
</tr>
<tr>
<td>2/12/2017</td>
<td>21.3</td>
<td>16.5</td>
<td>74</td>
<td>0.4</td>
<td>5.4</td>
<td>80</td>
</tr>
<tr>
<td>2/13/2017</td>
<td>21.9</td>
<td>17.2</td>
<td>75</td>
<td>2.9</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>2/14/2017</td>
<td>19.2</td>
<td>17.3</td>
<td>89</td>
<td>12.8</td>
<td>3.3</td>
<td>10</td>
</tr>
<tr>
<td>2/15/2017</td>
<td>20.8</td>
<td>18.4</td>
<td>87</td>
<td>6.2</td>
<td>3.3</td>
<td>80</td>
</tr>
<tr>
<td>2/16/2017</td>
<td>21</td>
<td>18.3</td>
<td>85</td>
<td>14.7</td>
<td>3.2</td>
<td>120</td>
</tr>
<tr>
<td>2/17/2017</td>
<td>19.8</td>
<td>16.1</td>
<td>80</td>
<td>11.5</td>
<td>3.3</td>
<td>10</td>
</tr>
<tr>
<td>2/18/2017</td>
<td>15</td>
<td>5.3</td>
<td>53</td>
<td>0</td>
<td>4.1</td>
<td>320</td>
</tr>
<tr>
<td>2/19/2017</td>
<td>13.2</td>
<td>3.8</td>
<td>54</td>
<td>0</td>
<td>3.5</td>
<td>320</td>
</tr>
<tr>
<td>2/20/2017</td>
<td>14.1</td>
<td>6</td>
<td>60</td>
<td>3.2</td>
<td>2.6</td>
<td>300</td>
</tr>
<tr>
<td>2/21/2017</td>
<td>15.4</td>
<td>6.6</td>
<td>58</td>
<td>1.8</td>
<td>2.2</td>
<td>290</td>
</tr>
<tr>
<td>2/22/2017</td>
<td>18.1</td>
<td>11.1</td>
<td>66</td>
<td>0</td>
<td>1.6</td>
<td>350</td>
</tr>
<tr>
<td>2/23/2017</td>
<td>19.4</td>
<td>14.9</td>
<td>76</td>
<td>0.3</td>
<td>2.4</td>
<td>60</td>
</tr>
<tr>
<td>2/24/2017</td>
<td>20.2</td>
<td>14.2</td>
<td>70</td>
<td>0</td>
<td>3.5</td>
<td>350</td>
</tr>
<tr>
<td>2/25/2017</td>
<td>20</td>
<td>12.6</td>
<td>63</td>
<td>1.6</td>
<td>2.2</td>
<td>340</td>
</tr>
<tr>
<td>2/26/2017</td>
<td>18.3</td>
<td>5.9</td>
<td>47</td>
<td>0.4</td>
<td>1.9</td>
<td>290</td>
</tr>
<tr>
<td>2/27/2017</td>
<td>19.8</td>
<td>3.7</td>
<td>40</td>
<td>0</td>
<td>1.9</td>
<td>300</td>
</tr>
<tr>
<td>2/28/2017</td>
<td>19.5</td>
<td>5.9</td>
<td>46</td>
<td>0</td>
<td>1.3</td>
<td>340</td>
</tr>
</tbody>
</table>
Appendix B: PM Calculations

\[ Q_{\text{act}} = F_i + F_f / 2 \]

Where: \( Q_{\text{act}} = \) Average sampling flow rate at field sampling conditions

\( F_i = \) Initial actual flow rate (m\(^3\)/min)

\( F_f = \) Final actual flow rate (m\(^3\)/min)

\[ V_{\text{act}} = Q_{\text{act}} \times \text{Sampling period} \]

\( V_{\text{act}} = \) Volume of sampled air (m\(^3\))

To calculate PM concentration:

\[ \text{TSP} = (W_f - W_i) \times 10^6 / V_{\text{act}} \]

Where:

\( \text{TSP} = \) mass concentration of total suspended particulate matter (µg/m\(^3\))

\( W_f = \) Initial weight of clean filter (g)

\( W_i = \) Final weight of exposed filter (g)

\( 10^6 = \) Conversion from g to µg

To calculate actual PM concentration at field condition:

\[ \text{TSP}_{\text{std}} = \text{TSP}_{\text{act}} \times (P_{\text{act}} / P_{\text{std}}) \times (T_{\text{act}} / T_{\text{std}}) \]

\( \text{TSP}_{\text{act}} = \) Actual concentration of PM at field conditions (µg/m\(^3\))

\( \text{TSP}_{\text{std}} = \) Concentration at standard conditions (µg/m\(^3\))

\( P_{\text{act}} = \) Average barometric pressure at the field during sampling (mm Hg)

\( P_{\text{std}} = 760 \) mm Hg

\( T_{\text{act}} = \) Average ambient temperature at the field conditions during the sampling period (K)

\( T_{\text{std}} = 298 \) K
Appendix C: Statistical Analysis

THE ANOVA MODEL FITTED IS: \( Y_i = \beta_0 + \beta_1 \text{SAMP\_DATE} + \beta_2 \text{STATION} + \beta_3 \text{SAMP\_DATE}\times\text{STATION} + \varepsilon \)

WHERE \( Y_i \) IS THE READING OF THE \( i \)TH ELEMENT

The SAS System 14:45 Friday, October 6, 2017 1

The GLM Procedure

Class Level Information

Class      Levels  Values
Samp_Date   4      1 2 3 4
Station     5      1 2 3 4 5

Number of observations  60

NOTE: Due to missing values, only 45 observations can be used in this analysis.

The SAS System 14:45 Friday, October 6, 2017 2

Dependent Variable: PM25

The GLM Procedure

Source       DF    Type I SS    Mean Square    F Value    Pr > F
Model        19  22965.98953  1208.73629    3.86    0.0010
Error        25  7833.22551   313.32902
Corrected Total 44  30799.21503

R-Square   Coeff Var   Root MSE   PM25 Mean
0.745668   30.03388    17.70110   58.93711

Source       DF    Type III SS   Mean Square    F Value    Pr > F
Samp_Date     3    7598.74765   2532.91588    8.08    0.0006
Station       4    1154.69557   288.67389    0.92    0.4672
Samp_Date*Station 12  14212.54631  1184.37886    3.78    0.0024

The SAS System 14:45 Friday, October 6, 2017 3

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

LSMEAN

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>PM25 LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36.8070000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>66.0622798</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>72.0567062</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>54.5246667</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: PM25

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0056</td>
<td>0.0003</td>
<td>0.1308</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0056</td>
<td>0.7938</td>
<td>0.4621</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0003</td>
<td>0.7938</td>
<td>0.0783</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1308</td>
<td>0.4621</td>
<td>0.0783</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 4

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

LSMEAN

<table>
<thead>
<tr>
<th>Station</th>
<th>PM25 LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56.3333828</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>55.4754167</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>58.8454167</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>64.2821699</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>52.8844274</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: PM25

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0000</td>
<td>0.9983</td>
<td>0.8793</td>
<td>0.9944</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.0000</td>
<td>0.9944</td>
<td>0.8230</td>
<td>0.9980</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9983</td>
<td>0.9944</td>
<td>0.9637</td>
<td>0.9538</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.8793</td>
<td>0.8230</td>
<td>0.8637</td>
<td>0.6475</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9944</td>
<td>0.9980</td>
<td>0.9538</td>
<td>0.6475</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 5
Appendix C: Statistical Analysis

The GLM Procedure
Class Level Information
Class     Levels     Values
Samp_Date  4        1 2 3 4
Station    5        1 2 3 4 5
Number of observations  60

Dependent Variable: Al

The GLM Procedure
Sum of
Source     DF    Type I SS    Mean Square    F Value    Pr > F
Samp_Date  3    144918.374    48306.125    5.62    0.0026
Station    4    275501.076    68875.269    8.02    <.0001
Samp_Date*Station 12    1013630.692    84469.224    9.83    <.0001

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Al
1/2 3 4
1    0.0543    0.0289    0.9954
2    0.2541    0.9934    0.0012
3    0.0058    0.0836    0.0015
4    0.9954    0.0312    0.0160

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Al
1/2 3 4
1    0.2541    0.0058    0.0003    0.9815
2    0.0003    0.0836    0.0015
3    0.0058    0.0836    0.0015
4    0.0003    0.0836    0.0015
5    0.9954    0.0251    0.0015
### Appendix C: Statistical Analysis

#### The SAS System

**The GLM Procedure**

**Class Level Information**

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

**Number of observations**: 60

---

**Dependent Variable**: Ca

#### The GLM Procedure

**Class Level Information**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>37859671.6</td>
<td>1992614.3</td>
<td>0.94</td>
<td>0.5454</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>84994409.3</td>
<td>2124860.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>122854081.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**R-Square**: 0.308168

**Coeff Var**: 48.14009

**Root MSE**: 1457.690

**Ca Mean**: 3028.017

#### Least Squares Means

**Adjustment for Multiple Comparisons**: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>6390577.65</td>
<td>2130192.55</td>
<td>1.00</td>
<td>0.4017</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>13921555.90</td>
<td>3480388.97</td>
<td>1.64</td>
<td>0.1836</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>17547538.10</td>
<td>1462294.84</td>
<td>0.69</td>
<td>0.7526</td>
</tr>
</tbody>
</table>

**Least Squares Means for effect Samp_Date**

| Pr > |t| for H0: LSMean(i)=LSMean(j) | Dependent Variable: Ca |
|------|-----------------------------|------------------------|
| i/j  | 1 | 2 | 3 | 4 |
| 1    | 0.5206 | 0.3906 | 0.7868 |
| 2    | 0.5206 | 0.9961 | 0.9705 |
| 3    | 0.3906 | 0.9961 | 0.9096 |
| 4    | 0.7868 | 0.9705 | 0.9096 |

**Least Squares Means for effect Station**

| Pr > |t| for H0: LSMean(i)=LSMean(j) | Dependent Variable: Ca |
|------|-----------------------------|------------------------|
| i/j  | 1 | 2 | 3 | 4 | 5 |
| 1    | 0.9733 | 0.7909 | 0.1228 | 0.8734 |
| 2    | 0.9733 | 0.9846 | 0.3629 | 0.9967 |
| 3    | 0.7909 | 0.9846 | 0.6786 | 0.9998 |
| 4    | 0.1228 | 0.3629 | 0.6786 | 0.5707 |
| 5    | 0.8734 | 0.9967 | 0.9998 | 0.5707 |
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017
The GLM Procedure
Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5
Number of observations 60

The SAS System 14:45 Friday, October 6, 2017
The GLM Procedure
Dependent Variable: Na

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>3496804.53</td>
<td>184042.34</td>
<td>0.84</td>
<td>0.6509</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>8767220.61</td>
<td>219180.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>12264025.14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square Coeff Var Root MSE Na Mean
0.285127 166.6504 468.1672 280.9277

Source DF Type I SS Mean Square F Value Pr > F
Samp_Date 3 1345329.086 448443.029 2.05 0.1228
Station 4 327805.641 81766.410 0.37 0.8264
Samp_Date*Station 12 1824409.807 152034.151 0.69 0.7476

Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>Na LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>530.946667</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>261.220000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>184.173333</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>177.370667</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Na

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4025</td>
<td>0.1396</td>
<td>0.1810</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.4025</td>
<td>0.9230</td>
<td>0.9608</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.1396</td>
<td>0.9230</td>
<td>0.9991</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1810</td>
<td>0.9608</td>
<td>0.9991</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Station</th>
<th>Na LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>185.224167</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>374.330833</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>238.225000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>255.483333</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>359.375000</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Na

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8585</td>
<td>0.9993</td>
<td>0.9959</td>
<td>0.8909</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.8585</td>
<td>0.9421</td>
<td>0.9707</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9993</td>
<td>0.9421</td>
<td>0.9999</td>
<td>0.9605</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9959</td>
<td>0.9707</td>
<td>0.9999</td>
<td>0.9821</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.8909</td>
<td>1.0000</td>
<td>0.9605</td>
<td>0.9821</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The GLM Procedure

Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5
Number of observations 60

The GLM Procedure

Dependent Variable: Mg

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>1296727.676</td>
<td>68248.825</td>
<td>2.19</td>
<td>0.0183</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>1245752.652</td>
<td>31143.816</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>2542480.328</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square Coeff Var Root MSE Mg Mean
0.510025 53.23480 176.4761 331.5052

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>396543.0896</td>
<td>132181.0299</td>
<td>4.24</td>
<td>0.0108</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>264266.5841</td>
<td>66066.6460</td>
<td>2.12</td>
<td>0.0960</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>635918.0028</td>
<td>52993.1669</td>
<td>1.70</td>
<td>0.1031</td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>Mg LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>465.553333</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>286.806667</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>251.633333</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>322.027333</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Mg

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0401</td>
<td>0.0100</td>
<td>0.1333</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0401</td>
<td>0.9471</td>
<td>0.9469</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0100</td>
<td>0.9471</td>
<td>0.6962</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1333</td>
<td>0.9469</td>
<td>0.6962</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Station</th>
<th>Mg LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>235.825833</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>346.516667</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>371.425000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>423.358333</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>280.400000</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Mg

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5457</td>
<td>0.3433</td>
<td>0.0890</td>
<td>0.9712</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5457</td>
<td>0.9968</td>
<td>0.8884</td>
<td>0.2920</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.3433</td>
<td>0.9968</td>
<td>0.9504</td>
<td>0.7146</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0890</td>
<td>0.8223</td>
<td>0.9504</td>
<td>0.2920</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9712</td>
<td>0.8884</td>
<td>0.7146</td>
<td>0.2920</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

