QUANTIFICATION AND CHARACTERIZATION OF PARTICULATE MATTER GENERATED FROM UNPAVED ROADS IN THE OIL DEVELOPMENT AREA OF WESTERN NORTH DAKOTA

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Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Western North Dakota, USA is experiencing particulate matter (PM) emissions, especially coarse (PM_{10}) and fine ($PM_{2.5}$), due to heavy traffic on unpaved roads from rapid oil development. Particulate matters may affect human and animal health, as well as soil quality. Thus, the purpose of this research was to quantify and characterize PM. Particulate matter samples were collected using miniVOL™ portable air samplers in the pre-conditioned quartz filters which were characterized using Scanning Electron Microscopy (SEM), Electron Dispersive Spectrometry (EDS). The pooled average PM_{10} concentrations varied between 30.84 ± 14.19 to 70.42 ± 38.37 µg/m^3 and $PM_{2.5}$ concentrations varied between 14.08 ± 6.56 µg/m^3 to 19.60 ± 7.51 µg/m^3. SEM and EDS analysis revealed that most of the particulates were quartz (46%), followed by silicates (36%), biogenic particles (9%), etc. Soil analysis revealed that the average concentrations of most of the metals were below the reference level except mercury and lead.

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DEDICATION

This thesis is dedicated to my parents and my wife

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LIST OF ABBREVIATIONS

PM..Particulate matter.

USEPA...United States Environmental Protection Agency.

PM_{10}..Particles with less than or equal to 10 μm diameter.

$PM_{2.5}$...Particles with less than 2.5 μm diameter.

TSP..Total Suspended Particulate.

NAAQS...National Ambient Air Quality Standards

USGS ....United States Geological Survey.

LIST OF APPENDIX TABLES

1. INTRODUCTION

North Dakota's oil production topped 1.1 million barrels per day in March, 2016 whereas this number was only 360 thousand barrels per day only five years ago in March, 2011. There are currently about 1600 oil wells active in North Dakota and 26 active drill rigs whereas there were 1271 active oil wells and 200 active drilling rigs in 2011 (Figure 1) (DMR, 2016) (USEIA, 2016). This significant increase in oil production has concurrently led an increase in oil rig activities and road traffic causing noticeable growth of airborne particulate matter in Western North Dakota. An oil well requires over 2,000 truck trips (1 truck carries 5460 gallons of oil) in its lifetime and these are driven mostly over unpaved roads in North Dakota (Dobb, 2013). This unpaved road traffic is a prime source of particulate matter (PM) which includes dust and has been recognized as criteria air pollutant due to its adverse impact on the environment and health (Mao et al., 2013).

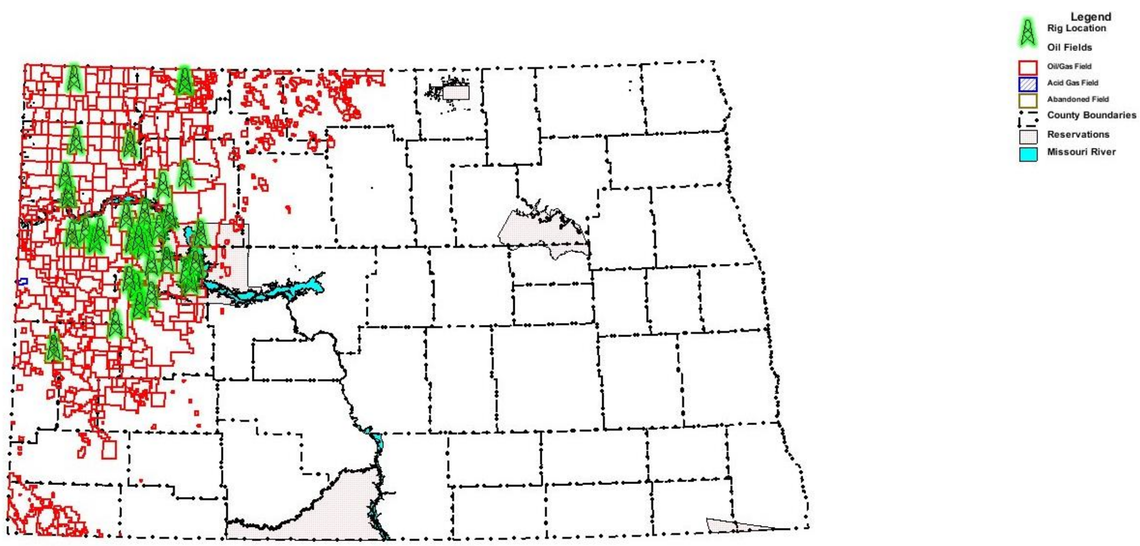


Figure 1. Oil fields and oil rigs locations in North Dakota (Source: www.dmr.gov.nd)

Particulate matter or dust particles can be of different types i.e., mineral dusts, metallic dusts, chemical dusts, organic and vegetable dusts, volcanic dusts, atmospheric dusts, cosmic dusts, etc. (IUPAC, 1990). Atmospheric or wind borne dust, also known as aeolian dust, comes from arid and dry regions where high velocity winds are able to remove mostly silt-sized material, deflating susceptible surfaces. This includes areas where grazing, ploughing, vehicle use, and other human activities have further destabilized the land, though not all source areas have been largely affected by anthropogenic impacts (Middleton & Goudie, 2001).

Particulate matter constitutes a major class of air pollution and can be divided into two groups on basis of inhalable concern: fine particles ($PM_{2.5}$) and coarse particles (PM_{10}). $PM_{2.5}$ results from fuel combustion from motor vehicles and power generation, while coarse particles (PM_{10}) are generally emitted due to vehicle traffic on unpaved roads, and materials handling, and as well as windblown dust. Inhalable PM includes both fine and coarse particles. Small particulates ($PM_{2.5}$) can be inhaled, resulting in respiratory diseases and often premature death (Donham & Thelin, 2004; Gonzales et al., 2011; Pattey & Qiu, 2012; Samet & Krewski, 2007). $PM_{2.5}$ from road surfaces is a significant source of air pollution (Gunawardana et al., 2012). These particles can enter and be deposited in the respiratory system and are associated with numerous health effects. Exposure to PM_{10} is primarily associated with the aggravation of respiratory conditions, such as asthma. In addition to health problems, PM is the major cause of reduced visibility, thus the safety concern. Dust may contain heavy metals and may be toxic to human, crop or animal health when their concentrations exceed certain thresholds (Guney et al., 2010). The amount of dust emissions from an unpaved road is dependent on amount of traffic, vehicle type, weight and speed of vehicle, wind speed and condition of the road (Mao et al., 2013).

Particulate matter can have both physical and chemical impacts on the vegetation grown alongside unpaved roads. Dust can physically block stomata of plants and chemical characteristics of dust may affect either soil or plants (Farmer, 1993). Dust cover on leaf surfaces may affect yield in a variety of ways, with the yield reduction depending upon the thickness of cover and to an extent, the type of plant (McCrea, 1984). The effect is likely to be greater on plants with young leaves as these retain a greater amount of dust, even after a moderate rainfall. Similarly, dust may carry and cause plant disease and increased pest infestation (Organic Life, 2015). Additionally, dust may also cause depressed appetite in livestock, which may result in a retarded growth rate of around 20% for each day the animal is kept on the contaminated pasture (McCrea, 1984). Long term exposure to dust or particulate matter to agricultural worker is likely to result in mild to chronic respiratory illness (Pattey & Qiu, 2012). It is reasonable to postulate that oil field workers, truck drivers, and local residents may exhibit some respiratory symptoms. Therefore, it is important to quantify dust emission rates resulting from unpaved road traffic in oil development area to assist in the development of techniques or technologies to control dust from the source.

It is also beneficial to know the chemical composition and morphology of particles. This gives a better understanding about the origin of particles whether it is of anthropogenic or natural sources. Particulate matter deposited on soil by transportation by the wind or some other medium can be detrimental to health, thus negatively impacting soil quality in that region. Thus, it is necessary to quantify dust emissions and adapt appropriate technology to mitigate adverse environmental impacts. Keeping that in mind, the present work focused on to quantify diurnal dust emission due to vehicle traffic on an unpaved roads and their impact on soil health. The hypothesis of this study is that increased traffic activities in the oil development areas is likely to increase particulate matter emissions, thus may affect the soil quality.

The specific objectives of this study were:

1. To quantify PM_{10} and $PM_{2.5}$ concentrations in the atmosphere,

2. To quantify and characterize the mineral composition in the dust,
3. To quantify the impacts of dust on roadside soil and determine elemental composition of metals present in the soil.

2. LITERATURE REVIEW

2.1. Particulate matter

Particulate matter (PM) is a mixture of liquid and solid particles suspended in the air which is frequently used as a measurement of levels of atmospheric air pollution (Stanek et al., 2011). Some particles, such as dust, dirt, soot, or smoke, are large or dark enough for naked eyes to see while, others are so small that needs an electron microscope to be detected (USEPA, 2016). Dust is fine particulate matter removed from land surfaces by wind erosion and small enough to be suspended in atmosphere (Toy & Foster, 2002). The size of these dust particles ranges from 1 to 100 µm in diameter, and they settle slowly by gravity forces (IUPAC, 1990). In referring to a particle size of airborne dust, the term 'particle diameter' is not enough to describe the particle size as the geometric size of a particle does not explain how it behaves in its airborne state, rather 'particle aerodynamic diameter' is used. The particle aerodynamic diameter is the diameter of a hypothetical sphere with a density of 1000 kg/m^3 having the same terminal settling velocity in calm air as the particle in question, regardless of its geometric size, shape and true density. So, dust is characterized in size according to this aerodynamic diameter. Smaller particles tend to stay in the air for longer period of time and they can also travel farther. These particles may be inhaled into human respiratory tracts. Therefore, they pose a significant risk to human health if exposed to a higher concentration for a certain period of time. That's why PM is considered as one of the six criteria air pollutants by the United States Environmental Protection Agency (USEPA) (USEPA, 2015).

Many different terms are used to characterize the particles. Total Suspended Particulates (TSP) are the total airborne particles that are measured by a high volume sampler without a size-selective inlet and an aerodynamic diameter which varies from 10 to 45 µm (USDFR, 1999).

Particulate matter can be classified into different terms. The most basic classification is based on size (i.e., coarse, and fine particles) expressed as concentration values. PM_{10} are inhalable particles with an aerodynamic diameter that are generally 10 µm and smaller whereas, $PM_{2.5}$ are fine inhalable particles with an aerodynamic diameter below 2.5 µm (USEPA, 2015). USEPA continuously evaluates and revises the National Ambient Air Quality Standards (NAAQS) of PM_{10} and $PM_{2.5}$ as required by the Clean Air Act (USEPA, 2015). NAAQS specifies that the PM_{10} should not exceed 150 $\mu g/m^3$ for a period of 24 hours and $PM_{2.5}$ should not exceed 35 $\mu g/m^3$ for a 24-hour period. Geographic locations exceeding these standard values might pose concerns to the population living in that area by negatively impacting the public welfare. Figure 2 shows size comparisons for PM particles.

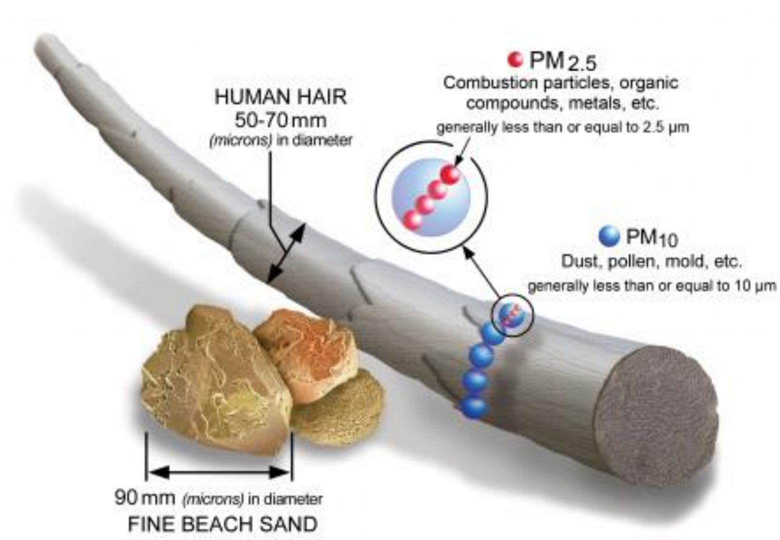


Figure 2. Size comparison of PM particles (USEPA, 2016)

Another classification of PM is based on the type of sources: primary and secondary particles. Primary particles result from various activities, such as: burning (smoke), dirt, road dust, industrial activities, spraying, and mold, pollen, etc. and then blown by the wind. Secondary particles are smaller than primary particles and these are usually formed through chemical transformation of gases (Guttikunda, 2008).

Numerous research studies have been carried out to quantify the particulate matter emission from different sources and its impacts on health. Thurston et al. (2011) conducted the first study in United States that used $PM_{2.5}$ composition data from USEPA chemical speculation network (CSN) and applied multivariate methods to identify and quantify the $PM_{2.5}$ by doing factor analysis. They identified PM sources, but, secondary aerosol constituents were not included in the source component identification factorization step. Their objective was to attribute the $PM_{2.5}$ mass and avoided secondary aerosol factors. There are many environmental and man-made factors that affect the amount of PM concentrations in atmosphere. Kuhn et al. (2005) sampled road dust from vehicles, particularly PM, on the front and back of a vehicle's tire and they found a positive relationship between PM emission factor and vehicle speed.

2.2. Sources of particulate matter

Particulate matter can be generated from various sources such as – natural sources, anthropogenic sources, etc. Natural sources primarily include the erosion of soil by the wind. General wind-entrained soil particles fall into two distinct size ranges: the coarser fraction is mainly quartz grains which tend to deposit close to the source and the clay particles which is <10 µm and can get transported further in the air. Airborne particles can also accumulate from the evaporation of droplets of sea water which leaves suspended salt crystals in the atmosphere (Gunawardana et al., 2012). Other natural sources include volcanoes, spores, and pollen. These primary natural sources contribute to a global particle production rate of 4900×10^6 ton/year (Colls & Tiwary, 2010).Other primary sources are biomass, wood,. and vegetative burning, vehicle emissions, secondary aerosols, etc.

Secondary aerosols are formed by photochemical, chemical and man-made processes and are known to be major constituents of fine particulate matter measured in most industrialized zones. All activities such as combustion, melting, grinding, crushing, ploughing or spraying produce particles; a variable portion of these will be fine enough to stay suspended in the atmosphere (Fuzzi et al., 2015). Oil combustion and diesel emissions from road transport are also major sources of PM emission. Particulate matter composition reveals high concentrations of elements including Al, Ca, Fe, Ti and Si classified as re-suspended road dust (Vallius et al., 2003), crustal dust (Koçak et al., 2009) or dust from construction activities. These can be interpreted as anthropogenic sources of PM which have a widespread impact on public health (WHO, 1999). Squizzato et al. (2016) quantified PM_1 (particles with aerodynamic diameter less than 1 µm) which provides better information on the anthropogenic fraction of PM pollution and found out 7 potential sources. Secondary inorganic aerosol (33%) and biomass burning (33%) were the major contributor followed by primary emissions, fossil fuel combustion, aged sulfate, road, traffic, and marine aerosols. Health impacts and environmental concerns are likely to depend on the PM sources and level of exposure.

2.3. Impacts of PM on environment

Particulate matter has various impacts on the environment. The emergence of air pollution as a public health issue in the 1950s led to the development of federally funded research programs which culminated into Clean Air Act and establishment of EPA in 1970. The mounting anecdotal evidence of PM's harmful effects on terrestrial and aquatic ecosystems launched acid rain as the first air pollution threat to the environment to receive international attention. Particulate matter also impairs vision which can lead to various dangers. Acid-forming aerosols have been found to limit the life expectancy of paints by causing discolorations, loss of gloss, and loss of thickness of the paint film layer. Various building stones and cement products are damaged from exposure to acid-forming aerosols (Riediker, 2007; Valavanidis et al., 2008).

These aerosols, when finally deposited in aquatic systems, cause deaths in aquatic life. The higher the light scattering efficiency, the less light from any given object reaches an observer's eyes, decreasing visibility. The light-scattering efficiency differs considerably for fine and coarse particles, ranging from 2.4 to 3.1 m^2/g for fine particles and 0.2 to 0.4 m^2/g for coarse particles. So, this widespread impacts of PM are negatively affecting the environment and our life regularly (Guney et al., 2010; Princeton; Samet & Krewski, 2007). However, the PM generated from vehicles in the oil development area of Western North Dakota are not well quantified and their impact on the health, soil and crops are not well documented.

2.4. Impacts of PM on health

Particulate matter is known to adversely affect human health by deep penetration into alveolar regions of lungs where it can diffuse into the circulatory system and accumulate in vital organs such as liver, brain, heart, etc. (Campbell et al., 2005). A limited number of epidemiologic studies have evaluated the linkages between $PM_{2.5}$ factors and health outcomes with a focus on mortality. PM sources i.e., crustal/soil/road dust have been linked directly to cardiovascular effects (Gong et al., 2003; Lanki et al., 2006). According to Valavanidis et al. (2008), fine particulate matter causes toxicity in human as they can penetrate deeper into the respiratory tract airways. Fine particulate matter ($PM_{2.5}$) exposure in the ambient air increases daily deaths and hospitalization for cardiovascular diseases (Schwartz et al., 2002) (Ballester et al., 2001). Kim et al. (2016) investigated the association between prenatal and postnatal exposure to PM_{10} and children's weight from birth to 60 months of age. It was determined that air pollution may delay growth in early childhood and exposure to air pollution may be more harmful to children when their birth weight is low. Volk et al. (2013) found that exposure to traffic-related air pollution, nitrogen dioxide, $PM_{2.5}$, and PM_{10} during pregnancy and during the first year of life was associated with autism. Further epidemiological and toxicological examinations of likely biological pathways will help determine whether these associations are causal.

These particles also promote the development of atherosclerosis (Künzli et al., 2005). It is estimated that an excess of 800,000 deaths each year may be attributed to particulate matter air pollution each year (WHO, 1999), secondary to myocardial infraction, life-threatening arrhythmias, or heart failure (Brook et al., 2004). Schwartz (1994) investigated the relationship between PM and hospital admissions for the elderly in Minneapolis-St. Paul, MN and collected data for persons who were 65 years or older for a period of 3 years (1986-1989). He looked for chronic obstructive pulmonary disease and for pneumonia. Time trends, weather, and seasonal fluctuations were three factors controlled by Poisson regression. PM_{10} and ozone were risk factors for pneumonia admissions and PM_{10} was solely responsible for obstructive pulmonary disease admissions. Hefflin et al. (1994) studied the effects of dust storms and respiratory diseases in southeast Washington State during October 1991. PM_{10} levels exceeded 1000 $\mu g/m^3$ which is about 6-7 times greater than the EPA standard for 24-hour value. Emergency room visits for bronchitis were slightly increased, estimated at 3.5% per 100 $\mu g/m^3$ increase in PM_{10}. Naturally occurring PM_{10} has a weaker effect on the respiratory health than PM_{10} that resulted from anthropogenic sources.

Particles of motor vehicle origin appear to be potent in increased mortality (Lanki et al., 2006; Schwartz et al., 2002). Microenvironments represented by vehicles produces a pathway for the air pollutants from mobile sources to expose to humans (Riediker, 2007). Less consistency was observed in associations between PM sources and respiratory health effects which may be due to a limited number of studies. But there is some evidence for associations with a $PM_{2.5}$

secondary sulfate factors. So, the negative impacts of PM on human health is significant enough to encourage further studies in the context.

2.5. Abatement technologies

Airborne particulate matter emissions can be minimized by pollution prevention and emission control measures. Prevention is more cost-effective than control. Approaches include management, choice of fuel, choice of technology and processes, fuel cleaning, use of natural shelter belts, buffers, etc. (Group, 1998). By improving combustion efficiency in vehicles, the amount of products of incomplete combustion, PM can be significantly reduced. PM can also be reduced by choosing cleaner fuels. Natural gas used as fuel emits much less particulate matter (WHO, 1999). Also, reduction of ash by fuel cleaning procedure can also reduce PM. Sedimentation is used for comparatively larger particles with an aerodynamic diameter more than 20 µm that works by regimenting the particles under gravity to a large volume chamber. For particles less than 20 µm aerodynamic diameter, a cyclone separator is used. These cyclone separators are cheap, reliable, straightforward devices used as pre-cleaners.

Apart from that, emission control technologies have existed for a long time. Inertial or impingement separators collects medium-size and coarse particles. Electrostatic precipitators' collection efficiency is over 99% and they effectively reduce dust loading (Moore, 1994). Fabric filters - baghouses are another option for control of PM emissions which can be used in industries (efficiency = 99.9% at 0.1 µm). Wet scrubbers rely on a liquid spray to remove dust particles from a gas stream. It is used where the contaminant cannot be removed easily in a dry form, soluble gases and wettable particles are present, and the contaminant will undergo some subsequent wet process. Krasowsky et al. (2015) quantified PM emission from in-use locomotives along with black carbon (BC), particle number, $PM_{2.5}$, and lung-deposited surface area (LDSA) and suggested LDSA as a potentially important health-relevant metric for near-source exposures.