### The SAS System 14:45 Friday, October 6, 2017 21

#### The GLM Procedure

#### Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

#### Number of observations 60

#### Dependent Variable: Fe

### The SAS System 14:45 Friday, October 6, 2017 22

#### The GLM Procedure

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>103468.1697</td>
<td>34489.3899</td>
<td>3.71</td>
<td>0.0191</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>259089.8658</td>
<td>64772.4664</td>
<td>6.96</td>
<td>0.0002</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>931577.3799</td>
<td>77631.4483</td>
<td>8.35</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

#### R-Square Coeff Var Root MSE Fe Mean
0.776719 31.74446 96.43925 303.7987

### The SAS System 14:45 Friday, October 6, 2017 23

#### Least Squares Means

#### Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>Fe LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>316.786667</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>264.153333</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>268.126667</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>366.128000</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4501</td>
<td>0.5179</td>
<td>0.5060</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.4501</td>
<td>0.9995</td>
<td>0.0299</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5179</td>
<td>0.9995</td>
<td>0.0393</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.5060</td>
<td>0.0299</td>
<td>0.0393</td>
<td></td>
</tr>
</tbody>
</table>

### The SAS System 14:45 Friday, October 6, 2017 24

#### Least Squares Means

#### Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Station</th>
<th>Fe LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>205.176667</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>306.933333</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>365.616667</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>381.733333</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>259.533333</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0926</td>
<td>0.0019</td>
<td>0.0006</td>
<td>0.6433</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0926</td>
<td>0.5745</td>
<td>0.3340</td>
<td>0.7491</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0019</td>
<td>0.5745</td>
<td>0.9939</td>
<td>0.0726</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0006</td>
<td>0.3340</td>
<td>0.9939</td>
<td>0.0273</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.6433</td>
<td>0.7491</td>
<td>0.0726</td>
<td>0.0273</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The GLM Procedure

Class Level Information
Class          Levels  Values
Samp_Date      4     1  2  3  4
Station        5     1  2  3  4  5
Number of observations  60

The SAS System  14:45 Friday, October 6, 2017 25
The GLM Procedure

Dependent Variable: Li

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>2.00125525</td>
<td>0.10532922</td>
<td>5.55</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>0.75865133</td>
<td>0.01896628</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>2.75990658</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square  0.725117  Coeff Var  76.68759  Root MSE  0.137718  Li Mean  0.179583

The GLM Procedure

Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>Li LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.18260000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.24426667</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.19920000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.09226667</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6141</td>
<td>0.9874</td>
<td>0.2901</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.6141</td>
<td>0.8068</td>
<td>0.0217</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9874</td>
<td>0.8068</td>
<td>0.1623</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2901</td>
<td>0.0217</td>
<td>0.1623</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System  14:45 Friday, October 6, 2017 26
The GLM Procedure

Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Station</th>
<th>Li LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.37225000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.18558333</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.14141667</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.14000000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0.05866667</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0156</td>
<td>0.0017</td>
<td>0.0016</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0156</td>
<td>0.9333</td>
<td>0.9258</td>
<td>0.1802</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0017</td>
<td>0.9333</td>
<td>1.0000</td>
<td>0.5862</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0016</td>
<td>0.9258</td>
<td>1.0000</td>
<td>0.6020</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>&lt;.0001</td>
<td>0.1802</td>
<td>0.5862</td>
<td>0.6020</td>
<td></td>
</tr>
</tbody>
</table>

107
### Appendix C: Statistical Analysis

The SAS System  
14:45 Friday, October 6, 2017 29

The GLM Procedure

**Class Level Information**

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations: 60

The SAS System  
14:45 Friday, October 6, 2017 30

The GLM Procedure

**Dependent Variable: V**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>173.7653430</td>
<td>57.9217810</td>
<td>41.34</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>59.3902091</td>
<td>14.8475523</td>
<td>10.60</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>164.8286788</td>
<td>13.7357232</td>
<td>9.80</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

**R-Square** 0.876561  
**Coef Var** 17.35900  
**Root MSE** 1.183690  
**V Mean** 6.818883

The SAS System  
14:45 Friday, October 6, 2017 31

The GLM Procedure

**Least Squares Means**

Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>V LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.74113333</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7.99040000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>8.92793333</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5.61608667</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.1963</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&lt;.0001</td>
<td>0.1495</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>0.1495</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1963</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System  
14:45 Friday, October 6, 2017 32

The GLM Procedure

**Least Squares Means**

Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Station</th>
<th>V LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.38116667</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>5.42833333</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>6.88908333</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>8.49591667</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6.90916667</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2980</td>
<td>0.8390</td>
<td>0.0008</td>
<td>0.0179</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0336</td>
<td>&lt;.0001</td>
<td>0.0314</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0336</td>
<td>0.0008 &lt;.0001</td>
<td>0.0153</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0008</td>
<td>0.0153</td>
<td>0.0164</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.8179</td>
<td>0.0314</td>
<td>1.0000</td>
<td>0.0164</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017

#### The GLM Procedure

**Class Level Information**

- **Class**: Samp_Date, Station
- **Levels**: 4, 5
- **Values**: 1 2 3 4

Number of observations: 60

#### Dependent Variable: Cr

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>70.0496897</td>
<td>3.6868258</td>
<td>0.56</td>
<td>0.9091</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>261.0727933</td>
<td>6.5268198</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>331.1224830</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**R-Square**: 0.211552

**Coeff Var**: 28.84941

**Root MSE**: 2.554764

**Cr Mean**: 8.855517

#### Least Squares Means for effect Samp_Date

| Samp_Date | Cr LSMEAN | Pr > |t| for H0: LSMean(i)=LSMean(j) |
|-----------|-----------|------|----------------------------|
| 1         | 8.9390667 | 0.9997 |
| 2         | 8.6440667 | 0.9979 |
| 3         | 8.8150000 | 0.9960 |
| 4         | 9.0239333 | 0.9960 |

#### Least Squares Means for effect Station

| Station | Cr LSMEAN | Pr > |t| for H0: LSMean(i)=LSMean(j) |
|---------|-----------|------|----------------------------|
| 1       | 7.6811667 | 0.9943 |
| 2       | 9.1966667 | 0.9988 |
| 3       | 10.1253333 | 0.9988 |
| 4       | 8.7786667 | 0.9988 |
| 5       | 8.4957500 | 0.9988 |

The SAS System 14:45 Friday, October 6, 2017
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 37

The GLM Procedure

Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5

Number of observations 60

The SAS System 14:45 Friday, October 6, 2017 38

The GLM Procedure

Dependent Variable: Mn

Sum of
Source DF Squares Mean Square F Value Pr > F
Model 19 339.2246829 17.8539307 3.47 0.0004
Error 40 205.5418573 5.1385464
Corrected Total 59 544.7665402

R-Square 0.622697 Coeff Var 43.41669
Root MSE 2.266836 Mn Mean 5.221117

Source DF Type I SS Mean Square F Value Pr > F
Samp_Date 3 6.7946190 2.2648730 0.44 0.7251
Station 4 77.3255164 19.3313791 3.76 0.0109
Samp_Date*Station 12 255.1045474 21.2587123 4.14 0.0003

Source DF Type III SS Mean Square F Value Pr > F
Samp_Date 3 6.7946190 2.2648730 0.44 0.7251
Station 4 77.3255164 19.3313791 3.76 0.0109
Samp_Date*Station 12 255.1045474 21.2587123 4.14 0.0003

Least Squares Means

Adjustment for Multiple Comparisons: Tukey

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSN Mean(i)=LSN Mean(j)
Dependent Variable: Mn

1/1 1 2
 1 0.8577 0.9909 1.0000
 2 0.9909 0.6991 0.8436
 3 0.9909 0.6991 0.9934
 4 1.0000 0.8436 0.9934

Least Squares Means for effect Station
Pr > |t| for H0: LSN Mean(i)=LSN Mean(j)
Dependent Variable: Mn

1/1 1 2 3 4 5
 1 0.1078 0.2042 0.4027 0.9818
 2 0.1078 0.5975 0.4957 0.0305
 3 0.2042 0.9975 0.9934 0.0660
 4 0.4027 0.9457 0.9934 0.1598
 5 0.9818 0.0305 0.0660 0.1598
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 41
The GLM Procedure
Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5
Number of observations 60
The GLM Procedure
Dependent Variable: Ni

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>39.68317827</td>
<td>13.22772609</td>
<td>5.59</td>
<td>0.0027</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4.11922517</td>
<td>1.02980629</td>
<td>0.44</td>
<td>0.7822</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>63.34914123</td>
<td>5.27909510</td>
<td>2.23</td>
<td>0.0287</td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 42
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>39.68317827</td>
<td>13.22772609</td>
<td>5.59</td>
<td>0.0027</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4.11922517</td>
<td>1.02980629</td>
<td>0.44</td>
<td>0.7822</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>63.34914123</td>
<td>5.27909510</td>
<td>2.23</td>
<td>0.0287</td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 43
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>39.68317827</td>
<td>13.22772609</td>
<td>5.59</td>
<td>0.0027</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4.11922517</td>
<td>1.02980629</td>
<td>0.44</td>
<td>0.7822</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>63.34914123</td>
<td>5.27909510</td>
<td>2.23</td>
<td>0.0287</td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 44
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>39.68317827</td>
<td>13.22772609</td>
<td>5.59</td>
<td>0.0027</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4.11922517</td>
<td>1.02980629</td>
<td>0.44</td>
<td>0.7822</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>63.34914123</td>
<td>5.27909510</td>
<td>2.23</td>
<td>0.0287</td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 45
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>39.68317827</td>
<td>13.22772609</td>
<td>5.59</td>
<td>0.0027</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4.11922517</td>
<td>1.02980629</td>
<td>0.44</td>
<td>0.7822</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>63.34914123</td>
<td>5.27909510</td>
<td>2.23</td>
<td>0.0287</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 45
The GLM Procedure
Class Level Information
Class         Levels Values
Samp_Date     4   1 2 3 4
Station       5   1 2 3 4 5
Number of observations 60

The SAS System 14:45 Friday, October 6, 2017 46
The GLM Procedure
Dependent Variable: Co

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 47
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey
Least Squares Means for effect Samp_Date
Pr > |t| for H0: LS Mean(i)=LS Mean(j)
Dependent Variable: Co

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 48
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey
Least Squares Means for effect Station
Pr > |t| for H0: LS Mean(i)=LS Mean(j)
Dependent Variable: Co

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 49

The GLM Procedure
Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5
Number of observations 60

The SAS System 14:45 Friday, October 6, 2017 50

The GLM Procedure
Dependent Variable: Zn

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>22765.7016</td>
<td>7588.56721</td>
<td>5.89</td>
<td>0.0020</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>3363.77849</td>
<td>840.94462</td>
<td>0.65</td>
<td>0.6286</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>11655.91543</td>
<td>971.32629</td>
<td>0.75</td>
<td>0.6920</td>
</tr>
</tbody>
</table>

R-Square Coeff Var Root MSE Zn Mean
0.422925 30.15175 35.90184 119.0705

The SAS System 14:45 Friday, October 6, 2017 51

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>22765.7016</td>
<td>7588.56721</td>
<td>5.89</td>
<td>0.0020</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>3363.77849</td>
<td>840.94462</td>
<td>0.65</td>
<td>0.6286</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>11655.91543</td>
<td>971.32629</td>
<td>0.75</td>
<td>0.6920</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5718</td>
<td>0.0014</td>
<td>0.0734</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0014</td>
<td>0.0450</td>
<td>0.4421</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0734</td>
<td>0.6199</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 14:45 Friday, October 6, 2017 52

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>4</td>
<td>129.948333</td>
<td>31.241833</td>
<td>4.48</td>
<td>0.0125</td>
</tr>
<tr>
<td>3</td>
<td>125.067500</td>
<td>31.241833</td>
<td>4.48</td>
<td>0.0125</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>116.396667</td>
<td>31.241833</td>
<td>4.48</td>
<td>0.0125</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6115</td>
<td>0.8439</td>
<td>0.9972</td>
<td>0.8857</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.6115</td>
<td>0.8439</td>
<td>0.9972</td>
<td>0.8857</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0893</td>
<td>0.9578</td>
<td>0.9756</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9578</td>
<td>0.9756</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9756</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 53
The GLM Procedure

#### Class Level Information
- **Samp_Date**: 4 1 2 3 4
- **Station**: 5 1 2 3 4 5
- Number of observations: 60

#### Summary of Model Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Samp_Date</strong></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td><strong>Station</strong></td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td><strong>Samp_Date*Station</strong></td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

#### Least Squares Means

**Adjustment for Multiple Comparisons: Tukey**

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>As LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect **Samp_Date**

| Pr > |t| for H0: LSMean(i)=LSMean(j) | Dependent Variable: As |
|------|-----------------------------|------------------------|
| 1/4  |                             |                        |
| 1    | 1                          | 2                      |
| 2    |                            | 3                      |
| 3    |                            | 4                      |
| 4    |                            | 5                      |

**Adjustment for Multiple Comparisons: Tukey**

<table>
<thead>
<tr>
<th>Station</th>
<th>As LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect **Station**

| Pr > |t| for H0: LSMean(i)=LSMean(j) | Dependent Variable: As |
|------|-----------------------------|------------------------|
| 1/5  |                             |                        |
| 1    | 1                          | 2                      |
| 2    |                            | 3                      |
| 3    |                            | 4                      |
| 4    |                            | 5                      |
| 5    |                            | 1                      |
Appendix C: Statistical Analysis

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations: 60

Dependent Variable: Sr

The GLM Procedure

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>11510.33208</td>
<td>605.80695</td>
<td>0.93</td>
<td>0.5575</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>26159.21268</td>
<td>653.98032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>37669.54476</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.305561
Coeff Var: 271.0621
Root MSE: 25.57304
Sr Mean: 9.434383