There are numerous mitigation practices that are being practiced around the world. The objective of mitigation is to reduce dust on the roads as well as maintaining a viable application cost at all seasons. Cavanagh (2006) proposed the design of roadside vegetation having the potential to capture road generated air pollution but no design features like tree width, tree height, etc. were given in the study. In cases of road dust mitigation by chemicals, a study done by Schwindt (2013) revealed that magnesium chloride is most commonly used and the most cost-effective form of treatment. It effectively reduces dust but the dry conditions in summer reduces its efficiency. Calcium chloride has effectiveness similar to magnesium chloride, but it is costlier and its effectiveness depends on the dryness. Calcium chloride with polymers which is called 'Durablend' is also used for controlling dust. Wisp is a synthetic oil that provided slight dust reduction for a very short period of time. Rhino snot is an acrylic copolymer that increased the hardness of the road and provided limited amount of dust control. Coherex is a petroleum emulsion that provided veneer to the surface of the road controlling dust until the veneer started breaking up due to traffic. 'Durabond' is lignin with additives that provides a veneer to the surface of the road. Brine water (reject from oil extraction activities) which consists of 20% salt (primarily sodium chloride) is also used to control dusts, but its impacts to the environment, especially salinity, are not well documented. However, brine water is free and has a very low application cost. One visual study reveals that it is effective in reducing dust (Schwindt, 2013).

2.6. Chemical and soil analysis

In recent years, there has been significant emphasis on physical (size and morphology) and chemical (composition) characterization of individual atmospheric particles due to their effect on chemical properties which may impact human health, soil health, animal health and thus, the environment. Detailed characterization of individual particles provides useful information about their atmospheric history, sources, reactivity, formation, transport and removal of atmospheric chemical species (Adachi & Tainosho, 2004; Li et al., 2010; Sen-lin et al., 2006). Scanning Electron Microscopy (SEM) along with Energy Dispersive X-Ray Spectroscopy (EDS) is commonly used for single particle study which provides particle morphology, elemental composition, and particle density of aerosols (Shi et al., 2003). It also gives better understanding about the origin of particles whether it is anthropogenic or natural.

In a study conducted in Beijing, China, Sen-lin et al. (2006) characterized mineralogy of certain airborne particulate matter (PM_{10}) by SEM/EDX and identified 38 minerals. Clay minerals were leading in the composition (30.1%). Annual average of quartz, calcite, compound particulates, carbonates were 13.5%, 10.9%, 11.95%, 10.31%, respectively. Čabanova et al. (2012) collected samples near a crosswalk of a busy road and near the parking place, and did chemical and phase analysis on them. The samples were characterized by a combination of analytical and microscopic techniques. SEM/EDS were used for characterizing morphology and size of particles and a total carbon analyzer was used for carbon. Fourier Transform Infrared Spectroscopy and Raman micro-spectroscopy were used for determining phase composition of dust samples. Major compounds were quartz, calcium aluminum silicate, and crystalline carbon.

Gunawardana et al. (2012) collected samples from Gold Coast, Southeast Queensland, Australia from different land uses and backgrounds. They analyzed the mineralogy and morphology of dust samples which were collected using a dry and wet vacuuming system. Results showed that 60% of the samples were quartz, clay, albite, microcline, chlorite, and muscovite. It had 2% organic matter and 30% potential pollutants. This large ratio of pollutants can have significant impact on the atmospheric aerosol content.

Inductively coupled plasma-mass spectrometry (ICP-MS) is considered attractive and one of the most sensitive techniques for the multi-elemental analysis of trace metals in various environmental samples. This technique usually requires a transformation (extraction) of the samples into solution before analysis. Using ICP-MS apparatus, the detection limits for trace metals can be down to sub-ppt or picomol/L levels in simple matrix solutions (Ahmed et al.; Dolan et al., 1990). The chemistry of PM is important as the particles may carry heavy metal and elements that are fine enough, so that they get attached with aerosols and they may travel further (Farmer, 1993). Studies suggest that heavy metals may be concentrated within the first few meters from the road and their concentration sharply decreases with distance from the center of the road (Blok, 2005; Guney et al., 2010). If heavy metals are deposited on agricultural crops due to off-road traffic, it may impact crop productivity and soil quality as well as the quality of crop productivity. Therefore, it is critically important to monitor soil quality next to oil development area. However, limited information is available on dust quantification and characterization in the Western North Dakota, USA and their impact on soil health.

Todhunter and Cihacek (1999) investigated the historical frequency of airborne dust in the Red River Valley, USA, however, they did not quantify the PM in their study. They reported the number of airborne dust events in the Red River Valley from 1948 to 1994. Ljepoja (2015) conducted a limited dust sampling in the Western North Dakota, but didn’t factor in environmental parameters and vehicle traffic. It is important to consider weather conditions, road conditions, and vehicle traffic while quantifying dust emission. At the same time, suitable management practices are needed to minimize dust emission.

Also, Schwindt (2013) conducted a dust mitigation study with different types of suppressants, but this study was limited to observation, no real quantification was carried out. This is why it is necessary to quantify and characterize the PM emissions in the Western North Dakota to adapt suitable management practices to minimize health and environmental impacts.

3. MATERIALS AND METHODS

3.1. Study area

This study was conducted near the North Dakota State University Dickinson Research Extension Center Manning Ranch Headquarters (Latitude: 47°12' N, Longitude: 102° 50' W), located in Dunn County about 35 kilometers north of Dickinson and 5 kilometers west of Manning, North Dakota, USA (Figure 3) (Site 1 and 2). Site 1, at the first location, was approximately 7 kilometers away from site 2. Another test location (Site 3) (Latitude: 47°12'45.6"N, Longitude: 102°36'16.7"W) was about 35 kilometers north and 13 kilometers east of Dickinson, North Dakota (Figure 4). There were two separate locations and were several miles apart from each other. These sites were chosen to represent a virgin location of oil drilling (site #2) and an established oil pad (site #1) for dust quantification due to vehicle movement. Site 1 was next to a busy road (15^{th} St., ND-22 Highway), where several oil pads existed, road was periodically treated with magnesium chloride. In contrast, site 2 was chosen next to a new oil pad drilling area, with a newly constructed gravel road for that oil pad activities only. Additional dust samples were collected from a new location (Figure 4), where sections of road were treated with different dust suppressants (e.g., control, brine, magnesium chloride) and this site had a comparatively high traffic (14^{th} St., ND-22 Highway).

The soil in study area mainly consisted of silt loams (more than 20% sand, silt plus clay content between 70% and 87%). Occasional badlands and buttes are common characteristics of the topography of this area. Prairie grasses are natural in this area and cultivated lands support crops such as alfalfa *(Medicago sativa),* spring wheat *(Triticum aestivum),* sunflower *(Helianthus annuus).*

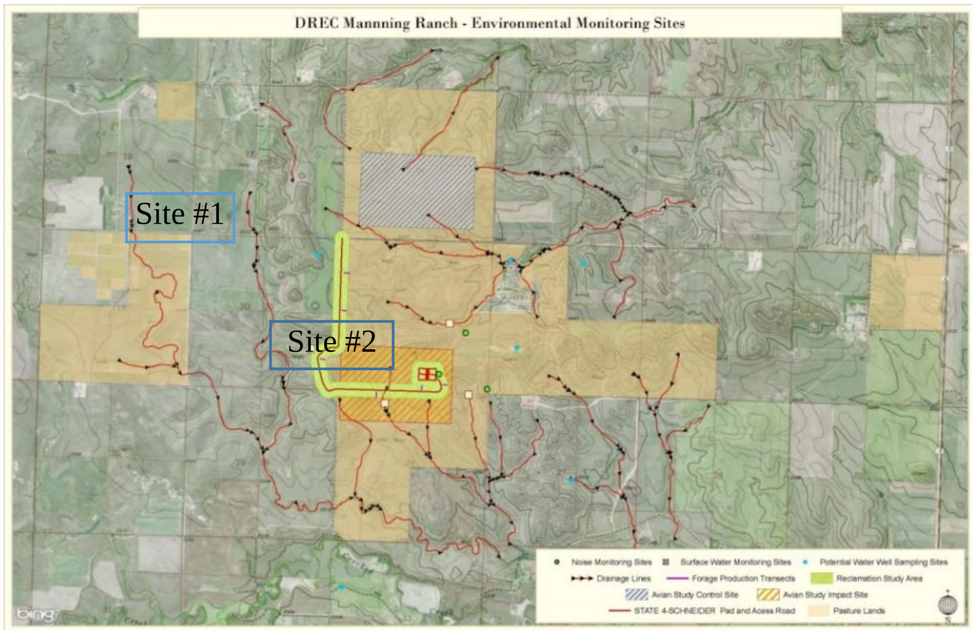


Figure 3. Sampling locations at Manning Ranch (Blue boxes) (Approximately within 5 kilometers west of Manning Ranch)

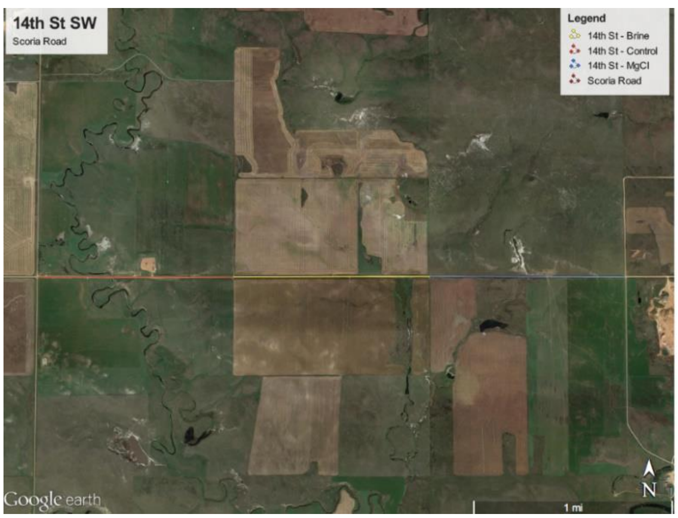


Figure 4. Map of the new sampling location (Red section is control with no additives, yellow section is brine-treated, blue section is magnesium chloride treated) (Approximately 15 kilometers east of Manning Ranch)

The weather profile for the study area is given in the following table (Table 1) (NDAWN, 2015). Average rainfall in this area is 423.8 mm (averaged over last 6 years) and during the study period the rainfall amount for year 2015 was lower than the normal range (416.56 mm). During sampling period in June, 2015, recorded rainfall was the highest (158.6 mm). Similarly, a strong wind pattern is also observed in the study area and average wind speed varies between 12.2 kmph to 13 kmph.

Table 1

Weather Profile near DREC Ranch near Manning, ND – North Dakota Agricultural Weather Network (NDAWN)

Year	Month	Average Air Temperature (°C)	Bare Soil Temperature (°C)	Average Wind Speed (kmph)	Maximum Wind Speed (kmph)	Total Rainfall (mm)
2015	April	6	7	15.1	39.6	13.0
2015	May	11	14	14.4	38.2	46.3
2015	June	18	21	10.4	37.4	158.6
2015	July	21	23	11.5	37.0	51.6
2015	August	11	22	9.0	32.4	59.5

3.2. Particulate matter sampling and calculation of PM concentration

In this study, soil sample, dust samples and weather data were collected during the study period and their collection procedure have been described below:

3.2.1. Airmetrics portable air sampler instrument

Dust samples were collected using EPA approved Airmetrics portable air samplers (Airmetrics, Springfield, OR, USA), which were lightweight, portable and battery operated. The sampler is equipped with particulate matter (PM) and total suspended particulate (TSP) heads. Depending on the type of impactor, $PM_{2.5}$ or PM_{10} samples can be collected (Figure 5). Airmetrics portable samplers were chosen due to low cost, portability, and flexibility (programmable capacity) that measure particulate matter: PM_{10} are particles that have aerodynamic diameter less than or equal to 10 micrometers (μm); $PM_{2.5}$ are particles that have aerodynamic diameter less than 2.5 micrometers (μm) and Total Suspended Particulates (TSP) are particles that have an aerodynamic diameter up to 45 micrometers (μm).

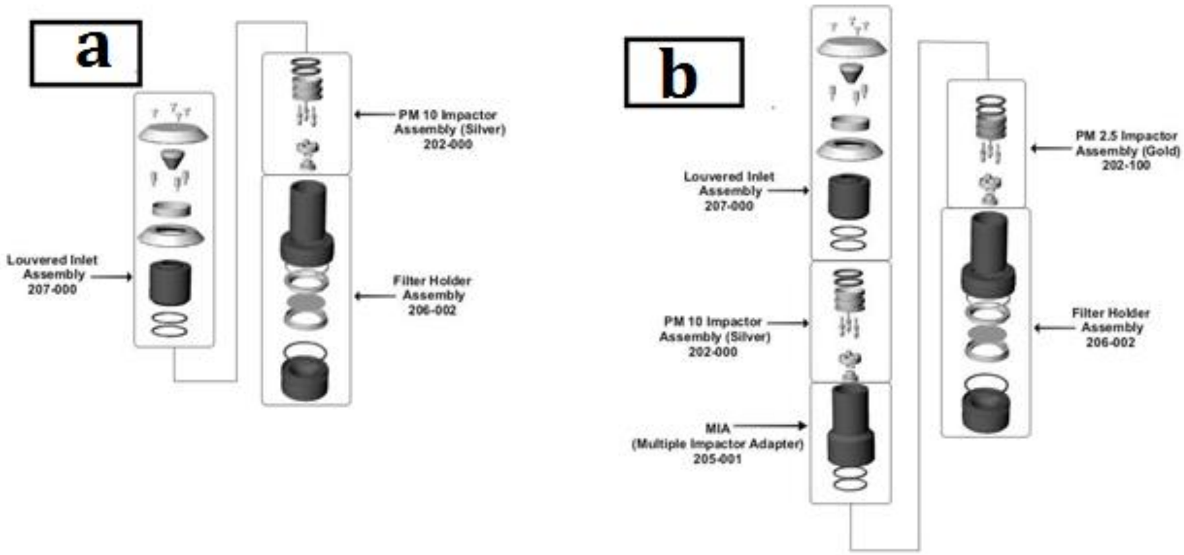


Figure 5. Schematic diagram and combination of impactor of the TAS (; a. exterior of sampler, b. interior of sampler, a. PM10 impactor assembly, b. PM2.5 impactor assembly (Airmetrics, Springfield, OR, USA) Photos taken from Airmetrics MiniVol™ TAS Manual – www.airmetrics.com)

Before deploying samplers, they were checked in the lab for any leakage by performing a single point flow check, and compared with the calibration curve that was established during the original calibration. The typical set air flow rate for the sampler is 0.005 ± (0.05 × 0.005) cubic meter per minute under ambient conditions. However, based on the ambient temperature and barometric pressure, actual rotameter set point was adjusted to operate at 0.005 m^3/min (5 liter/min) at actual condition. The sampler flow rate was set according to flow rate calculated as $Q_{ind} = l_{sp}$. This is given by the equation 1.

$$Q_{ind} = l_{sp} = \frac{5 \times \sqrt{\left[\frac{P_{std}}{P_{act}} \times \frac{T_{act}}{T_{std}}\right]} - b_{vol}}{m_{vol}} \qquad (1)$$

Where:

m_{vol}, b_{vol} = the sampler's calibration slope and intercept

Q_{ind} = Flow Rate (liters/min) = l_{sp}

P_{std} = standard atmospheric pressure, 760 mmHg

P_{act} = actual ambient pressure, mmHg

T_{std} = standard temperature, 298K

T_{act}= actual ambient temperature, K

For each sampler, separate Q_{ind} was calculated and set point flow rate was adjusted to achieve an actual flow rate of 0.005 m^3/min ± (0.05 × 0.005) m^3/min.

The sampler was mounted to a pole vertically as shown in Figure 6. After several samplings, the impactor was cleaned and greased for the next sampling.

Figure 6. MiniVol™ Portable Air Sampler in operation at site #1 (vertically mounted)

3.2.2. Filter preparation and conditioning, and setup

High purity fiber circular Whatman™ Millipore® 47mm quartz (SiO_2) (pore size = 2.2 µm) (Figure 7b) (GE Healthcare Bio-sciences, Pittsburgh, PA, USA) filters were used in this study for dust sampling. These quartz filters were used because they have high filtration rate, good trace level analysis, are heat resistant and useful for measuring diesel emissions. Before using them for dust sampling, filters were labelled with ultra-fine Sharpie® pen while wearing latex gloves and kept into petri-dishes (48 mm in diameter) and conditioned in an environmentally controlled room (relative humidity = 50.5 ± 0.2%, temperature = 22.6 ± 1.4 °C) at the Nanoscale Science and Engineering (CNSE) Research lab at NDSU. Conditioning was done for eliminating organic species and presence of semi-volatile materials. Pre- and post-sampling weight of filters were measured with a Sartorius CP2P microbalance (Sartorius Corporation, NY, USA) in an environmentally controlled room to determine particulate matter mass with a resolution of 1 μg (0.001 mg) (Figure 7a). To avoid static, a polonium bar at the back of the microbalance was used. During conditioning, filters were reweighted 2-3 times for consistent weight. The differences in weight after each measurement should not exceed 0.5% of the previous weight. After conditioning, filters were used within 7 days and protective holders were used during transportation. On the field, a cassette separator was used for insertion and removal of these filters to and from the cassette. After inserting the filter, pre-calculated actual flow rate was adjusted for the sampler and sampling was started.

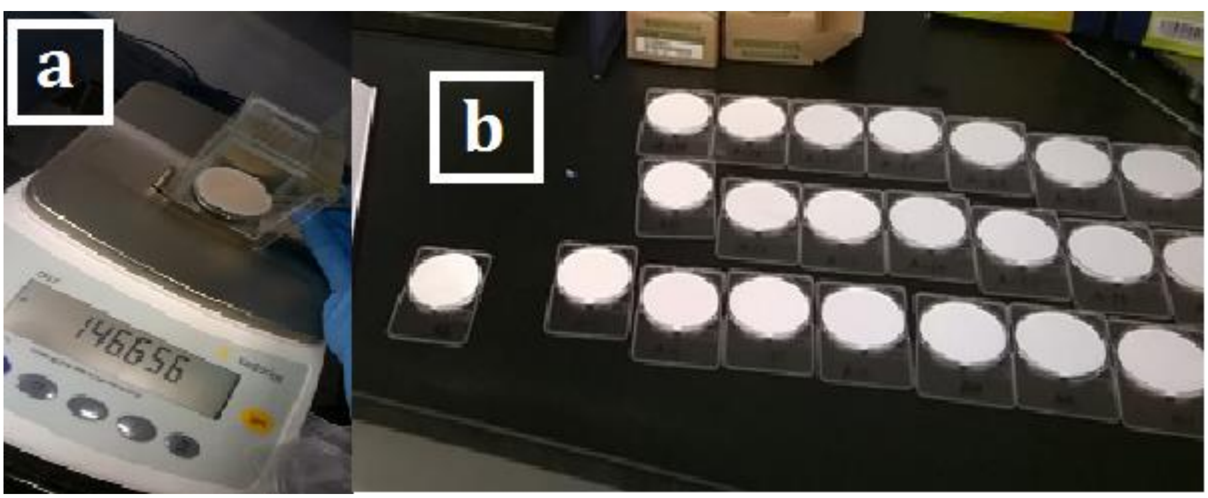


Figure 7. a. Sartorius CP2P Microbalance at CNSE Lab, NDSU; b. Millipore Quartz Filters while being conditioned.

3.2.3. Sampling setup

At each site, four air samplers were used and their deployment has been illustrated in Figure 8. For site #1 (Figure 8a), three samplers were set on the south side (downwind) (Ljepoja, 2015) of the road and one sampler was set on the north side. The north side of the road had PM_{10} only, whereas south side had two PM_{10} and one $PM_{2.5}$ configured samplers. The weather station was installed about 60 m away from the road on the south side. In site #2 (Figure 8b), same configuration was applied, but no weather station was installed, since both stations were only 5 kilometers apart. In the case of the additional new site (Figure 8c), TSP configured samplers were deployed on the both north and south side of the untreated section. For the brine treated section, the north side of the road had one TSP sampler and south side of the road had one TSP, one PM_{10} and one $PM_{2.5}$ sampler. However, for magnesium chloride treated section of the road, only TSP samplers were deployed on both sides.

Besides the dust sample, composite soil samples (mixture of three samples) were collected at site 2 at different distances (12 m, 30 m, 60 m, 90 m from the center of the road on both south and north side) using a 25.4 mm soil core sampler (inside the cutting tip, diameter = 19 mm). Each soil core was taken at a 150 mm depth. Before collecting the soil sample in sampler bags, vegetation and ground litter were removed to avoid contamination by plant materials. Then, the cores were stored in ziploc bags and labelled with a unique ID. The sampling was done on a monthly basis to see the impact of dust on soil quality.