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4003</td>
<td>0.3408</td>
<td>0.6162</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.4003</td>
<td>0.9995</td>
<td>0.9839</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.3408</td>
<td>0.9995</td>
<td>0.9652</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.6162</td>
<td>0.9839</td>
<td>0.9652</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9999</td>
<td>0.9992</td>
<td>0.9954</td>
<td>0.4191</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9999</td>
<td>0.9992</td>
<td>0.9990</td>
<td>0.4922</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9962</td>
<td>1.0000</td>
<td>0.6422</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9954</td>
<td>0.9990</td>
<td>1.0000</td>
<td>0.6524</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.4191</td>
<td>0.4922</td>
<td>0.6422</td>
<td>0.6524</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The GLM Procedure

Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5

Number of observations 60

The GLM Procedure
Dependent Variable: Cd

Source DF Type II SS Mean Square F Value Pr > F
Samp_Date 3 0.14016378 0.04672126 3.44 0.0257
Station 4 0.06801677 0.01700419 1.25 0.3050
Samp_Date*Station 12 0.12926563 0.01077214 0.79 0.6550

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

Least Squares Means for effect Samp_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Cd

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>LSMEAN Cd LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.26420000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.34133333</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.37620000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.38304444</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Cd

<table>
<thead>
<tr>
<th>Station</th>
<th>LSMEAN Cd LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.35191667</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.29775000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.34725000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.39700000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0.31833333</td>
<td>5</td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

The SAS System  14:45 Friday, October 6, 2017  65

### The GLM Procedure

#### Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations: 60

The SAS System  14:45 Friday, October 6, 2017  66

### The GLM Procedure

**Dependent Variable: Ba**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>465.6023754</td>
<td>24.5053882</td>
<td>3.44</td>
<td>0.0005</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td>284.8009553</td>
<td>7.1200239</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>59</td>
<td>750.4033307</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- R-Square: 0.620469
- Coeff Var: 30.76449
- Root MSE: 2.668337
- Ba Mean: 8.673433

#### Least Squares Means

**Adjustment for Multiple Comparisons: Tukey LSMEAN**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>16.6169202</td>
<td>5.5399734</td>
<td>0.78</td>
<td>0.5132</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>246.0103982</td>
<td>61.5025996</td>
<td>8.64</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>202.9750570</td>
<td>16.9145881</td>
<td>2.38</td>
<td>0.0202</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samp_Date</td>
<td>3</td>
<td>16.6169202</td>
<td>5.5399734</td>
<td>0.78</td>
<td>0.5132</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>246.0103982</td>
<td>61.5025996</td>
<td>8.64</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Samp_Date*Station</td>
<td>12</td>
<td>202.9750570</td>
<td>16.9145881</td>
<td>2.38</td>
<td>0.0202</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Samp_Date

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9998</td>
<td>0.9905</td>
<td>0.5395</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.9998</td>
<td>0.9960</td>
<td>0.5869</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.9995</td>
<td>0.9960</td>
<td>0.7232</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.5395</td>
<td>0.5869</td>
<td>0.7232</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9999</td>
<td>0.0001</td>
<td>0.1487</td>
<td>0.0650</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.9999</td>
<td>0.0002</td>
<td>0.1983</td>
<td>0.0908</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0759</td>
<td>0.1700</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.1487</td>
<td>0.1983</td>
<td>0.0759</td>
<td>0.0951</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0.0650</td>
<td>0.0908</td>
<td>0.1700</td>
<td>0.0951</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The SAS System 14:45 Friday, October 6, 2017 69
The GLM Procedure
Class Level Information
Class Levels Values
Samp_Date 4 1 2 3 4
Station 5 1 2 3 4 5
Number of observations 60

The SAS System 14:45 Friday, October 6, 2017 70
The GLM Procedure
Dependent Variable: Pb

Sum of
Source DF Squares Mean Square F Value Pr > F
Model 19 146.3519783 7.7027357 3.00 0.0017
Error 40 102.6358473 2.5658962
Corrected Total 59 248.9878257

R-Square Coeff Var Root MSE Pb Mean
0.587788 178.5478 1.601841 0.897150

Source DF Type I SS Mean Square F Value Pr > F
Samp_Date 3 13.8464565 4.6154855 1.80 0.16 29
Station 4 14.6184996 3.6546249 1.42 0.2436 0.0007
Samp_Date*Station 12 117.8870223 9.8239185 3.83 0.0007

Source DF Type III SS Mean Square F Value Pr > F
Samp_Date 3 13.8464565 4.6154855 1.80 0.1629
Station 4 14.6184996 3.6546249 1.42 0.2436
Samp_Date*Station 12 117.8870223 9.8239185 3.83 0.0007

Least Squares Means
Adjustment for Multiple Comparisons: Tukey

<table>
<thead>
<tr>
<th>Samp_Date</th>
<th>Pb LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.226267</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.845067</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.581867</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.935400</td>
<td>4</td>
</tr>
</tbody>
</table>

Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Pb

1/2 3 1
1 0.7167 0.1110 0.6228
2 0.7167 0.5934 0.9987
3 0.1110 0.5934 0.6884
4 0.6228 0.9987 0.6884

Least Squares Means for effect Samp_Date

<table>
<thead>
<tr>
<th>Station</th>
<th>Pb LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.89975</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.07275</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.00000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1.50567</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>1.50567</td>
<td>5</td>
</tr>
</tbody>
</table>

Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Pb

1/2 3 4 5
1 0.9989 0.9989 0.6462 0.8849
2 0.9989 1.0000 0.5429 0.9400
3 0.9989 1.0000 0.4813 0.9633
4 0.6462 0.5429 0.4813 0.1653
5 0.8849 0.9400 0.8633 0.1653
### Appendix C: Statistical Analysis

NOTE: I COMPUTED THE MEANS & STANDARD ERRORS. YOU CAN USE THEM FOR YOUR REPORTING BUT USE THE TURKEY TEST STATISTICAL DIFFERENCES TO COMPARE THESE MEANS

---

#### The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>153.6347835</td>
<td>13.6538909</td>
<td>106.6215555</td>
<td>213.9679639</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>1259.47</td>
<td>178.916634</td>
<td>397.6000000</td>
<td>2124.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>582.111111</td>
<td>413.348111</td>
<td>379.2000000</td>
<td>839.9000000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>1858.47</td>
<td>238.6053617</td>
<td>757.9000000</td>
<td>3027.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>1384.10</td>
<td>156.2810662</td>
<td>667.6000000</td>
<td>1889.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>1567.03</td>
<td>118.795798</td>
<td>739.0000000</td>
<td>1810.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>13.679111</td>
<td>7.7752978</td>
<td>6.3800000</td>
<td>19.540000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>17.866667</td>
<td>1.8717466</td>
<td>7.2390000</td>
<td>21.120000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>115.9588889</td>
<td>0.3711485</td>
<td>10.0700000</td>
<td>13.600000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>0.1557778</td>
<td>0.1007623</td>
<td>0.0000000</td>
<td>0.9100000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>132.943333</td>
<td>26.1436501</td>
<td>70.6900000</td>
<td>323.200000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>29.0155556</td>
<td>3.8312313</td>
<td>14.3000000</td>
<td>52.1800000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>0.5244444</td>
<td>0.0394416</td>
<td>0.0990000</td>
<td>0.4830000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>34.3788889</td>
<td>4.2761520</td>
<td>17.5400000</td>
<td>56.9400000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>9</td>
<td>2.7748889</td>
<td>0.8847971</td>
<td>0</td>
<td>7.3410000</td>
<td></td>
</tr>
</tbody>
</table>

---

#### The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>190.010836</td>
<td>11.9337354</td>
<td>115.497285</td>
<td>239.825555</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>1258.29</td>
<td>208.2876214</td>
<td>351.7000000</td>
<td>2465.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>1154.50</td>
<td>1660.49</td>
<td>277.00</td>
<td>1906.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>666.6000000</td>
<td>102.4323929</td>
<td>242.3000000</td>
<td>1213.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>2302.45</td>
<td>296.2876214</td>
<td>627.9000000</td>
<td>3436.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>1518.55</td>
<td>178.4527835</td>
<td>912.6000000</td>
<td>2499.00</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>11.0060000</td>
<td>0.1701836</td>
<td>0.2000000</td>
<td>1.9500000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>13.9810000</td>
<td>0.3844281</td>
<td>10.7700000</td>
<td>18.6100000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>13.6700000</td>
<td>0.8245484</td>
<td>10.3800000</td>
<td>17.4100000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>17.3597000</td>
<td>1.8661932</td>
<td>8.3500000</td>
<td>26.4600000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>11.0038000</td>
<td>0.7838067</td>
<td>8.4010000</td>
<td>15.6200000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>0.0573000</td>
<td>0.0428123</td>
<td>0</td>
<td>0.4260000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>124.5240000</td>
<td>15.7734028</td>
<td>58.7000000</td>
<td>204.2000000</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PM10 PM10</td>
<td>10</td>
<td>34.9450000</td>
<td>4.9800596</td>
<td>9.8950000</td>
<td>56.0700000</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>10</td>
<td>145.297000</td>
<td>16.3851203</td>
<td>77.980000</td>
<td>214.050000</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>10</td>
<td>1433.71</td>
<td>389.5061826</td>
<td>311.600000</td>
<td>3660.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>10</td>
<td>9340.00</td>
<td>2043.45</td>
<td>3791.00</td>
<td>20480.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>10</td>
<td>758.900000</td>
<td>125.0347463</td>
<td>120.900000</td>
<td>1252.00</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>10</td>
<td>1847.94</td>
<td>472.259450</td>
<td>376.200000</td>
<td>4410.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>10</td>
<td>1568.23</td>
<td>388.1998586</td>
<td>499.000000</td>
<td>3752.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>10</td>
<td>1.005300</td>
<td>0.3247419</td>
<td>0.032000</td>
<td>2.695000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>10</td>
<td>10.189000</td>
<td>1.1608898</td>
<td>5.649000</td>
<td>14.710000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>10</td>
<td>12.062000</td>
<td>1.2006303</td>
<td>8.184000</td>
<td>13.280000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>10</td>
<td>15.217100</td>
<td>3.1697469</td>
<td>4.983000</td>
<td>32.240000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>10</td>
<td>10.195000</td>
<td>1.2335396</td>
<td>4.985000</td>
<td>15.520000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>10</td>
<td>0.315700</td>
<td>0.0211054</td>
<td>0.000000</td>
<td>1.581000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>10</td>
<td>123.160000</td>
<td>16.4520851</td>
<td>59.510000</td>
<td>237.500000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>10</td>
<td>31.460000</td>
<td>8.2691083</td>
<td>6.408000</td>
<td>73.930000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>10</td>
<td>0.350000</td>
<td>0.0364989</td>
<td>0.125000</td>
<td>0.541000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>10</td>
<td>30.234000</td>
<td>6.3463059</td>
<td>14.660000</td>
<td>65.310000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>10</td>
<td>0.631500</td>
<td>0.3583771</td>
<td>0</td>
<td>3.156000</td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 3

### Station=1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>163.505000</td>
<td>3.8787257</td>
<td>159.630256</td>
<td>167.428206</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1125.50</td>
<td>7.5000000</td>
<td>1118.00</td>
<td>1233.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>11160.00</td>
<td>1070.00</td>
<td>10090.00</td>
<td>12230.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>632.300000</td>
<td>16.000000</td>
<td>622.300000</td>
<td>642.300000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2805.00</td>
<td>20.000000</td>
<td>2480.00</td>
<td>2525.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1235.50</td>
<td>21.500000</td>
<td>1214.00</td>
<td>1257.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.793500</td>
<td>0.010500</td>
<td>0.783000</td>
<td>0.804000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>9.330000</td>
<td>0.066500</td>
<td>9.264000</td>
<td>9.970000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>12.450000</td>
<td>0.130000</td>
<td>12.320000</td>
<td>12.580000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>20.065000</td>
<td>0.095000</td>
<td>19.970000</td>
<td>20.160000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>16.630000</td>
<td>0.130000</td>
<td>10.500000</td>
<td>10.760000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>225.400000</td>
<td>53.600000</td>
<td>171.800000</td>
<td>279.000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>33.150000</td>
<td>0.255000</td>
<td>32.860000</td>
<td>33.370000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.203500</td>
<td>0.027500</td>
<td>0.176000</td>
<td>0.231000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>26.010000</td>
<td>0.820000</td>
<td>25.190000</td>
<td>26.830000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>3.163500</td>
<td>1.083500</td>
<td>2.080000</td>
<td>4.270000</td>
</tr>
</tbody>
</table>