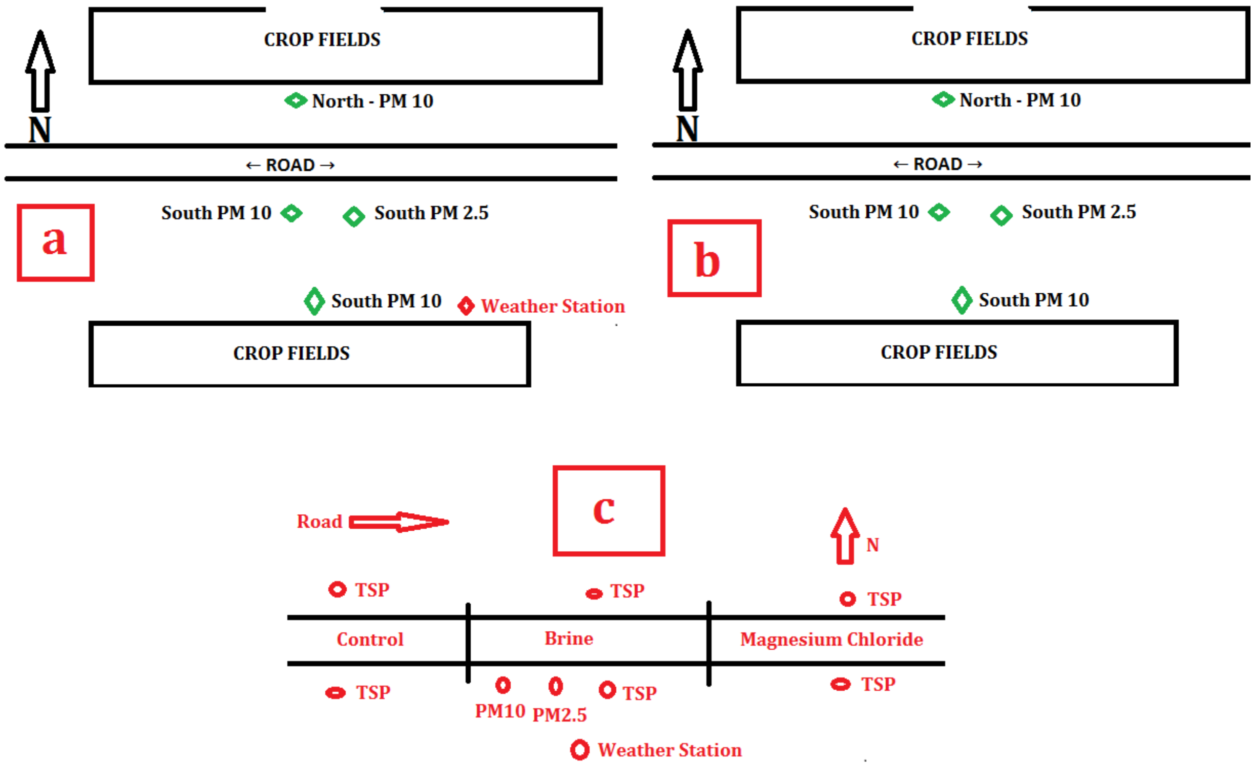


Figure 8. Experimental Setup of different locations: a. experimental setup at site #1; b. experimental design at site #2; c. experimental design at site 3

3.2.4. Meteorological data

In-situ meteorological data (e.g., temperature, relative humidity, pressure, wind speed, gust speed, and wind direction) were collected at site 1 using Hobo micro weather station data logger (H21-002) (Onset, Bourne, MA, USA) (Figure 9). Additionally, weather data was also downloaded from North Dakota Agricultural Weather Network (NDAWN) and National Weather Service (NWS) to correlate important factors with the dust emissions.

Figure 9. Onset Hobo Data Logger (H21-002) (Partially taken from Onset Website – www.onsetcomp.com)

3.2.5. Vehicle tracking

Two battery-operated Simmons Whitetail Cameras (119234C) (Simmons Outdoor Products, Overland Park, KS, USA) were used for tracking the number of vehicles passing through the study site (Figure 10). Camera was equipped with motion sensor and night vision (Infra-red) capabilities for capturing photos even during night time of a passing vehicle. These cameras were set up on the same pole as the air sampler in such a way that it would pick up both fast and slow moving objects efficiently. After each sampling, number of vehicles passed during the sampling period was counted and correlated with total dust emission during the sampling.

Figure 10. Simmons Camera (deployed in site #2)

3.2.6. Calculation

PM concentration of air sample taken with the MiniVol sampler was calculated as follows:

$$PM_{act} = \frac{M_{PM}}{V_{act}} \quad (2)$$

Where:

PM_{act} = actual PM concentration, µg/m^3 (actual condition)

M_{PM} = PM concentration, µg/m^3 (Standard condition)

V_{act} = Volume of air, m^3 (actual condition)

The volume of actual air passed through the filter during sampling period at actual ambient condition would be calculated as:

$$V_{act} = \frac{60_{min/hr} \times Q_{act} \times t_{hr}}{1000_{l/m^3}} \quad (3)$$

Where:

Q_{act} = Flow rate of the sampler, liters/min;

t_{hr} = Sampling period, hr

The flow rate through the sampler is:

$$Q_{act}=\left(m_{vol}\times Q_{ind}+b_{vol}\right)\times\sqrt{\left[\frac{P_{std}}{P_{act}}\times\frac{T_{act}}{T_{std}}\right]} \quad (4)$$

Where:

m_{vol}, b_{vol} = the sampler's calibration slope and intercept

Q_{ind} = Flow Rate (liters/min)

P_{std} = standard atmospheric pressure, 760 mmHg

P_{act} = actual ambient pressure, mmHg

T_{std} = standard temperature, 298K

T_{act}= actual ambient temperature, K

3.3. Sample analysis

After the quantification of dust amount, random filters were taken for Scanning Electron Microscope (SEM) analysis. At the same time, dust morphology and mineral identification were done by the Energy Dispersive X-Ray Spectroscopy (EDS) analysis. Both SEM and EDS analysis were done in Electron Microscopy Center, NDSU on a JEOL JSM-6490LV SEM (JEOL USA, Inc, MA, USA). For SEM analysis, four small rectangular sections were taken from each filter with a razor blade and attached to cylindrical aluminum mounts with a double-stick carbon adhesive tape (Ted Pella, Redding, CA, USA) (Figure 11). In this analysis, samples were not coated with carbon or gold because of the possibility of having biogenic organisms in the filters, because biogenic organisms are basically made of carbon and oxygen (C + O > 75% of the total molecular weight), which may bias the quantification. During EDS analysis, when the carbon was <10%, the carbon was excluded from 'quant spectrum' option. About 10-20 images were taken per sub-sample and when necessary, EDS was done on the image by picking up several points. The magnification level used for taking the images was x1500.

The magnification level and spot size was fixed according to particles countered in the filters. Energy-dispersive X-ray information was also collected using a Nanotrace EDS detector with a NORVAR light-element window and Noran System Six imaging system (ThermoFisher Scientific, Madison WI, USA) at an accelerating voltage of 15keV for the JSM-6490LV.

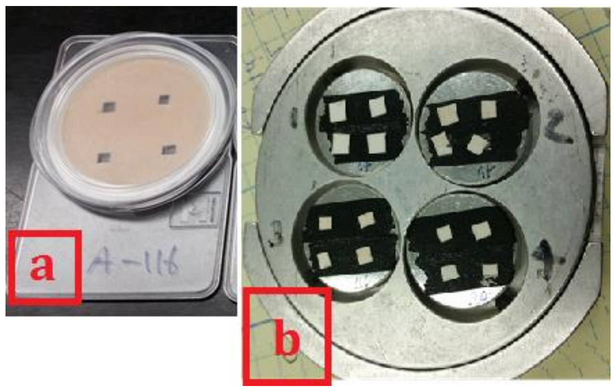
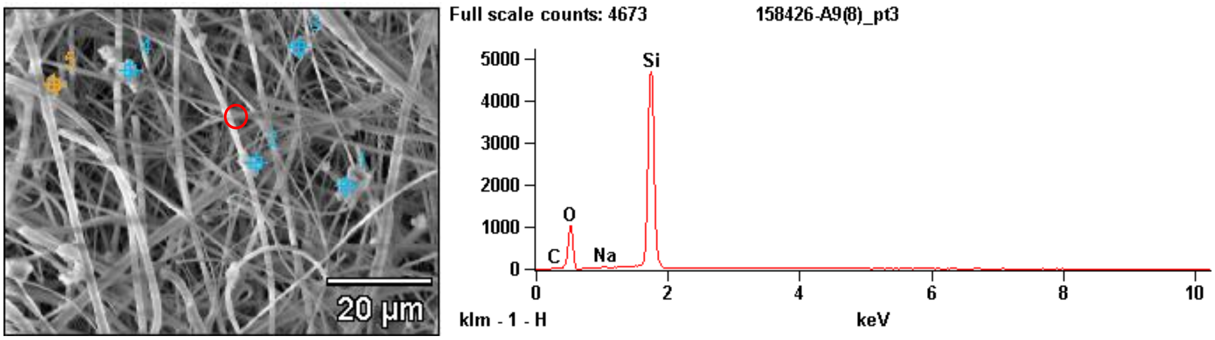


Figure 11. Sample Preparation for SEM analysis: a. small sections cut from filter; b. sections placed on carbon tape on cylindrical mounts

3.3.1. Identification of mineral phase from SEM results

Relative atomic weight percentages were taken from SEM results to calculate approximate empirical formulas. In ideal case, each coefficient for a crystallographic site will be a whole number, and will give accurate mineral formula. SEM/EDS outputs data as percentage weight of atoms or oxides present in the sample. These data together with the atomic mass of corresponding elements are used to calculate empirical formula of the mineral. The procedure is simple for pure phases and complex with phases with impurities and trace elements. Figure 12 shows a sample SEM image and EDS spectrum for quartz mineral, and the calculation procedure for identifying the mineral.

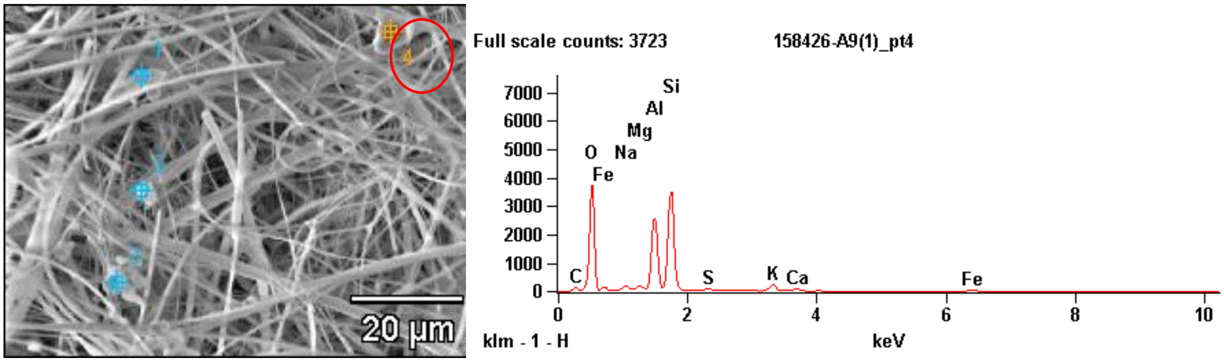


Elements	O	Si	Na	Notes
wt. %	53.06	46.40	0.54	Mineral: Quartz (SiO_2);
grams/mol	16.0	28.09	22.98	Major elements: O, Si; Trace elements: Na;
mols	3.32	1.65	0.02	Nearly Spherical particles;
Normalized mols	2	1	Negligible	Formula: 2 O, 1 Si

Figure 12. Calculation of possible mineral/phase group from SEM data (Quartz)

Reported weight percentages were divided by atomic mass to obtain number of moles normalized. this particular sample had the ratio of 1 mol Si and 2 mol O (and a trace amount of Na). So, it was determined to be quartz.

The procedure is similar for a complex mineral oxide weight as shown in Figure 13. In this case, molar mass of oxide is used instead of the atomic mass. In this case, the calculation is complex. If the number of moles could not be brought to a whole number, an approximate empirical formula is calculated. Morphology and knowledge in mineralogy and crystallography can be beneficial in this case for identification. Figure 13 shows the calculation for an aluminosilicate mineral phase. The mole numbers can’t be brought to whole numbers which could be due to the electron beam accuracy of SEM machine and fluorescence from silica filters.



Elements	O	Na	Mg	Al	Si	S	K	Ca	Fe	Notes
wt. %	47.58	1.18	0.61	15.63	26.55	0.70	3.01	1.42	3.31	Possible Mineral Phase: Aluminosilicates Major elements: O, Si, Al; Trace elements: Na, Mg, S, K, Ca, Fe; Nearly Spherical particles; Formula: 136 O, 2 Na, 1 Mg, 27 Al, 43 Si, 1 S, 4 K, 2 Ca, 3 Fe
grams/mol	16.0	22.98	24.3	26.98	28.09	32.06	39.09	40.07	55.86	
mols	2.97	0.05	0.025	0.58	0.94	0.02	0.078	0.035	0.059	
Normalized mols	136	2	1	27	43	1	4	2	3	

Figure 13. Calculating possible complex mineral formulas from SEM data (Aluminosilicates)

3.4. Soil analysis

After collecting the soil cores from site 2, soil samples were air dried for at least 72 hours before processing and unique ID was given to each sample. The soil was hand crushed to pass through a 2 mm sieve and plants residues and rock fragments were removed. Then, a 10 g subsample of soil was taken from the bulk samples for ball-milling. The soil subsamples were milled to pass through a No. 80 (80-mesh opening=180 µm). Then, the prepared samples were analyzed using Inductively coupled plasma mass spectrometry (ICP-MS) at Activation Laboratories Ltd (Ancaster, ON, Canada) using the Ultratrace 2 method (aqua regia digest).

3.5. Statistical analysis

Statistical analysis was done using SAS 9.4 software to predict particulate matter concentration by PROC STEPWISE statement with Forward Selection Method (FSM). PROC CORR was also used to determine the correlation between independent and dependent variables. The independent variables were temperature, pressure, vehicle count, rainfall, wind speed, and wind direction. This PROC STEPWISE statement chooses the best model and provides an equation with maximized r^2 value.

4. RESULTS AND DISCUSSION

4.1. Particulate matter concentrations

Particulate matter (PM) is one of the Ambient Air Quality Standards (AAQSs) pollutants and constitute a major class of air pollution (Cooper & Alley, 2002). Figure 14 shows the average PM concentrations (PM_{10} and $PM_{2.5}$) measured at site 1 over two years with respect to the number of vehicles and the amount of rainfall during the corresponding sampling dates, while, figure 15 shows an example of PM concentrations exceeding NAAQS values on June 28-30, 2016 with respect to the sampling locations (i.e., north or south side, corresponding distances from the center of the roads). Figure 16 shows the yearly average PM concentrations (PM_{10} and $PM_{2.5}$). Table 2 shows the stepwise regression analysis of PM at site 1.

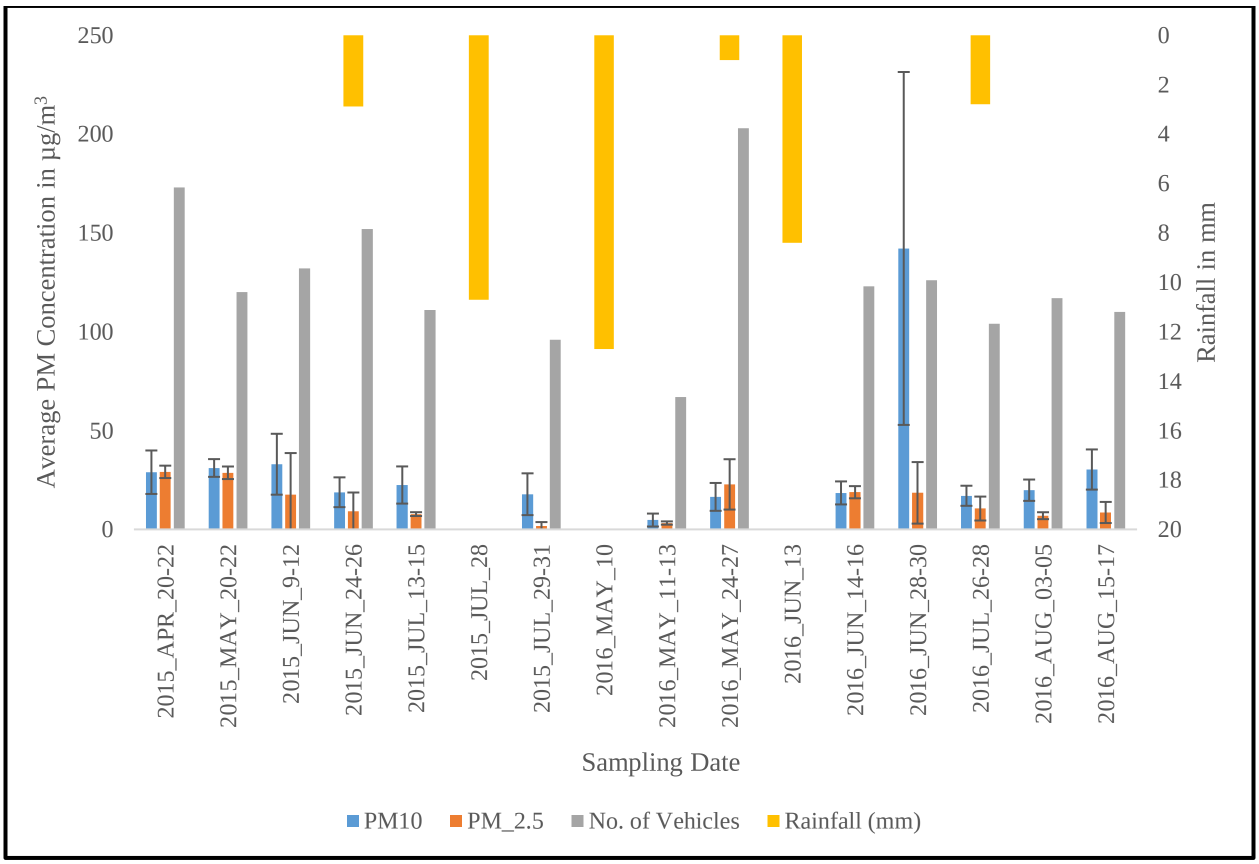


Figure 14. Average PM concentrations with respect to traffic and rainfall at site 1.

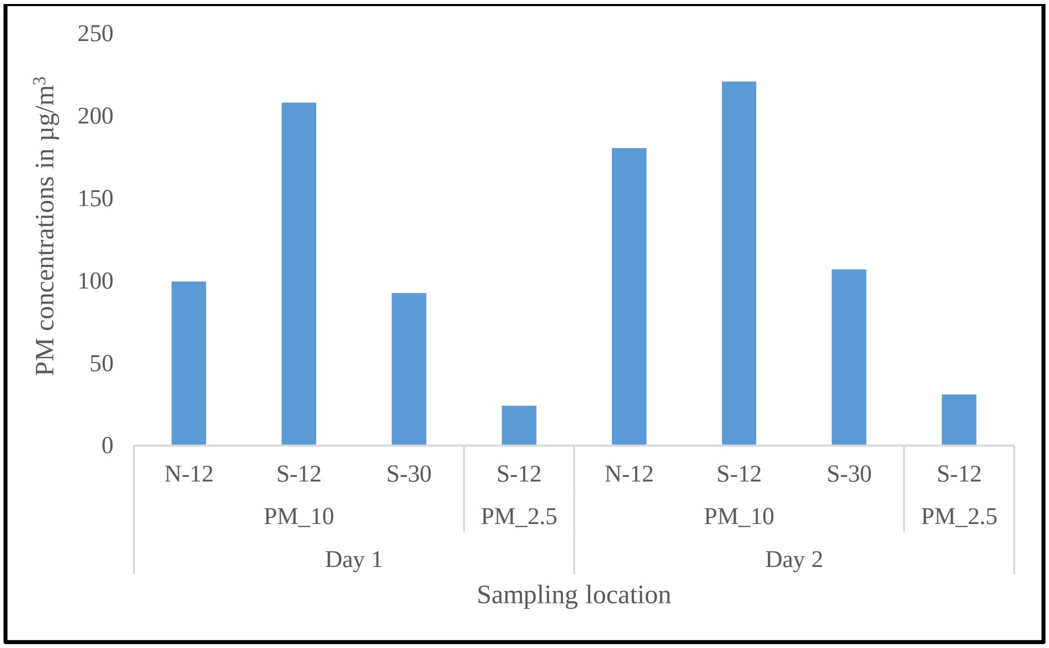


Figure 15. Average PM concentrations on June 28-30, 2016 exceeding NAAQS value with respect to sampling locations at site 1 (N-12 refers to north side sampler at 12 m distance from the center of the road).

Figure 16. Yearly average PM concentrations at site 1.

Table 2

Stepwise regression analysis results of PM concentrations at site 1

Particulate matter type	Year of sampling	Stepwise regression model equations
PM_{10}	2015 & 2016 combined	No variables were statistically significant
	2015	PM_{10} = 28.516 – 79. 55 × rainfall_in_mm *(r^2 = 0.07)*
	2016	PM_{10} = 46.978 + 1.4615 × vehicle_count – 32.2796 × wind_speed – 0.37429 × wind_direction -51.06820 × rainfall_in_mm *(r^2 = 0.30)*
$PM_{2.5}$	2015 & 2016 combined	$PM_{2.5}$ = -0.75421 + 0.19184 × vehicle_count *(r^2 = 0.16)*
	2015	$PM_{2.5}$ = 0.98252 + 0.02480 × wind_direction + 63.485 × rainfall_in_mm *(r^2 = 0.51)*
	2016	$PM_{2.5}$ = -11.33165 + 0.43686 × vehicle_count *(r^2 = 0.38)*

Notes: All variables here are significant at 0.15 level (p=0.15), r^2 values reported are model r^2 values.