### Station=2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>158.481393</td>
<td>5.2004407</td>
<td>153.2809986</td>
<td>163.681800</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>2254.00</td>
<td>141.000000</td>
<td>2113.00</td>
<td>2395.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>10560.00</td>
<td>1085.00</td>
<td>9480.00</td>
<td>11650.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>1071.00</td>
<td>52.000000</td>
<td>1019.00</td>
<td>1123.00</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2427.50</td>
<td>165.500000</td>
<td>2262.00</td>
<td>2593.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>2194.00</td>
<td>117.000000</td>
<td>2077.00</td>
<td>2311.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>1.460500</td>
<td>0.097500</td>
<td>1.363000</td>
<td>1.558000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>9.033500</td>
<td>0.530500</td>
<td>8.503000</td>
<td>9.564000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>14.590000</td>
<td>0.760000</td>
<td>14.130000</td>
<td>15.650000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>27.175000</td>
<td>2.125000</td>
<td>25.050000</td>
<td>29.300000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>14.015000</td>
<td>0.995000</td>
<td>13.020000</td>
<td>15.010000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.382000</td>
<td>0.070000</td>
<td>0.312000</td>
<td>0.452000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>179.000000</td>
<td>59.200000</td>
<td>119.800000</td>
<td>238.200000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>36.100000</td>
<td>1.450000</td>
<td>28.650000</td>
<td>31.550000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.731500</td>
<td>0.010500</td>
<td>0.016300</td>
<td>0.184000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>29.700000</td>
<td>1.120000</td>
<td>28.250000</td>
<td>30.490000</td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>119.5699325</td>
<td>8.1441752</td>
<td>111.4257573</td>
<td>127.714077</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1038.50</td>
<td>10.5000000</td>
<td>1028.00</td>
<td>1049.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>9048.00</td>
<td>281.0000000</td>
<td>8767.00</td>
<td>9329.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>846.2500000</td>
<td>218.7500000</td>
<td>635.5000000</td>
<td>1057.00</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>1912.50</td>
<td>71.5000000</td>
<td>1841.00</td>
<td>1984.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1120.00</td>
<td>2.0000000</td>
<td>1118.00</td>
<td>1122.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.6430000</td>
<td>0.0270000</td>
<td>0.6160000</td>
<td>0.6700000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>7.0540000</td>
<td>0.0620000</td>
<td>6.9920000</td>
<td>7.1160000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>13.8750000</td>
<td>1.5050000</td>
<td>12.3700000</td>
<td>15.3800000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>13.6450000</td>
<td>0.3950000</td>
<td>13.2800000</td>
<td>14.0400000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>9.9080000</td>
<td>0.0490000</td>
<td>9.8590000</td>
<td>9.9570000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>74.2650000</td>
<td>7.5850000</td>
<td>66.6800000</td>
<td>81.8500000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>28.2900000</td>
<td>0.6200000</td>
<td>27.6700000</td>
<td>28.9100000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.2370000</td>
<td>0.0660000</td>
<td>0.1710000</td>
<td>0.3030000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>23.3450000</td>
<td>1.0650000</td>
<td>22.2800000</td>
<td>24.4100000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0.1270000</td>
<td>0.1270000</td>
<td>0</td>
<td>0.2540000</td>
</tr>
</tbody>
</table>

The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>173.1228166</td>
<td>13.7360277</td>
<td>159.3867899</td>
<td>186.858443</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1548.00</td>
<td>17.0000000</td>
<td>1531.00</td>
<td>1565.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>15610.00</td>
<td>3500.00</td>
<td>12110.00</td>
<td>19110.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>701.7500000</td>
<td>90.4500000</td>
<td>611.3000000</td>
<td>792.2000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2738.50</td>
<td>116.5000000</td>
<td>2622.00</td>
<td>2855.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1509.00</td>
<td>22.0000000</td>
<td>1487.00</td>
<td>1531.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.9925000</td>
<td>0.0895000</td>
<td>0.9030000</td>
<td>1.0820000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>10.0540000</td>
<td>0.4060000</td>
<td>9.6480000</td>
<td>10.4600000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>12.0250000</td>
<td>0.3750000</td>
<td>11.6500000</td>
<td>12.4000000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>19.4850000</td>
<td>0.8750000</td>
<td>18.8100000</td>
<td>20.1600000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>11.1750000</td>
<td>0.3050000</td>
<td>11.0700000</td>
<td>11.2800000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>187.5000000</td>
<td>76.4000000</td>
<td>111.1000000</td>
<td>263.9000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>34.1200000</td>
<td>2.1500000</td>
<td>31.9700000</td>
<td>36.2700000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.2645000</td>
<td>0.2645000</td>
<td>0</td>
<td>0.5290000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>30.4700000</td>
<td>0.0700000</td>
<td>30.4000000</td>
<td>30.5400000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0.1270000</td>
<td>0.1270000</td>
<td>0</td>
<td>0.2540000</td>
</tr>
</tbody>
</table>

The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>163.5506531</td>
<td>3.8776275</td>
<td>159.630256</td>
<td>167.4282806</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1125.50</td>
<td>7.5000000</td>
<td>1118.00</td>
<td>1133.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>11360.00</td>
<td>1070.00</td>
<td>10890.00</td>
<td>12330.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>632.3000000</td>
<td>10.0000000</td>
<td>622.3000000</td>
<td>642.3000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2505.00</td>
<td>20.0000000</td>
<td>2485.00</td>
<td>2525.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1235.50</td>
<td>21.5000000</td>
<td>1214.00</td>
<td>1257.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.7935000</td>
<td>0.0105000</td>
<td>0.7830000</td>
<td>0.8040000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>9.8300000</td>
<td>0.0665000</td>
<td>9.8640000</td>
<td>9.9770000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>12.4500000</td>
<td>0.1300000</td>
<td>12.3200000</td>
<td>12.5900000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>20.0650000</td>
<td>0.0950000</td>
<td>19.9700000</td>
<td>20.1600000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>10.6300000</td>
<td>0.1300000</td>
<td>10.5000000</td>
<td>10.7600000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>225.4000000</td>
<td>53.6000000</td>
<td>171.8000000</td>
<td>279.0000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>33.1150000</td>
<td>0.2550000</td>
<td>32.8600000</td>
<td>33.3700000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.2305000</td>
<td>0.0275000</td>
<td>0.1760000</td>
<td>0.2310000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>26.0100000</td>
<td>0.8200000</td>
<td>25.1900000</td>
<td>26.8300000</td>
</tr>
</tbody>
</table>

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure

The MEANS Procedure
Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>Pb</td>
<td>2</td>
<td>3.1635000</td>
<td>1.0835000</td>
<td>2.0800000</td>
<td>4.2470000</td>
</tr>
</tbody>
</table>

---

**Sampling_Date=1 Station=2**

**The SAS System 18:34 Sunday, October 8, 2017 6**

---

**Sampling_Date=1 Station=3**

---

**Sampling_Date=1 Station=4**
### Appendix C: Statistical Analysis

#### The SAS System 18:34 Sunday, October 8, 2017 7

---

**Sampling Date=1 Station=5**

---

**The MEANS Procedure**

<table>
<thead>
<tr>
<th>Variable Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>2</td>
<td>38.5937</td>
<td>0.2355500</td>
<td>38.00000</td>
<td>40.00000</td>
</tr>
<tr>
<td>Al</td>
<td>2</td>
<td>1489.50</td>
<td>1.0300000</td>
<td>1460.000</td>
<td>1519.000</td>
</tr>
<tr>
<td>Ca</td>
<td>2</td>
<td>515.50</td>
<td>4.6755000</td>
<td>496.00000</td>
<td>535.00000</td>
</tr>
<tr>
<td>Na</td>
<td>2</td>
<td>784.00000</td>
<td>5.4900000</td>
<td>759.00000</td>
<td>814.00000</td>
</tr>
<tr>
<td>Mg</td>
<td>2</td>
<td>243.50</td>
<td>2.0350000</td>
<td>220.00000</td>
<td>268.00000</td>
</tr>
<tr>
<td>Fe</td>
<td>2</td>
<td>1960.50</td>
<td>15.205000</td>
<td>1900.000</td>
<td>2020.000</td>
</tr>
<tr>
<td>Li</td>
<td>2</td>
<td>2.7050000</td>
<td>0.2660000</td>
<td>2.4300000</td>
<td>3.0700000</td>
</tr>
<tr>
<td>V</td>
<td>2</td>
<td>13.045000</td>
<td>0.6500000</td>
<td>12.000000</td>
<td>14.000000</td>
</tr>
<tr>
<td>Cr</td>
<td>2</td>
<td>15.540000</td>
<td>1.3000000</td>
<td>13.000000</td>
<td>18.000000</td>
</tr>
<tr>
<td>Mn</td>
<td>2</td>
<td>20.820000</td>
<td>1.3000000</td>
<td>19.000000</td>
<td>23.000000</td>
</tr>
<tr>
<td>Ni</td>
<td>2</td>
<td>12.130000</td>
<td>1.4700000</td>
<td>10.000000</td>
<td>14.000000</td>
</tr>
<tr>
<td>Co</td>
<td>2</td>
<td>0.2460000</td>
<td>0.0120000</td>
<td>0.2240000</td>
<td>0.2680000</td>
</tr>
<tr>
<td>Zn</td>
<td>2</td>
<td>78.540000</td>
<td>5.2800000</td>
<td>56.000000</td>
<td>104.00000</td>
</tr>
<tr>
<td>As</td>
<td>2</td>
<td>20.870000</td>
<td>1.2700000</td>
<td>18.000000</td>
<td>22.00000</td>
</tr>
<tr>
<td>Sr</td>
<td>2</td>
<td>227.50000</td>
<td>3.5726478</td>
<td>200.00000</td>
<td>300.00000</td>
</tr>
<tr>
<td>Cd</td>
<td>2</td>
<td>34.515000</td>
<td>2.3650000</td>
<td>30.000000</td>
<td>40.000000</td>
</tr>
<tr>
<td>Ba</td>
<td>2</td>
<td>35.165000</td>
<td>2.2050000</td>
<td>32.000000</td>
<td>38.000000</td>
</tr>
<tr>
<td>Pb</td>
<td>2</td>
<td>2.1275000</td>
<td>1.5785000</td>
<td>1.5400000</td>
<td>2.2500000</td>
</tr>
</tbody>
</table>

---

**Sampling Date=2 Station=1**

---

**The MEANS Procedure**

<table>
<thead>
<tr>
<th>Variable Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>2</td>
<td>191.98736</td>
<td>3.5726478</td>
<td>180.00000</td>
<td>202.00000</td>
</tr>
<tr>
<td>Al</td>
<td>2</td>
<td>2070.50</td>
<td>53.500000</td>
<td>1900.0000</td>
<td>2240.0000</td>
</tr>
<tr>
<td>Ca</td>
<td>2</td>
<td>1489.50</td>
<td>1.0300000</td>
<td>1460.0000</td>
<td>1519.0000</td>
</tr>
<tr>
<td>Na</td>
<td>2</td>
<td>784.00000</td>
<td>5.4900000</td>
<td>759.000000</td>
<td>814.000000</td>
</tr>
<tr>
<td>Mg</td>
<td>2</td>
<td>243.50</td>
<td>2.0350000</td>
<td>220.00000</td>
<td>268.00000</td>
</tr>
<tr>
<td>Fe</td>
<td>2</td>
<td>1960.50</td>
<td>15.205000</td>
<td>1900.0000</td>
<td>2020.0000</td>
</tr>
<tr>
<td>Li</td>
<td>2</td>
<td>2.7050000</td>
<td>0.2660000</td>
<td>2.4300000</td>
<td>3.0700000</td>
</tr>
<tr>
<td>V</td>
<td>2</td>
<td>13.045000</td>
<td>0.6500000</td>
<td>12.000000</td>
<td>14.000000</td>
</tr>
<tr>
<td>Cr</td>
<td>2</td>
<td>15.540000</td>
<td>1.3000000</td>
<td>13.000000</td>
<td>18.000000</td>
</tr>
<tr>
<td>Mn</td>
<td>2</td>
<td>20.820000</td>
<td>1.3000000</td>
<td>19.000000</td>
<td>23.000000</td>
</tr>
<tr>
<td>Ni</td>
<td>2</td>
<td>12.130000</td>
<td>1.4700000</td>
<td>10.000000</td>
<td>14.000000</td>
</tr>
<tr>
<td>Co</td>
<td>2</td>
<td>0.2460000</td>
<td>0.0120000</td>
<td>0.2240000</td>
<td>0.2680000</td>
</tr>
<tr>
<td>Zn</td>
<td>2</td>
<td>78.540000</td>
<td>5.2800000</td>
<td>56.000000</td>
<td>104.00000</td>
</tr>
<tr>
<td>As</td>
<td>2</td>
<td>20.870000</td>
<td>1.2700000</td>
<td>18.000000</td>
<td>22.00000</td>
</tr>
<tr>
<td>Sr</td>
<td>2</td>
<td>227.50000</td>
<td>3.5726478</td>
<td>200.00000</td>
<td>300.00000</td>
</tr>
<tr>
<td>Cd</td>
<td>2</td>
<td>34.515000</td>
<td>2.3650000</td>
<td>30.000000</td>
<td>40.000000</td>
</tr>
<tr>
<td>Ba</td>
<td>2</td>
<td>35.165000</td>
<td>2.2050000</td>
<td>32.000000</td>
<td>38.000000</td>
</tr>
<tr>
<td>Pb</td>
<td>2</td>
<td>2.1275000</td>
<td>1.5785000</td>
<td>1.5400000</td>
<td>2.2500000</td>
</tr>
</tbody>
</table>