However, based on 24-hour sampling period, the PM_{10} concentration value ranged from 7.55 µg/m^3 to 60.5 µg/m^3 in 2015 and from 0.79 µg/m^3 to 261.45 µg/m^3 in 2016. Similarly, the $PM_{2.5}$ concentration value ranged from 0.34 µg/m^3 to 15.85 µg/m^3 in 2015 and from 2.63 µg/m^3 to 37.00 µg/m^3 in 2016. Figure 16 shows the average PM_{10} concentrations in 2015 and 2016 were 25.33 ± 9.74 µg/m^3 and 35.56 ± 20.25 µg/m^3, respectively; and the average $PM_{2.5}$ concentrations in 2015 and 2016 were 15.64 ± 6.65 µg/m^3 and 20.25 ± 6.48 µg/m^3, respectively. Most of the time, the PM_{10} concentration was below the NAAQS value (150 µg/m^3). However, during June 28-30, 2016 sampling (figure 15), the average PM_{10} concentration was 142.14 ± 89.28 µg/m^3 which exceeded the NAAQS threshold values. This may be attributed to the gravel road construction and ongoing well pad construction near site 1 (15th St). The average PM concentrations for 2016 were slightly higher than that of 2015 which might be due to drier weather and road construction/leveling activities. In site 1, $PM_{2.5}$ concentration value exceeded (37 μg/m^3) NAAQS reference value for $PM_{2.5}$ (35 μg/m^3 for 24-hour sampling period) for one instance (June 28-30, 2016) during the sampling time. Except for one or two incidents, the PM concentrations were below the NAAQS reference value despite of having high traffic.

PM emissions from a road likely depends on road conditions (dry vs. wet, treated vs. un-treated), the number of vehicles, and weather conditions (precipitation, calm vs. windy), etc. The lower PM concentration in site #1 during June 24-26, 2015 was likely due to road treatment. The road (15^{th} St) adjacent to site 1 was periodically treated with dust suppressants i.e., magnesium chloride. Besides, there was 2.88 mm of rainfall during that sampling period, which might also contribute to lower PM emissions. There was a significant drop in PM emissions during May 11-13, 2016, which may be attributed to freezing and thawing effect as well as lower traffic activities.

A stepwise regression analysis was conducted to find out the impact of different variables on PM emission. Statistical analysis revealed that, in 2015 sampling, the rainfall was poorly correlated (r^2=0.07) with PM_{10} concentrations; but, the combination of rainfall and wind direction had a better relationship (r^2=0.51) in case of $PM_{2.5}$ concentration emission at a significance level of p=0.15. In 2016, PM_{10} concentrations were moderately correlated (r^2 = 0.30) with vehicle passing by, wind speed, wind direction, and rainfall. A similar or equally better correlation (r^2 = 0.39) was observed for the $PM_{2.5}$ concentrations.

Figure 17 shows the average PM concentrations (PM_{10} and $PM_{2.5}$) measured at site 2 with respect to the number of vehicles and the amount of rainfall during the corresponding sampling dates. Figure 18 shows an example sampling date (May 20-22, 2015) when the measured PM concentration exceeded the NAAQS values at site 2 and figure 19 shows the yearly average PM concentration at site 2. Table 3 shows the stepwise regression analysis of PM at site 2.

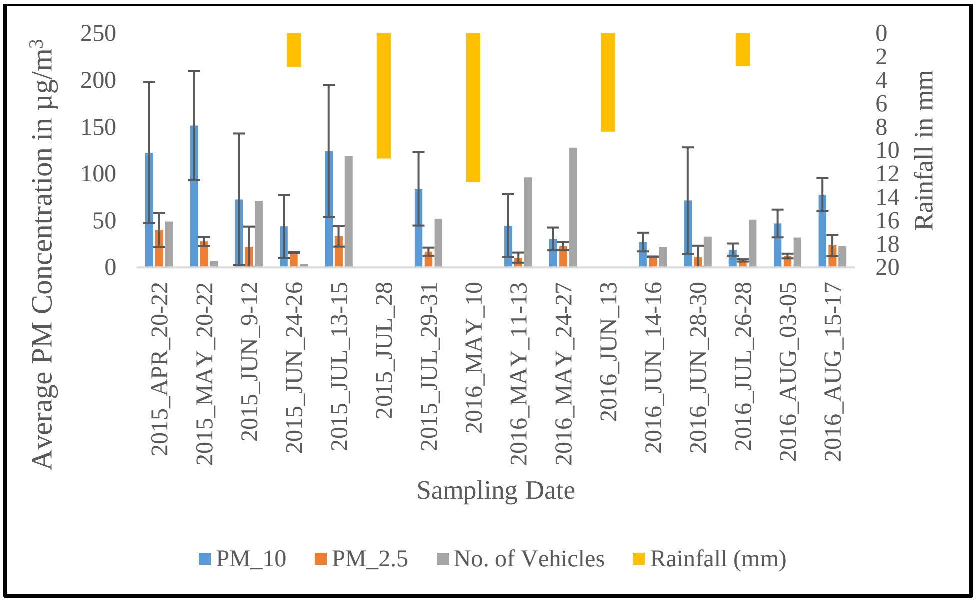


Figure 17. Average PM concentrations with respect to traffic and rainfall at site 2.

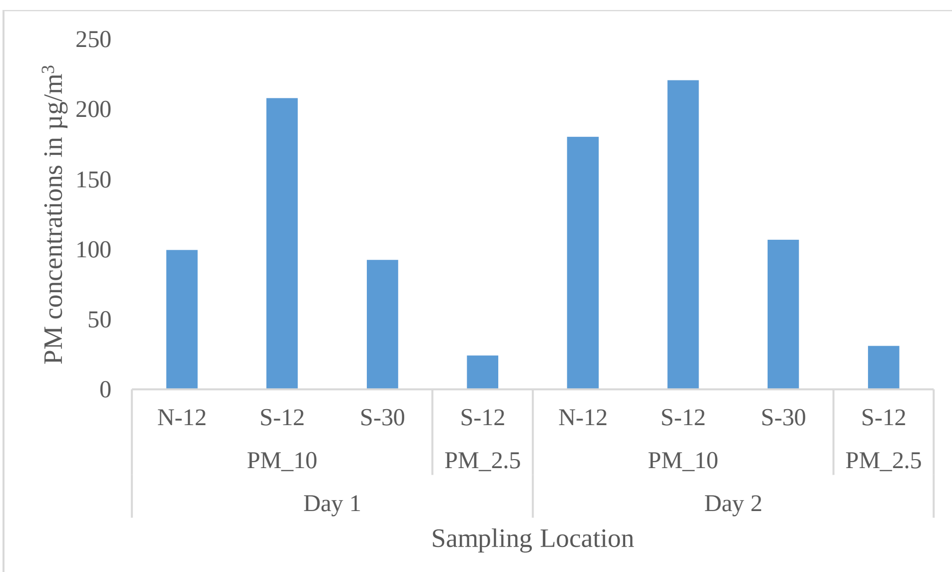


Figure 18. Average PM concentrations on May 20-22, 2015 exceeding NAAQS value with respect to sampling locations at site 2 (N-12 refers to north side sampler at 12 m distance from the center of the road).

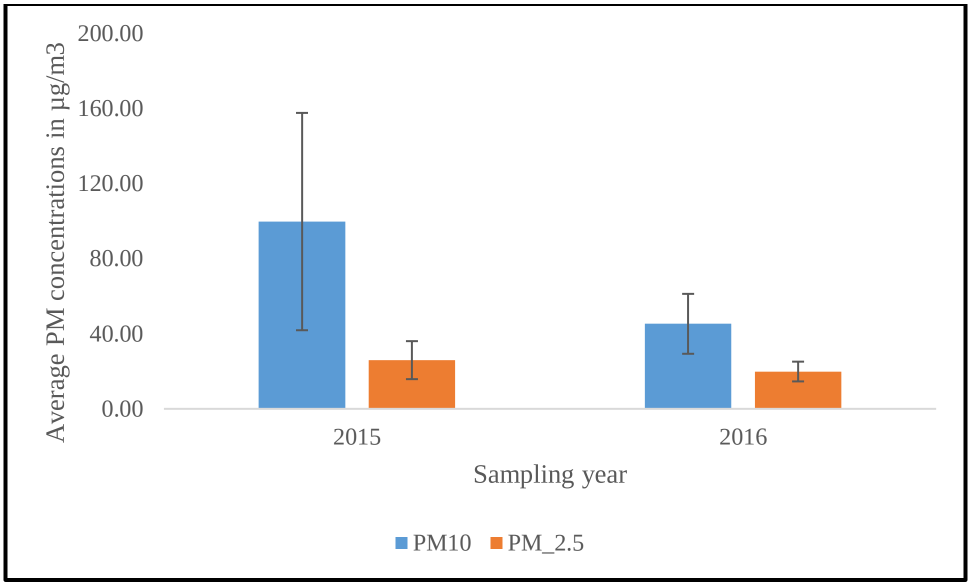


Figure 19. Yearly average PM concentrations in site 2.

Table 3

Stepwise regression analysis results of PM concentrations at site 2

Particulate matter type	Year of sampling	Stepwise regression model equations
PM_{10}	2015 & 2016 combined	PM_{10} =72.08904 – 51.12641 × rainfall_in_mm *(r^2 = 0.07)*
	2015	PM_{10} = 99.74191 – 552.38530 × rainfall_in_mm *(r^2 = 0.10)*
	2016	PM_{10} = 70.44775 – 2.63587 × wind_speed – 35.85478 × rainfall_in_mm *(r^2 = 0.20)*
$PM_{2.5}$	2015 & 2016 combined	No variables were statistically significant
	2015	$PM_{2.5}$ = -14.91731 + 0.50329 × vehicle_count + 0.11719 × wind_direction *(r^2 = 0.58)*
	2016	No variables were statistically significant

Notes: All variables here are significant at 0.15 level (p=0.15), r^2 values reported are model r^2 values.