---

**Sampling Date=2 Station=2**

---

**The MEANS Procedure**

<table>
<thead>
<tr>
<th>Variable Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>2</td>
<td>117.3200295</td>
<td>5.5700295</td>
<td>110.750000</td>
<td>122.890000</td>
</tr>
<tr>
<td>Al</td>
<td>2</td>
<td>1268.50</td>
<td>19.500000</td>
<td>1219.0000</td>
<td>1328.0000</td>
</tr>
<tr>
<td>Ca</td>
<td>2</td>
<td>8014.50</td>
<td>323.50000</td>
<td>7691.0000</td>
<td>8338.0000</td>
</tr>
<tr>
<td>Na</td>
<td>2</td>
<td>566.250000</td>
<td>1.2500000</td>
<td>559.000000</td>
<td>573.500000</td>
</tr>
<tr>
<td>Mg</td>
<td>2</td>
<td>1751.50</td>
<td>18.500000</td>
<td>1733.0000</td>
<td>1770.0000</td>
</tr>
<tr>
<td>Fe</td>
<td>2</td>
<td>1482.50</td>
<td>4.5000000</td>
<td>1478.0000</td>
<td>1487.0000</td>
</tr>
<tr>
<td>Li</td>
<td>2</td>
<td>1.0670000</td>
<td>0.0240000</td>
<td>1.0430000</td>
<td>1.0910000</td>
</tr>
<tr>
<td>V</td>
<td>2</td>
<td>13.7700000</td>
<td>0.6060000</td>
<td>13.7100000</td>
<td>13.8300000</td>
</tr>
<tr>
<td>Cr</td>
<td>2</td>
<td>14.0530000</td>
<td>0.8550000</td>
<td>13.2000000</td>
<td>14.9100000</td>
</tr>
<tr>
<td>Mn</td>
<td>2</td>
<td>20.3150000</td>
<td>0.0250000</td>
<td>20.2900000</td>
<td>20.3400000</td>
</tr>
<tr>
<td>Ni</td>
<td>2</td>
<td>12.0950000</td>
<td>0.3850000</td>
<td>11.7100000</td>
<td>12.4800000</td>
</tr>
<tr>
<td>Co</td>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Zn</td>
<td>2</td>
<td>82.9400000</td>
<td>12.2500000</td>
<td>70.6900000</td>
<td>95.1900000</td>
</tr>
<tr>
<td>As</td>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sr</td>
<td>2</td>
<td>24.7100000</td>
<td>0.3500000</td>
<td>24.3600000</td>
<td>25.0600000</td>
</tr>
</tbody>
</table>

---
### Appendix C: Statistical Analysis

**Table 1: Sampling Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>165.0029303</td>
<td>4.2750001</td>
<td>160.7279302</td>
<td>169.2779305</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1051.50</td>
<td>31.5000000</td>
<td>1020.00</td>
<td>1083.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>8968.50</td>
<td>461.5000000</td>
<td>8507.00</td>
<td>9430.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>462100000</td>
<td>17.5000000</td>
<td>444600000</td>
<td>479600000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>1791.50</td>
<td>3.5000000</td>
<td>1784.00</td>
<td>1799.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1300.00</td>
<td>39.00000000</td>
<td>1261.00</td>
<td>1339.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.8255000</td>
<td>0.1665000</td>
<td>0.6590000</td>
<td>0.9920000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>11.9900000</td>
<td>0.2700000</td>
<td>11.7200000</td>
<td>12.2600000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>14.4250000</td>
<td>1.4000000</td>
<td>13.0200000</td>
<td>15.8300000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>12.9250000</td>
<td>0.2650000</td>
<td>12.6600000</td>
<td>13.1900000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>12.2550000</td>
<td>0.7650000</td>
<td>11.4900000</td>
<td>13.0200000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.4550000</td>
<td>0.4550000</td>
<td>0.9100000</td>
<td>0.9100000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>109.8700000</td>
<td>37.3300000</td>
<td>72.5400000</td>
<td>147.2000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>30.4950000</td>
<td>0.0750000</td>
<td>30.4200000</td>
<td>30.5700000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.4375000</td>
<td>0.0455000</td>
<td>0.3920000</td>
<td>0.4830000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>43.6500000</td>
<td>4.2350000</td>
<td>39.2300000</td>
<td>47.7000000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>1.2405000</td>
<td>1.2405000</td>
<td>0</td>
<td>2.4810000</td>
</tr>
</tbody>
</table>

**Table 2: Sampling Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>110.0622168</td>
<td>3.4406610</td>
<td>106.621558</td>
<td>113.5028779</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>601.1000000</td>
<td>3.5000000</td>
<td>597.6000000</td>
<td>604.6000000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>5135.5000000</td>
<td>278.5000000</td>
<td>4851.0000000</td>
<td>5414.0000000</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>439.4000000</td>
<td>62.0000000</td>
<td>379.2000000</td>
<td>499.6000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>874.1000000</td>
<td>16.2000000</td>
<td>857.9000000</td>
<td>890.3000000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>688.9500000</td>
<td>21.3500000</td>
<td>667.6000000</td>
<td>710.3000000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.3212500</td>
<td>0.0275000</td>
<td>0.2940000</td>
<td>0.3490000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>13.9400000</td>
<td>0</td>
<td>13.9400000</td>
<td>13.9400000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>10.8120000</td>
<td>1.6580000</td>
<td>9.1540000</td>
<td>12.4700000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>7.5850000</td>
<td>0.3460000</td>
<td>7.2330000</td>
<td>7.9310000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>11.1000000</td>
<td>1.0300000</td>
<td>10.0700000</td>
<td>12.1300000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>117.5350000</td>
<td>39.6650000</td>
<td>77.8700000</td>
<td>157.2000000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>117.5350000</td>
<td>39.6650000</td>
<td>77.8700000</td>
<td>157.2000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>14.7600000</td>
<td>0.4600000</td>
<td>14.3000000</td>
<td>15.2200000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.2220000</td>
<td>0.0190000</td>
<td>0.2030000</td>
<td>0.2410000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>17.7250000</td>
<td>0.1850000</td>
<td>17.5400000</td>
<td>17.9100000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0.3890000</td>
<td>0.0530000</td>
<td>0.3360000</td>
<td>0.4420000</td>
</tr>
</tbody>
</table>

**Table 3: Sampling Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>1</td>
<td>213.679639</td>
<td>213.9679639</td>
<td>213.9679639</td>
<td>213.9679639</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>1</td>
<td>1352.00</td>
<td>1352.00</td>
<td>1352.00</td>
<td>1352.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>1</td>
<td>14960.00</td>
<td>14960.00</td>
<td>14960.00</td>
<td>14960.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>1</td>
<td>561.1000000</td>
<td>561.1000000</td>
<td>561.1000000</td>
<td>561.1000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>1</td>
<td>3027.00</td>
<td>3027.00</td>
<td>3027.00</td>
<td>3027.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>1</td>
<td>1683.00</td>
<td>1683.00</td>
<td>1683.00</td>
<td>1683.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>1</td>
<td>0.8990000</td>
<td>0.8990000</td>
<td>0.8990000</td>
<td>0.8990000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>1</td>
<td>10.5300000</td>
<td>10.5300000</td>
<td>10.5300000</td>
<td>10.5300000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>1</td>
<td>13.5700000</td>
<td>13.5700000</td>
<td>13.5700000</td>
<td>13.5700000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>1</td>
<td>18.7900000</td>
<td>18.7900000</td>
<td>18.7900000</td>
<td>18.7900000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>1</td>
<td>12.4700000</td>
<td>12.4700000</td>
<td>12.4700000</td>
<td>12.4700000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>1</td>
<td>135.0000000</td>
<td>135.0000000</td>
<td>135.0000000</td>
<td>135.0000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>1</td>
<td>52.1800000</td>
<td>52.1800000</td>
<td>52.1800000</td>
<td>52.1800000</td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>PM10</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
</tr>
<tr>
<td>Ba</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
</tr>
<tr>
<td>Pb</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>195.3131784</td>
<td>1.6131784</td>
<td>193.7000000</td>
<td>196.9263568</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>739.4500000</td>
<td>9.8500000</td>
<td>729.6000000</td>
<td>749.3000000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>12890.00</td>
<td>1760.00</td>
<td>11130.00</td>
<td>14650.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>461.1500000</td>
<td>12.5500000</td>
<td>448.6000000</td>
<td>473.7000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2187.00</td>
<td>1.0000000</td>
<td>2186.00</td>
<td>2188.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1009.60</td>
<td>11.4000000</td>
<td>998.2000000</td>
<td>1021.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>1.2555000</td>
<td>0.0015000</td>
<td>1.2540000</td>
<td>1.2570000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>12.0350000</td>
<td>0.0750000</td>
<td>11.9600000</td>
<td>12.1100000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>11.1400000</td>
<td>8.2000000</td>
<td>10.9400000</td>
<td>11.3400000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>12.3400000</td>
<td>9.5000000</td>
<td>11.8400000</td>
<td>12.8400000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>8.6785000</td>
<td>0.2775000</td>
<td>8.4010000</td>
<td>8.9560000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>149.1350000</td>
<td>55.0650000</td>
<td>94.0700000</td>
<td>204.2200000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>25.5050000</td>
<td>0.2350000</td>
<td>25.2700000</td>
<td>25.7400000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.3675000</td>
<td>0.0665000</td>
<td>0.3010000</td>
<td>0.4340000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>39.0550000</td>
<td>1.0150000</td>
<td>38.0400000</td>
<td>40.0700000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>4.6275000</td>
<td>0.4985000</td>
<td>4.1290000</td>
<td>5.1260000</td>
</tr>
</tbody>
</table>

**Sampling_Date=3 Station=1**

<table>
<thead>
<tr>
<th>PM10</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
</tr>
<tr>
<td>Ba</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
</tr>
<tr>
<td>Pb</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
</tr>
</tbody>
</table>

**Sampling_Date=3 Station=2**

<table>
<thead>
<tr>
<th>PM10</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
</tr>
<tr>
<td>Ba</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
</tr>
<tr>
<td>Pb</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
</tr>
</tbody>
</table>

**Sampling_Date=3 Station=3**

<table>
<thead>
<tr>
<th>PM10</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
<td>0.1580000</td>
</tr>
<tr>
<td>Ba</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
<td>56.9400000</td>
</tr>
<tr>
<td>Pb</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
<td>4.8600000</td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 10

The SAS System 18:34 Sunday, October 8, 2017 11

The SAS System 18:34 Sunday, October 8, 2017 11

The MEANS Procedure

**The MEANS Procedure**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>239.5947958</td>
<td>0.2307097</td>
<td>239.3640862</td>
<td>239.8255055</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>1282.50</td>
<td>42.5000000</td>
<td>1240.00</td>
<td>1325.00</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>12270.00</td>
<td>1660.00</td>
<td>10610.00</td>
<td>13930.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>569.3500000</td>
<td>49.6500000</td>
<td>519.7000000</td>
<td>619.0000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>2467.00</td>
<td>30.0000000</td>
<td>2437.00</td>
<td>2497.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1718.00</td>
<td>19.0000000</td>
<td>1699.00</td>
<td>1737.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>1.0395000</td>
<td>0.0625000</td>
<td>1.0130000</td>
<td>1.0660000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>18.2650000</td>
<td>0.3450000</td>
<td>17.9200000</td>
<td>18.6100000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>14.8250000</td>
<td>0.8850000</td>
<td>13.9400000</td>
<td>15.7100000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>19.5450000</td>
<td>1.0750000</td>
<td>18.4700000</td>
<td>20.6200000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>13.9350000</td>
<td>1.8950000</td>
<td>12.0400000</td>
<td>15.8300000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>133.2650000</td>
<td>42.0350000</td>
<td>91.2300000</td>
<td>175.3000000</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

### Sampling_Date=3 Station=4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>189.957381</td>
<td>0.1527619</td>
<td>189.8044761</td>
<td>190.1100000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>42.9000000</td>
<td>7.6800000</td>
<td>35.2200000</td>
<td>50.5800000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.47000000</td>
<td>0.02550000</td>
<td>0.44500000</td>
<td>0.49500000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>56.7200000</td>
<td>1.47000000</td>
<td>54.8000000</td>
<td>57.7400000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>6.08150000</td>
<td>0.76450000</td>
<td>5.31700000</td>
<td>6.84600000</td>
</tr>
</tbody>
</table>

### Sampling_Date=5 Station=4

The MEANS Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>129.2218781</td>
<td>13.7239496</td>
<td>115.4979285</td>
<td>142.9458277</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>59.0000000</td>
<td>67.3000000</td>
<td>53.7000000</td>
<td>86.6000000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>367.50</td>
<td>896.5000000</td>
<td>277.00</td>
<td>4577.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>279.7500000</td>
<td>37.4500000</td>
<td>242.3000000</td>
<td>317.2000000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>719.7500000</td>
<td>91.8500000</td>
<td>627.9000000</td>
<td>811.6000000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1018.80</td>
<td>106.2000000</td>
<td>912.6000000</td>
<td>1125.00</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.26100000</td>
<td>0.05900000</td>
<td>0.20200000</td>
<td>0.32000000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>13.7700000</td>
<td>1.71000000</td>
<td>12.6000000</td>
<td>14.9400000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>10.5050000</td>
<td>5.12500000</td>
<td>10.3800000</td>
<td>10.6300000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>9.15350000</td>
<td>8.03500000</td>
<td>8.35000000</td>
<td>9.95700000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>9.78250000</td>
<td>0.03150000</td>
<td>9.76900000</td>
<td>9.79600000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.16000000</td>
<td>0.38000000</td>
<td>0.12000000</td>
<td>0.20000000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>81.4600000</td>
<td>10.3300000</td>
<td>71.1300000</td>
<td>91.7900000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0.16000000</td>
<td>0.38000000</td>
<td>0.12000000</td>
<td>0.20000000</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>11.6575000</td>
<td>1.76250000</td>
<td>9.89500000</td>
<td>13.4200000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.44850000</td>
<td>0.04550000</td>
<td>0.40300000</td>
<td>0.49400000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>43.1550000</td>
<td>3.63500000</td>
<td>39.5200000</td>
<td>46.7900000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>1.98600000</td>
<td>1.98600000</td>
<td>0.00000000</td>
<td>3.97200000</td>
</tr>
</tbody>
</table>

### Sampling_Date=1 Station=1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>117.1350000</td>
<td>6.2750000</td>
<td>110.8600000</td>
<td>123.4100000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>704.6000000</td>
<td>12.2000000</td>
<td>692.4000000</td>
<td>716.8000000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>4446.50</td>
<td>34.5000000</td>
<td>4412.00</td>
<td>4481.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>1232.00</td>
<td>20.0000000</td>
<td>1212.00</td>
<td>1252.00</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>1021.50</td>
<td>1.50000000</td>
<td>1022.00</td>
<td>1025.00</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>760.0500000</td>
<td>8.55000000</td>
<td>759.5000000</td>
<td>760.6000000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.39100000</td>
<td>0.02700000</td>
<td>0.36400000</td>
<td>0.41800000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>7.04950000</td>
<td>0.04250000</td>
<td>7.07000000</td>
<td>7.09200000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>10.2215000</td>
<td>9.65450000</td>
<td>9.83400000</td>
<td>10.6800000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>7.22700000</td>
<td>0.33100000</td>
<td>6.89600000</td>
<td>7.55800000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>5.87700000</td>
<td>0.11000000</td>
<td>5.78500000</td>
<td>5.99600000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.16000000</td>
<td>0.38000000</td>
<td>0.12000000</td>
<td>0.20000000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>85.5850000</td>
<td>15.0150000</td>
<td>70.5700000</td>
<td>100.6000000</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

### Sample Data

#### Sampling Date=4 Station=2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>80.510000</td>
<td>2.530000</td>
<td>77.960000</td>
<td>83.040000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>365.150000</td>
<td>53.550000</td>
<td>311.600000</td>
<td>418.700000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>403.000000</td>
<td>239.000000</td>
<td>379.100000</td>
<td>426.900000</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>147.600000</td>
<td>26.700000</td>
<td>120.900000</td>
<td>174.300000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>470.750000</td>
<td>92.550000</td>
<td>378.200000</td>
<td>563.300000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>566.000000</td>
<td>67.000000</td>
<td>499.000000</td>
<td>633.000000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.66250000</td>
<td>0.03050000</td>
<td>0.03200000</td>
<td>0.09300000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>7.17150000</td>
<td>1.52250000</td>
<td>5.64000000</td>
<td>8.69400000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>8.91550000</td>
<td>0.73150000</td>
<td>8.18400000</td>
<td>9.64700000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>5.77970000</td>
<td>0.79600000</td>
<td>4.98300000</td>
<td>6.57500000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>6.84945000</td>
<td>1.86450000</td>
<td>4.98500000</td>
<td>8.71400000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>202.500000</td>
<td>35.000000</td>
<td>167.500000</td>
<td>237.500000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>8.15400000</td>
<td>1.74600000</td>
<td>6.40800000</td>
<td>9.90000000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.33150000</td>
<td>0.10550000</td>
<td>0.22600000</td>
<td>0.43700000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>15.8000000</td>
<td>1.14000000</td>
<td>14.6600000</td>
<td>16.9400000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Sampling Date=4 Station=3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>206.195000</td>
<td>7.855000</td>
<td>198.340000</td>
<td>214.050000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>392.000000</td>
<td>88.000000</td>
<td>384.000000</td>
<td>396.000000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>1926.0000</td>
<td>122.0000</td>
<td>1804.0000</td>
<td>2048.0000</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>1055.50000</td>
<td>23.500000</td>
<td>1032.0000</td>
<td>1079.0000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>433.500000</td>
<td>86.500000</td>
<td>423.700000</td>
<td>441.000000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>368.700000</td>
<td>65.000000</td>
<td>362.200000</td>
<td>375.200000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>2.62100000</td>
<td>0.07400000</td>
<td>2.54700000</td>
<td>2.69500000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>14.4150000</td>
<td>0.29500000</td>
<td>14.1200000</td>
<td>14.7100000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>18.8700000</td>
<td>5.41000000</td>
<td>18.4600000</td>
<td>19.2800000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>30.7400000</td>
<td>1.50000000</td>
<td>29.2400000</td>
<td>32.2400000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>14.7600000</td>
<td>0.76000000</td>
<td>14.0000000</td>
<td>15.5200000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>1.53900000</td>
<td>0.06200000</td>
<td>1.45900000</td>
<td>1.58100000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>108.760000</td>
<td>16.2400000</td>
<td>92.5200000</td>
<td>125.000000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>72.6850000</td>
<td>1.24500000</td>
<td>71.4400000</td>
<td>73.9300000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.38400000</td>
<td>0.03300000</td>
<td>0.35100000</td>
<td>0.47100000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>64.4300000</td>
<td>0.88000000</td>
<td>63.5500000</td>
<td>65.3100000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0.03950000</td>
<td>0.03950000</td>
<td>0</td>
<td>0.07900000</td>
</tr>
</tbody>
</table>

#### Sampling Date=4 Station=4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>197.655000</td>
<td>10.305000</td>
<td>187.350000</td>
<td>207.960000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1769.50000</td>
<td>19.500000</td>
<td>1750.0000</td>
<td>1789.0000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>1336.00000</td>
<td>139.00000</td>
<td>1217.0000</td>
<td>1460.0000</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>641.000000</td>
<td>12.3000000</td>
<td>628.700000</td>
<td>653.300000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>251.000000</td>
<td>21.0000000</td>
<td>248.900000</td>
<td>253.100000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>1951.50000</td>
<td>24.5000000</td>
<td>1927.0000</td>
<td>1976.0000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>1.56500000</td>
<td>0.40500000</td>
<td>1.16000000</td>
<td>1.97100000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>14.2700000</td>
<td>0.35000000</td>
<td>13.9200000</td>
<td>14.6200000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>12.2500000</td>
<td>0.04000000</td>
<td>12.2100000</td>
<td>12.2900000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>17.6850000</td>
<td>0.68500000</td>
<td>17.0000000</td>
<td>18.3700000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>11.6600000</td>
<td>0.53000000</td>
<td>11.1300000</td>
<td>12.1900000</td>
</tr>
</tbody>
</table>
### Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0.0595000</td>
<td>0.0595000</td>
<td>0</td>
<td>0.1190000</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>127.000000</td>
<td>22.600000</td>
<td>104.400000</td>
<td>149.600000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>47.4150000</td>
<td>0.8150000</td>
<td>46.600000</td>
<td>48.230000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.3580000</td>
<td>0.0480000</td>
<td>0.3100000</td>
<td>0.4060000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>37.8150000</td>
<td>0.1550000</td>
<td>37.660000</td>
<td>37.9700000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>0.4465000</td>
<td>0.4465000</td>
<td>0</td>
<td>0.8930000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>N</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>PM10</td>
<td>2</td>
<td>124.990000</td>
<td>3.8500000</td>
<td>121.140000</td>
<td>128.840000</td>
</tr>
<tr>
<td>Al</td>
<td>Al</td>
<td>2</td>
<td>757.300000</td>
<td>6.8000000</td>
<td>750.500000</td>
<td>764.100000</td>
</tr>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>2</td>
<td>5398.50</td>
<td>691.500000</td>
<td>4707.00</td>
<td>6090.00</td>
</tr>
<tr>
<td>Na</td>
<td>Na</td>
<td>2</td>
<td>718.400000</td>
<td>26.000000</td>
<td>692.400000</td>
<td>744.400000</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg</td>
<td>2</td>
<td>91.3500000</td>
<td>26.050000</td>
<td>885.200000</td>
<td>938.000000</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe</td>
<td>2</td>
<td>876.600000</td>
<td>9.6000000</td>
<td>867.000000</td>
<td>886.200000</td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td>2</td>
<td>0.3865000</td>
<td>0.0235000</td>
<td>0.3630000</td>
<td>0.4100000</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>2</td>
<td>8.0390000</td>
<td>0.1330000</td>
<td>7.9060000</td>
<td>8.1720000</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>2</td>
<td>10.0900000</td>
<td>0.3900000</td>
<td>9.7000000</td>
<td>10.4800000</td>
</tr>
<tr>
<td>Mn</td>
<td>Mn</td>
<td>2</td>
<td>14.6545000</td>
<td>6.9555000</td>
<td>7.6990000</td>
<td>21.6100000</td>
</tr>
<tr>
<td>Ni</td>
<td>Ni</td>
<td>2</td>
<td>10.9510000</td>
<td>3.2990000</td>
<td>7.6520000</td>
<td>14.2500000</td>
</tr>
<tr>
<td>Co</td>
<td>Co</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zn</td>
<td>Zn</td>
<td>2</td>
<td>91.9550000</td>
<td>32.4450000</td>
<td>59.5100000</td>
<td>124.400000</td>
</tr>
<tr>
<td>As</td>
<td>As</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>Sr</td>
<td>2</td>
<td>15.0500000</td>
<td>0.6100000</td>
<td>14.4400000</td>
<td>15.6600000</td>
</tr>
<tr>
<td>Cd</td>
<td>Cd</td>
<td>2</td>
<td>0.4530000</td>
<td>0.0880000</td>
<td>0.3650000</td>
<td>0.5410000</td>
</tr>
<tr>
<td>Ba</td>
<td>Ba</td>
<td>2</td>
<td>17.2950000</td>
<td>0.4550000</td>
<td>16.8400000</td>
<td>17.7500000</td>
</tr>
<tr>
<td>Pb</td>
<td>Pb</td>
<td>2</td>
<td>2.6715000</td>
<td>0.4845000</td>
<td>2.1870000</td>
<td>3.1560000</td>
</tr>
</tbody>
</table>

---

**The SAS System 18:34 Sunday, October 8, 2017 15**

**The GLM Procedure**

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

**The SAS System 18:34 Sunday, October 8, 2017 16**

**The GLM Procedure**

Dependent Variable: PM10  PM10

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>74132.18035</td>
<td>3901.69370</td>
<td>46.52</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>75725.57889</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square 0.978958  Coef Var 5.811600  Root MSE 9.157679  PM10 Mean 157.5759

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>14926.39396</td>
<td>4975.46465</td>
<td>59.33</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>15609.27417</td>
<td>3902.31854</td>
<td>46.53</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>41596.51222</td>
<td>3633.04269</td>
<td>43.32</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
</table>
### Appendix C: Statistical Analysis

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer  

**Least Squares Means for effect Sampling_Date**  
Pr > |t| for H0: LSMean(i)=LSMean(j)  
Dependent Variable: PM10

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.0018</td>
<td>.2118</td>
<td>.1787</td>
<td>.0164</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.0018</td>
<td></td>
<td></td>
<td>.0164</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>.7187</td>
<td>.0164</td>
<td></td>
<td></td>
<td>.0018</td>
<td>.2118</td>
<td>.1787</td>
</tr>
</tbody>
</table>

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer  

**Least Squares Means for effect Station**  
Pr > |t| for H0: LSMean(i)=LSMean(j)  
Dependent Variable: PM10

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.0019</td>
<td>.0219</td>
<td>.0999</td>
<td>.0002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.0019</td>
<td></td>
<td>.0303</td>
<td>.0001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>.9999</td>
<td>.0001</td>
<td></td>
<td></td>
<td>.0219</td>
<td>.0999</td>
<td>.0002</td>
</tr>
<tr>
<td>5</td>
<td>.9978</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure  
Class Level Information  

**Class**  
**Levels**  
**Values**  
Sampling_Date  4  1  2  3  4  5  6  7
Station  5  1  2  3  4  5

Number of observations 40  
NOTE: Due to missing values, only 39 observations can be used in this analysis.
## Appendix C: Statistical Analysis

### Source Table

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>23263547.90</td>
<td>1224397.26</td>
<td>208.66</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>111491.69</td>
<td>5867.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>23375039.60</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### R-Square Coeff Var Root MSE Al Mean

<table>
<thead>
<tr>
<th>R-Square</th>
<th>Coeff Var</th>
<th>Root MSE</th>
<th>Al Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.995230</td>
<td>5.836652</td>
<td>76.60277</td>
<td></td>
</tr>
</tbody>
</table>

### Type I SS Table

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>214361.17</td>
<td>71453.72</td>
<td>12.18</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4566524.77</td>
<td>1141631.19</td>
<td>194.55</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>18482661.96</td>
<td>1540221.83</td>
<td>262.48</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Type III SS Table

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>204703.70</td>
<td>68234.57</td>
<td>11.63</td>
<td>0.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>3735120.45</td>
<td>933780.11</td>
<td>159.13</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>18482661.96</td>
<td>1540221.83</td>
<td>262.48</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Least Squares Means

#### Sampling_Date

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1303.01000</td>
<td>1303.01000</td>
<td>1303.01000</td>
<td>1303.01000</td>
</tr>
<tr>
<td>2</td>
<td>1268.72000</td>
<td>1268.72000</td>
<td>1268.72000</td>
<td>1268.72000</td>
</tr>
<tr>
<td>3</td>
<td>1248.29000</td>
<td>1248.29000</td>
<td>1248.29000</td>
<td>1248.29000</td>
</tr>
<tr>
<td>4</td>
<td>1433.71000</td>
<td>1433.71000</td>
<td>1433.71000</td>
<td>1433.71000</td>
</tr>
</tbody>
</table>

#### Station

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1160.01250</td>
<td>1160.01250</td>
<td>1160.01250</td>
<td>1160.01250</td>
</tr>
<tr>
<td>2</td>
<td>1285.03750</td>
<td>1285.03750</td>
<td>1285.03750</td>
<td>1285.03750</td>
</tr>
<tr>
<td>3</td>
<td>1736.12500</td>
<td>1736.12500</td>
<td>1736.12500</td>
<td>1736.12500</td>
</tr>
<tr>
<td>4</td>
<td>1571.65000</td>
<td>1571.65000</td>
<td>1571.65000</td>
<td>1571.65000</td>
</tr>
<tr>
<td>5</td>
<td>814.33750</td>
<td>814.33750</td>
<td>814.33750</td>
<td>814.33750</td>
</tr>
</tbody>
</table>

### Least Squares Means for effect Sampling_Date

#### Pr > |t| for H0: LMSMean(i)=LMSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7763</td>
<td>0.4036</td>
<td>0.0059</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.7763</td>
<td>0.9402</td>
<td>0.0010</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.4036</td>
<td>0.9402</td>
<td>0.0002</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0059</td>
<td>0.0010</td>
<td>0.0002</td>
<td></td>
</tr>
</tbody>
</table>

### Least Squares Means for effect Station

#### Pr > |t| for H0: LMSMean(i)=LMSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0295</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0295</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0032</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0332</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The GLM Procedure

Class Level Information

Class          Levels  Values
Sampling_Date   4       1 2 3 4
Station         5       1 2 3 4 5

Number of observations  40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

Dependent Variable: Ca

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>884411098.9</td>
<td>46547952.6</td>
<td>7.92</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>111630265.5</td>
<td>5875277.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>996841364.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square  Coeff Var  Root MSE  Ca Mean
    0.887926    23.72154    2423.897  10218.13

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>26699502.0</td>
<td>8899834.0</td>
<td>1.51</td>
<td>0.2429</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>181802359.7</td>
<td>45450589.9</td>
<td>7.74</td>
<td>0.0007</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>675909237.2</td>
<td>56325769.8</td>
<td>9.59</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

| Sampling_Date | Ca LSMEAN
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10108.8000</td>
</tr>
<tr>
<td>2</td>
<td>10353.4000</td>
</tr>
<tr>
<td>3</td>
<td>11544.5000</td>
</tr>
<tr>
<td>4</td>
<td>9340.0000</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>1/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9964</td>
<td>0.5594</td>
<td>0.8922</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9964</td>
<td>0.7242</td>
<td>0.8922</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5594</td>
<td>0.7242</td>
<td>0.2109</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.8922</td>
<td>0.8922</td>
<td>0.2109</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer
Appendix C: Statistical Analysis

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9924</td>
<td>0.6872</td>
<td>0.9977</td>
<td>0.0600</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9924</td>
<td>0.4346</td>
<td>0.9441</td>
<td>0.1295</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.6872</td>
<td>0.4346</td>
<td>0.8522</td>
<td>0.0330</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9977</td>
<td>0.9441</td>
<td>0.8522</td>
<td>0.0330</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0600</td>
<td>0.1295</td>
<td>0.0043</td>
<td>0.0043</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9924</td>
<td>0.6872</td>
<td>0.9977</td>
<td>0.0600</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9924</td>
<td>0.4346</td>
<td>0.9441</td>
<td>0.1295</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.6872</td>
<td>0.4346</td>
<td>0.8522</td>
<td>0.0330</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9977</td>
<td>0.9441</td>
<td>0.8522</td>
<td>0.0330</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0600</td>
<td>0.1295</td>
<td>0.0043</td>
<td>0.0043</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Class Level Information

Class | Levels | Values
Sampling_Date | 4 | 1 2 3 4
Station | 5 | 1 2 3 4 5

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

Dependent Variable: Na Na

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>3034984.100</td>
<td>159736.005</td>
<td>11.38</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>266704.400</td>
<td>14037.074</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>3301688.500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square Coeff Var root MSE Na Mean
0.919222 16.82212 118.4782 704.3000

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>345713.086</td>
<td>115237.695</td>
<td>8.21</td>
<td>0.0010</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>166476.285</td>
<td>41619.071</td>
<td>2.96</td>
<td>0.0464</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>2522794.729</td>
<td>210232.894</td>
<td>14.98</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>332588.518</td>
<td>110862.839</td>
<td>7.90</td>
<td>0.0013</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>134491.488</td>
<td>33622.872</td>
<td>2.40</td>
<td>0.0865</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>2522794.729</td>
<td>210232.894</td>
<td>14.98</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

LSMEAN

Sampling_Date Na LSMEAN Number
Appendix C: Statistical Analysis

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Na

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0012</td>
<td>0.0518</td>
<td>0.7216</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0012</td>
<td>0.2738</td>
<td>0.3307</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0518</td>
<td>0.2738</td>
<td>0.3307</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.7216</td>
<td>0.0110</td>
<td>0.3307</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Na

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0012</td>
<td>0.9424</td>
<td>0.8752</td>
<td>0.0618</td>
</tr>
<tr>
<td>2</td>
<td>0.4483</td>
<td>0.8658</td>
<td>0.9363</td>
<td>0.7042</td>
</tr>
<tr>
<td>3</td>
<td>0.9424</td>
<td>0.8658</td>
<td>0.9996</td>
<td>0.2233</td>
</tr>
<tr>
<td>4</td>
<td>0.8752</td>
<td>0.9363</td>
<td>0.9996</td>
<td>0.2994</td>
</tr>
<tr>
<td>5</td>
<td>0.0618</td>
<td>0.7042</td>
<td>0.2233</td>
<td>0.2994</td>
</tr>
</tbody>
</table>

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations: 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.
### Appendix C: Statistical Analysis

#### Source Table

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>I</td>
<td>1379023.57</td>
<td>459674.52</td>
<td>28.71</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>I</td>
<td>27402273.60</td>
<td>2283522.80</td>
<td>142.60</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>I</td>
<td>5652753.09</td>
<td>1413188.27</td>
<td>88.25</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>I</td>
<td>27402273.60</td>
<td>2283522.80</td>
<td>142.60</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

#### Source Table (III)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>III</td>
<td>1108454.15</td>
<td>369484.72</td>
<td>23.07</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>III</td>
<td>5652753.09</td>
<td>1413188.27</td>
<td>88.25</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>III</td>
<td>27402273.60</td>
<td>2283522.80</td>
<td>142.60</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

#### Least Squares Means

**Least Squares Means for effect Sampling_Date**  
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Mg LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2093.61000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1975.32000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2302.45000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1847.94000</td>
<td>4</td>
</tr>
</tbody>
</table>

**Least Squares Means for effect Station**  
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>Station</th>
<th>Mg LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2037.00000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2010.31250</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2623.62500</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2217.40000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>1385.81250</td>
<td>5</td>
</tr>
</tbody>
</table>

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017

---

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017

---

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017

---

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017

---

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017

---

The GLM Procedure  
Least Squares Means  
Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System  
18:34 Sunday, October 8, 2017
Appendix C: Statistical Analysis

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>21231355.17</td>
<td>1117439.75</td>
<td>231.34</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>91775.08</td>
<td>4830.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>21323130.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.995696
Coef Var: 4.781317
Root MSE: 69.50012
Fe Mean: 1453.577

The GLM Procedure

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>353337.03</td>
<td>119779.01</td>
<td>24.38</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>4543275.31</td>
<td>1135818.83</td>
<td>235.15</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>16334742.84</td>
<td>1361228.57</td>
<td>281.81</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Fe LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1330.45000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1422.99000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1515.58000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1568.23000</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0474</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0474</td>
<td>0.0472</td>
<td>0.0014</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>0.0472</td>
<td>0.3540</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&lt;.0001</td>
<td>0.0014</td>
<td>0.3540</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

<table>
<thead>
<tr>
<th>Station</th>
<th>Fe LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1241.42250</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1408.12500</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1956.25000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1647.73750</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>1043.03750</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0011</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0003</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>2</td>
<td>0.0011</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>4</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>5</td>
<td>0.0003</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

Dependent Variable: Li

Source | DF | Type I SS | Mean Square | F Value | Pr > F
---|---|---|---|---|---
Sampling_Date | 3 | 0.67685700 | 0.22561900 | 6.51 | 0.0033
Station | 4 | 3.95298271 | 0.98824568 | 28.49 | <.0001
Sampling_Date*Station | 12 | 15.72246369 | 1.31020531 | 37.78 | <.0001

Least Squares Means

The GLM Procedure

Adjustment for Multiple Comparisons: Tukey-Kramer
Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0066</td>
<td>0.0227</td>
<td>0.2054</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0066</td>
<td>0.8874</td>
<td>0.2984</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0227</td>
<td>0.8874</td>
<td>0.6676</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2054</td>
<td>0.2984</td>
<td>0.6676</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Li LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.28625000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.92662500</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.28225000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1.17750000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0.45750000</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Li

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0082</td>
<td>1.0000</td>
<td>0.7689</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0082</td>
<td>0.0090</td>
<td>0.0924</td>
<td>0.0012</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.0000</td>
<td>0.0090</td>
<td>0.7916</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.7689</td>
<td>0.0924</td>
<td>0.7916</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>&lt;.0001</td>
<td>0.0012</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

Dependent Variable: V

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>389.1924830</td>
<td>20.4838149</td>
<td>40.60</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>9.5865680</td>
<td>0.5045562</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>398.7990510</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square 0.975960  Coeff Var 6.247892  Root MSE 0.710321  V Mean 11.3697

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>181.5128801</td>
<td>60.5042934</td>
<td>119.92</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>77.9308922</td>
<td>19.4827231</td>
<td>38.61</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>129.7487107</td>
<td>10.8123926</td>
<td>21.43</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

**Least Squares Means for effect Sampling_Date**

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0003</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&lt;.0001</td>
<td>0.0041</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>0.0041</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable: V

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

**Least Squares Means for effect Station**

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9683</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.3203</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9683</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.6535</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.9166</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.9166</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.3203</td>
<td>0.6535</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable: V

The GLM Procedure
Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.
### Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>243.959309</td>
<td>12.8397858</td>
<td>7.69</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>31.731203</td>
<td>1.6700633</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>275.6871339</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.884901  
Coeff Var: 9.90828  
Root MSE: 1.292309  
Cr Mean: 13.04272

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>I</td>
<td>16.854694</td>
<td>5.6181565</td>
<td>3.36</td>
<td>0.0403</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>III</td>
<td>71.3278988</td>
<td>17.8319747</td>
<td>10.68</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td></td>
<td>147.3929543</td>
<td>12.2827462</td>
<td>7.35</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date  
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Cr

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5420</td>
<td>0.5827</td>
<td>0.5281</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5420</td>
<td>0.9992</td>
<td>0.0668</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5827</td>
<td>0.9992</td>
<td>0.0673</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.5281</td>
<td>0.0668</td>
<td>0.0673</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station  
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Cr

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6933</td>
<td>0.0009</td>
<td>0.8797</td>
<td>0.5729</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.6933</td>
<td>0.0150</td>
<td>0.9958</td>
<td>0.0862</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0009</td>
<td>0.0150</td>
<td>0.0068</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.8797</td>
<td>0.9958</td>
<td>0.0068</td>
<td>0.1625</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 49
### Appendix C: Statistical Analysis

5 0.5729 0.0862 <.0001 0.1625
The SAS System 18:34 Sunday, October 8, 2017 51

The GLM Procedure
Class Level Information
Class Levels Values
Sampling_Date 4 1 2 3 4
Station 5 1 2 3 4 5

Number of observations 40
NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure
Dependent Variable: Mn Mn

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>38.170892</td>
<td>12.723631</td>
<td>1.99</td>
<td>0.1496</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>295.616110</td>
<td>73.904027</td>
<td>11.56</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>1553.180014</td>
<td>129.431668</td>
<td>20.25</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>Mn LSMEAN</td>
</tr>
<tr>
<td>1</td>
<td>17.4878000</td>
</tr>
<tr>
<td>2</td>
<td>16.0870000</td>
</tr>
<tr>
<td>3</td>
<td>17.3597000</td>
</tr>
<tr>
<td>4</td>
<td>15.2171000</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j):

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6456</td>
<td>0.9995</td>
<td>0.2199</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.6456</td>
<td>0.7095</td>
<td>0.8824</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9995</td>
<td>0.7095</td>
<td>0.2632</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2199</td>
<td>0.8824</td>
<td>0.2632</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 54

The GLM Procedure
Least Squares Means
### Appendix C: Statistical Analysis

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Mn LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.1130000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>18.4185000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>19.2137500</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>17.5275000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>12.4167500</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1073</td>
<td>0.0308</td>
<td>0.3458</td>
<td>0.2985</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9684</td>
<td>0.6745</td>
<td>0.0006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9529</td>
<td>0.6745</td>
<td>0.0092</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0021</td>
<td>0.0006</td>
<td>0.0092</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Due to missing values, only 39 observations can be used in this analysis.

### The GLM Procedure

#### Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

#### Number of observations

40

#### Dependent Variable: Mn

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>289.4767362</td>
<td>11.0250914</td>
<td>4.27</td>
<td>0.0014</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>49.0986975</td>
<td>2.5841420</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>258.5754337</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### R-Square

0.810118

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>18.0696912</td>
<td>6.0232304</td>
<td>2.33</td>
<td>0.1067</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>56.9170730</td>
<td>14.2292683</td>
<td>5.51</td>
<td>0.0041</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>134.4899721</td>
<td>11.2074977</td>
<td>4.34</td>
<td>0.0023</td>
</tr>
</tbody>
</table>

#### Source

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>18.2529754</td>
<td>6.0843251</td>
<td>2.35</td>
<td>0.1042</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>134.1353421</td>
<td>13.7830353</td>
<td>5.33</td>
<td>0.0047</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>134.4899721</td>
<td>11.2074977</td>
<td>4.34</td>
<td>0.0023</td>
</tr>
</tbody>
</table>

NOTE: Due to missing values, only 39 observations can be used in this analysis.
Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Ni</th>
<th>LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.7868000</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12.0100000</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>11.0038000</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10.0195000</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Ni

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3904</td>
<td>0.9901</td>
<td>0.7129</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.3904</td>
<td>0.5534</td>
<td>0.0703</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.9901</td>
<td>0.5534</td>
<td>0.5327</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.7129</td>
<td>0.0703</td>
<td>0.5327</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Ni</th>
<th>LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.3288750</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10.5756250</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>12.7145000</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>11.8037500</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>10.3523750</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Ni

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5441</td>
<td>0.0038</td>
<td>0.0432</td>
<td>0.7511</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5441</td>
<td>0.0983</td>
<td>0.5579</td>
<td>0.9989</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0038</td>
<td>0.0983</td>
<td>0.7874</td>
<td>0.0798</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0432</td>
<td>0.5579</td>
<td>0.7874</td>
<td>0.4558</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.7511</td>
<td>0.9989</td>
<td>0.0798</td>
<td>0.4558</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure
Class Level Information

Class | Levels | Values |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure
Dependent Variable: Co  Co

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>4.71241444</td>
<td>0.24802181</td>
<td>9.65</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>0.48851900</td>
<td>0.02571153</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>5.20093344</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square  Coeff Var  Root MSE  Co Mean
## Appendix C: Statistical Analysis

### Source Table

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type</th>
<th>I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td></td>
<td>0.42176928</td>
<td>0.14058976</td>
<td>5.47</td>
<td>0.0070</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td></td>
<td>1.22506957</td>
<td>0.30626739</td>
<td>11.91</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td></td>
<td>3.06557559</td>
<td>0.25544663</td>
<td>9.94</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Source Table (Type III)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type</th>
<th>III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td></td>
<td>0.42187277</td>
<td>0.14062426</td>
<td>5.47</td>
<td>0.0070</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td></td>
<td>1.21108958</td>
<td>0.30279240</td>
<td>11.78</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td></td>
<td>3.06573595</td>
<td>0.25544663</td>
<td>9.94</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Least Squares Means

#### Sampling_Date

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Co LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.07640000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.14020000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.05370000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.31570000</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Station

<table>
<thead>
<tr>
<th>Station</th>
<th>Co LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.06150000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.09550000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.49350000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.08200000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0.00000000</td>
<td>5</td>
</tr>
</tbody>
</table>

### Least Squares Means for effect Sampling_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8308</td>
<td>0.9887</td>
<td>0.1255</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9887</td>
<td>0.6641</td>
<td>0.0084</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0167</td>
<td>0.1255</td>
<td>0.0084</td>
<td></td>
</tr>
</tbody>
</table>

### Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>Station</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9927</td>
<td>0.0003</td>
<td>0.9990</td>
<td>0.9485</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9927</td>
<td>0.0003</td>
<td>0.9998</td>
<td>0.7926</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0003</td>
<td>0.0007</td>
<td>0.0005</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.9990</td>
<td>0.9998</td>
<td>0.0005</td>
<td>0.8676</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9485</td>
<td>0.7926</td>
<td>0.0001</td>
<td>0.8676</td>
<td></td>
</tr>
</tbody>
</table>

---

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The GLM Procedure

Dependent Variable: Zn

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>88168.4780</td>
<td>4640.4462</td>
<td>1.17</td>
<td>0.3687</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>75435.4803</td>
<td>3970.2884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>163603.9583</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.538914
Coeff Var: 47.59707
Root MSE: 63.01022
Mean: 132.3826

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>4209.94949</td>
<td>1403.31650</td>
<td>0.35</td>
<td>0.7872</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>32294.14010</td>
<td>8073.53503</td>
<td>2.03</td>
<td>0.1303</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>51664.38845</td>
<td>4305.36570</td>
<td>1.08</td>
<td>0.4235</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>28409.23062</td>
<td>7102.30766</td>
<td>1.79</td>
<td>0.1728</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>32294.14010</td>
<td>8073.53503</td>
<td>2.03</td>
<td>0.1303</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>51664.38845</td>
<td>4305.36570</td>
<td>1.08</td>
<td>0.4235</td>
</tr>
</tbody>
</table>

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Zn LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>148.941000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>133.149000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>124.542000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>123.160000</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)

<table>
<thead>
<tr>
<th>1/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9496</td>
<td>0.8222</td>
<td>0.7972</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9496</td>
<td>0.9911</td>
<td>0.9863</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.8222</td>
<td>0.9911</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.7972</td>
<td>0.9863</td>
<td>1.0000</td>
<td></td>
</tr>
</tbody>
</table>

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Zn LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>170.130000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>153.472500</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>106.540000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>135.358750</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>96.739750</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Zn

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9832</td>
<td>0.2951</td>
<td>0.8025</td>
<td>0.2233</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.2951</td>
<td>0.5810</td>
<td>0.9772</td>
<td>0.4584</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.8025</td>
<td>0.9772</td>
<td>0.8877</td>
<td>0.7754</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2233</td>
<td>0.4584</td>
<td>0.9982</td>
<td>0.7754</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017

The GLM Procedure

Class Level Information

Class  Levels  Values
Sampling_Date  4  1  2  3  4
Station  5  1  2  3  4  5

Number of observations  40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The SAS System 18:34 Sunday, October 8, 2017

The GLM Procedure

Dependent Variable: As  As

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square  Coeff Var  Root MSE  As Mean
0.000000  0.0  0

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017

The GLM Procedure

Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>As LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Appendix C: Statistical Analysis

Dependent Variable: As

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>2</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>3</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>4</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 70

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station As LSMEAN Number</th>
<th>LSMEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMe(i)=LSMean(j)

Dependent Variable: As

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>2</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>3</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>4</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>5</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 71

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The SAS System 18:34 Sunday, October 8, 2017 72

The GLM Procedure

Dependent Variable: Sr Sr

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>9521.768429</td>
<td>501.145707</td>
<td>26.85</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>354.668344</td>
<td>18.666755</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>9876.436774</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square Coeff Var Root MSE Sr Mean
0.964089 13.87190 4.320504 31.14572

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>194.875742</td>
<td>64.958581</td>
<td>3.48</td>
<td>0.0363</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>2432.757589</td>
<td>608.189397</td>
<td>32.58</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>6894.135099</td>
<td>574.511258</td>
<td>30.78</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>
Appendix C: Statistical Analysis

Table: Source Analysis

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>143.122858</td>
<td>47.707619</td>
<td>2.56</td>
<td>0.0857</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>1889.318109</td>
<td>472.329527</td>
<td>25.30</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>6894.135099</td>
<td>574.511258</td>
<td>30.78</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Sr LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29.2990000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>31.3320000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>34.5945000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>31.4608000</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Sr

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7494</td>
<td>0.0577</td>
<td>0.6827</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.7494</td>
<td>0.3969</td>
<td>0.9999</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0577</td>
<td>0.3969</td>
<td>0.3906</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.6827</td>
<td>0.9999</td>
<td>0.3906</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Sr LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26.7837500</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>27.3835000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>43.5925000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>35.6587500</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>24.9393750</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Sr

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9986</td>
<td>&lt;.0001</td>
<td>0.0048</td>
<td>0.9259</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0088</td>
<td>0.5209</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0124</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0048</td>
<td>0.0088</td>
<td>0.0124</td>
<td>0.0014</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9259</td>
<td>0.8209</td>
<td>&lt;.0001</td>
<td>0.0014</td>
<td></td>
</tr>
</tbody>
</table>

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.
## Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>0.40132374</td>
<td>0.02112230</td>
<td>1.54</td>
<td>0.1757</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>0.25980800</td>
<td>0.01367411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>0.66113174</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **R-Square**: 0.607025
- **Coeff Var**: 36.94521
- **Root MSE**: 0.116936
- **Cd Mean**: 0.316513

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>0.19496072</td>
<td>0.06498691</td>
<td>4.75</td>
<td>0.0123</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>0.10711360</td>
<td>0.02697840</td>
<td>1.96</td>
<td>0.1421</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>0.09924942</td>
<td>0.00827079</td>
<td>0.60</td>
<td>0.8125</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>0.20310478</td>
<td>0.06770159</td>
<td>4.95</td>
<td>0.0105</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>0.09492031</td>
<td>0.02373008</td>
<td>1.74</td>
<td>0.1838</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>0.09924942</td>
<td>0.00827079</td>
<td>0.60</td>
<td>0.8125</td>
</tr>
</tbody>
</table>

The **GLM Procedure**

**Least Squares Means**

**Adjustment for Multiple Comparisons: Tukey-Kramer**

### Least Squares Means for effect Sampling_Date

<table>
<thead>
<tr>
<th>Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.24180000</td>
<td>0.24480000</td>
<td>0.41280000</td>
<td>0.35080000</td>
</tr>
</tbody>
</table>

**Pr > |t| for H0: LSMean(i)=LSMean(j)**

Dependent Variable: Cd

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9999</td>
<td>0.0193</td>
<td>0.1939</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9999</td>
<td>0.0298</td>
<td>0.2481</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0193</td>
<td>0.0298</td>
<td>0.6429</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1939</td>
<td>0.2481</td>
<td>0.6429</td>
<td></td>
</tr>
</tbody>
</table>

### Least Squares Means for effect Station

**Pr > |t| for H0: LSMean(i)=LSMean(j)**

Dependent Variable: Cd

<table>
<thead>
<tr>
<th>Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.26512500</td>
<td>0.25100000</td>
<td>0.38212500</td>
<td>0.31700000</td>
<td>0.34750000</td>
</tr>
</tbody>
</table>

The **GLM Procedure**

**Least Squares Means**

**Adjustment for Multiple Comparisons: Tukey-Kramer**

### Least Squares Means for effect Sampling_Date

<table>
<thead>
<tr>
<th>Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.9999</td>
<td>0.3028</td>
<td>0.8981</td>
<td>0.6778</td>
</tr>
<tr>
<td>2</td>
<td>0.9999</td>
<td>0.2069</td>
<td>0.7896</td>
<td>0.5411</td>
</tr>
<tr>
<td>3</td>
<td>0.3028</td>
<td>0.2069</td>
<td>0.7973</td>
<td>0.9795</td>
</tr>
</tbody>
</table>

The **SAS System** 18:34 Sunday, October 8, 2017 77
### Appendix C: Statistical Analysis

The SAS System 18:34 Sunday, October 8, 2017 79

The GLM Procedure

Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations 40

NOTE: Due to missing values, only 39 observations can be used in this analysis.

The SAS System 18:34 Sunday, October 8, 2017 80

The GLM Procedure

#### Dependent Variable: Ba Ba

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>7509.320847</td>
<td>395.227413</td>
<td>80.66</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>93.100450</td>
<td>4.900024</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>7602.421297</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.987754  Coeff Var: 6.679592  Root MSE: 2.213600  Ba Mean: 33.13974

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>1828.493749</td>
<td>609.497916</td>
<td>124.39</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>1960.283061</td>
<td>490.070765</td>
<td>100.01</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>3720.544037</td>
<td>310.045336</td>
<td>63.27</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>1908.052679</td>
<td>636.017560</td>
<td>129.80</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>1865.247614</td>
<td>466.311904</td>
<td>95.17</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>3720.544037</td>
<td>310.045336</td>
<td>63.27</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

The GLM Procedure

Least Squares Means

**Adjustment for Multiple Comparisons: Tukey-Kramer**

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>LSMEAN Ba LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.7770000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>36.6350000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>43.2930000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>38.2340000</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date

Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Ba

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

The SAS System 18:34 Sunday, October 8, 2017 81

The GLM Procedure

The GLM Procedure

The GLM Procedure

The GLM Procedure
### Appendix C: Statistical Analysis

#### Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Ba LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29.0150000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>27.8762500</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>46.8775000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>31.8850000</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>33.0200000</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station

| Pr > |t| for H0: LSMean(i)=LSMean(j) |
|------|-----------------------------|
| Dependent Variable: Ba |

<table>
<thead>
<tr>
<th>i/j</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8390</td>
<td>&lt;.0001</td>
<td>0.1116</td>
<td>0.0216</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.8390</td>
<td>&lt;.0001</td>
<td>0.0138</td>
<td>0.0026</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1116</td>
<td>0.0138</td>
<td>&lt;.0001</td>
<td>0.8666</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0216</td>
<td>0.0026</td>
<td>&lt;.0001</td>
<td>0.8666</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Due to missing values, only 39 observations can be used in this analysis.

---

The GLM Procedure

#### Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Station</td>
<td>5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Number of observations: 40

---

The GLM Procedure

#### Dependent Variable: Pb

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>19</td>
<td>172.8626412</td>
<td>9.0559285</td>
<td>7.47</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>23.0411820</td>
<td>1.2126938</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>38</td>
<td>195.1038232</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.881903

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>39.568763</td>
<td>13.1895878</td>
<td>10.88</td>
<td>0.0002</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>24.305939</td>
<td>6.0764849</td>
<td>5.01</td>
<td>0.0063</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>108.187938</td>
<td>9.0156615</td>
<td>7.43</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling_Date</td>
<td>3</td>
<td>43.0242452</td>
<td>14.341451</td>
<td>11.83</td>
<td>0.0001</td>
</tr>
<tr>
<td>Station</td>
<td>4</td>
<td>25.6547376</td>
<td>6.4136844</td>
<td>5.29</td>
<td>0.0049</td>
</tr>
<tr>
<td>Sampling_Date*Station</td>
<td>12</td>
<td>108.187938</td>
<td>9.0156615</td>
<td>7.43</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

---

The GLM Procedure

Least Squares Means

Adjustment for Multiple Comparisons: Tukey-Kramer

---

The SAS System 18:34 Sunday, October 8, 2017
Appendix C: Statistical Analysis

<table>
<thead>
<tr>
<th>Sampling_Date</th>
<th>Pb LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65810000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.98340000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2.54420000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.63150000</td>
<td>4</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Sampling_Date
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Pb

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

<table>
<thead>
<tr>
<th>Station</th>
<th>Pb LSMEAN</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.47962500</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.60675000</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.84037500</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.21537500</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>2.37937500</td>
<td>5</td>
</tr>
</tbody>
</table>

Least Squares Means for effect Station
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Pb