The pooled average PM_{10} concentrations at site 2 were 70.42 ± 38.37 µg/m^3 and $PM_{2.5}$ concentrations were 19.60 ± 7.51 µg/m^3 at standard pressure and temperature measured over a two-year sampling period. However, the PM_{10} concentration over a 24-h sampling ranged from 1.91 µg/m^3 to 253.60 µg/m^3 in 2015 and from 5.17 µg/m^3 to 179.66 µg/m^3 in 2016, which is higher than the pooled average concentration. Similarly, $PM_{2.5}$ concentration value ranged from 2.56 µg/m^3 to 52.91 µg/m^3 in 2015 and from 3.27 µg/m^3 to 31.52 µg/m^3 in 2016. Figure 19 shows that the average PM_{10} concentrations in 2015 and 2016 were 99.74 ± 57.88 µg/m^3 and 45.29 ± 15.95 µg/m^3, respectively, and the average $PM_{2.5}$ concentrations in 2015 and 2016 were 25.94 ± 10.12 µg/m^3 and 19.88 ± 5.27 µg/m^3, respectively. Same as site #1, t the average PM_{10} concentrations in site #2 were lower in 2016 than 2015. This may be attributed to lower traffic from decrease oil extraction activities in the sampling area.

In 2016, the average PM_{10} concentrations (199.32 ± 36.13 µg/m^3) and $PM_{2.5}$ concentrations (47.02 ± 8.33 µg./m3) exceeded the NAAQS reference values (PM_{10} = 150 µg/m^3; $PM_{2.5}$ = 35 µg/m^3 for 24-hour sampling period). This was likely attributed to various factors i.e., high traffic on a loose gravel road and untreated road conditions. Also, traffic next to the sampling area likely contributed to higher PM concentration, except May 20-22, 2015 when gravel were applied to road. For example, on May 20-22, 2015, the average PM_{10} concentration was 151.4 ± 58.32 µg/m^3 that exceeded NAAQS PM_{10} value (figure 18). The lower PM concentrations during June 24-26, 2015 was likely due to lower traffic and 2.88 mm rainfall. During July 13-15, 2015, there were higher PM concentrations compared to the amount of traffic which may be attributed to the ongoing underground cable/pipe installation about 30 m to the south of the road, as well as drier road conditions. Despite of having comparatively higher traffic count, the PM concentrations during May 11-13, 2016 were low likely due to the rainfall on May

10th (12.5 mm) and high wind speeds. A similar pattern was also observed during May 24-27, 2016 (2.8 mm rainfall on May 25th), June 14-16, 2016 (8.4 mm rainfall on June 13th) and July 26-28, 2016 (2.88 mm rainfall).

From stepwise regression analysis, in 2015, the PM_{10} concentrations had weak correlation ($r^2 = 0.07$) with rainfall but $PM_{2.5}$ concentrations seemed to have a better relationship ($r^2 = 0.58$) with vehicle count and wind direction (p=0.15). In 2016, the PM_{10} concentrations had a weak correlation ($r^2 = 0.20$) with wind speed and rainfall, whereas $PM_{2.5}$ had no association with other factors (p=0.15).

Figure 20 shows the average Total Suspended Particulates (TSP) concentrations in site 3. This site had three 1 mile segments: a) control section (with no additives or treatments), b) treated with brine, and c) treated with magnesium chloride. The TSP concentrations in control, brine treated section, and magnesium chloride treated section were 374.59 ± 214.27 $\mu g/m^3$, 407.66 ± 220.84 $\mu g/m^3$, and 200.94 ± 90.11 $\mu g/m^3$, respectively. Magnesium chloride was found to be most effective in reducing dust because of its hygroscopic property. It captures moisture from air and keeps the surface damp, thus, keeping particles together and minimizing emissions. Magnesium chloride is easily available, easy to apply, and inexpensive. On the other hand, brine was less effective in reducing dust. However, due to limited data, it may not be conclusive which treatment is more effective in reducing the dust.

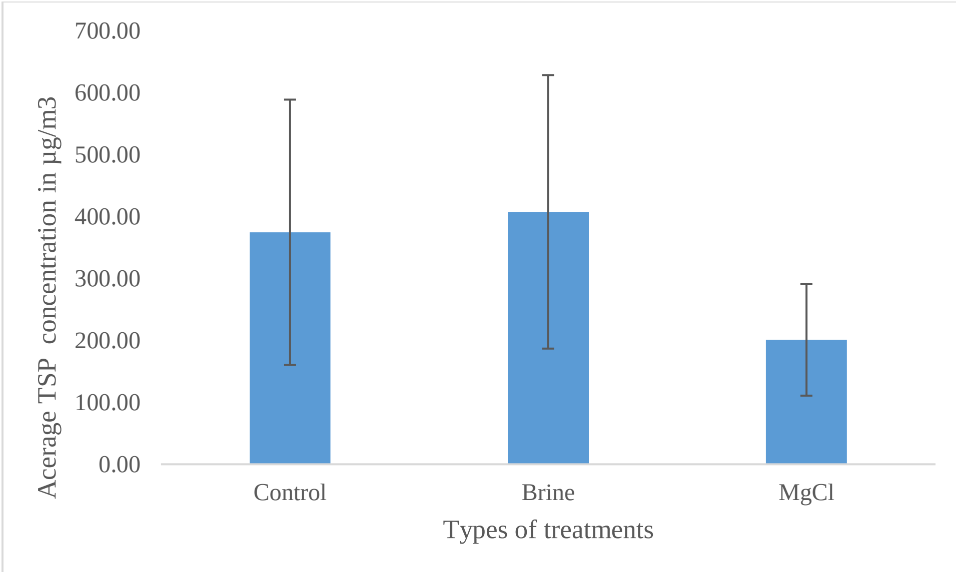


Figure 20. Average TSP concentrations in relation to types of treatments at site 3.

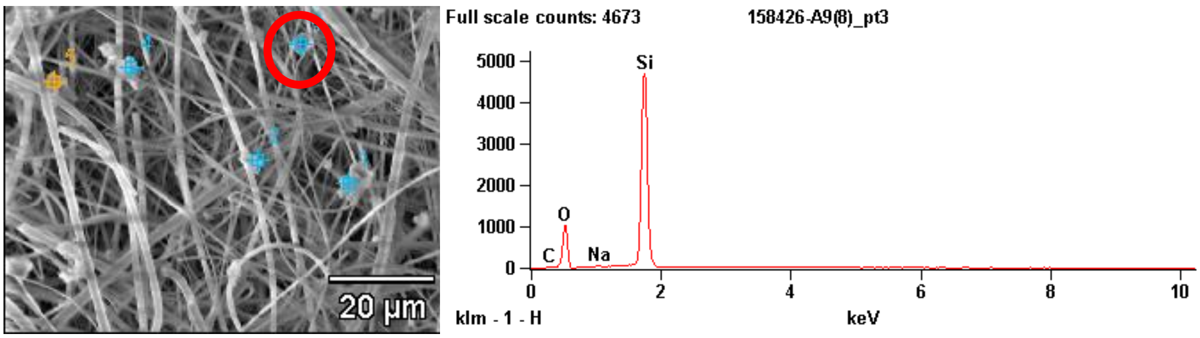
4.2. Mineralogical characterization of particulate matter

Based on elemental composition and morphology, 299 particles were analyzed using SEM-EDS. These particles were classified into three major groups: geogenic particles (derived from soil sediments, weathered rock surfaces), anthropogenic particles (particles derived from industrial and combustion activities), and biogenic particles (fungal hyphae with root outgrowth, organic plant fragments, living micro-organisms).

4.2.1. Geogenic particles

Most of the analyzed particles were found to be geogenic particles. These particles with crustal origin include silicates of iron, magnesium, aluminum, calcium, quartz, Fe/Ti oxides, calcium particles, chloride particles, carbonate minerals etc.

Quartz (SiO_2) is one of the most common minerals found in on earth's surface as it is a significant component of many sedimentary, metamorphic, and igneous rocks. Quartz can occur in many different colors, habits, and forms. Quartz crystals can be prismatic and can also appear in massive form with no definable shape with no visible aggregate or crystals. The source of quartz can be of both anthropogenic and natural origins. Quartz is characterized by high content of oxygen (O) and silicon (Si) (Si + O>90% by weight) summing up to 100% with an atomic ratio of 1 Si to 2 O. Figure 21 shows a quartz particle with a spherical particle morphology with Na as trace element.



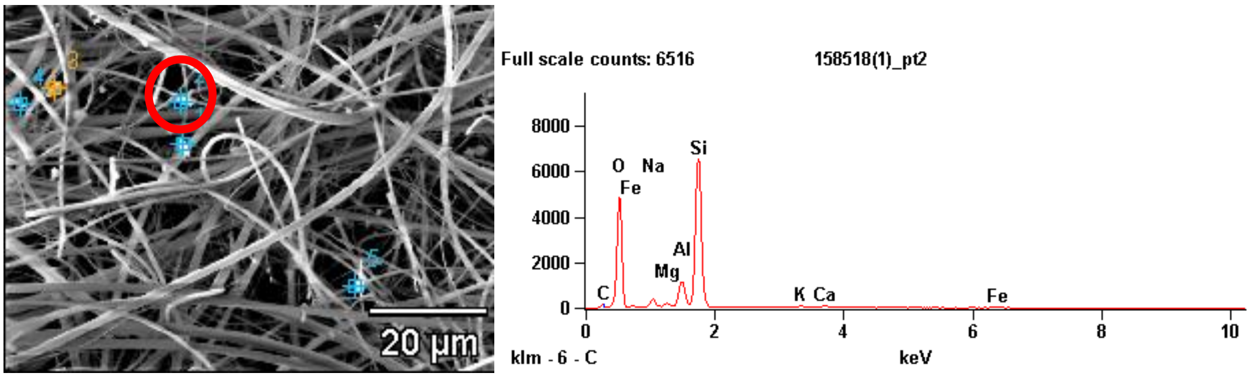
Weight %	O	Na	Mg	Al	Si	K	Ca	Ti	Fe
158426-A9(8)_pt3	53.06S	0.54			46.40				

SEM ID Number	Mineral Group	Major Elements	Minor Elements	Morphology	Formulas from SEM data
158426-A9(8)_pt3	Quartz	Si, O	Na	Spherical	141 O, 1 Na, 70 Si

Figure 21. Particulate matter identification from actual samples (Quartz)

Non-quartz silicates particles are identified by high Si, aluminum (Al), O, and iron (Fe) content with variable content of sodium (Na), magnesium (Mg), potassium (K), calcium (Ca), titanium (Ti) with trace amounts of phosphorus (P) and sulfur (S), and sometimes carbon (C). Most particles in this group showed irregular, sub-spherical, and spherical morphology. Possible phases/minerals include feldspars, clays, oxides, carbonates, etc. Figure 22 shows possible identification of aluminosilicates group (Al_2SiO_5) containing O, Si, and Al with lesser amounts of Na, Mg, K, and Ca. It showed irregular morphology.

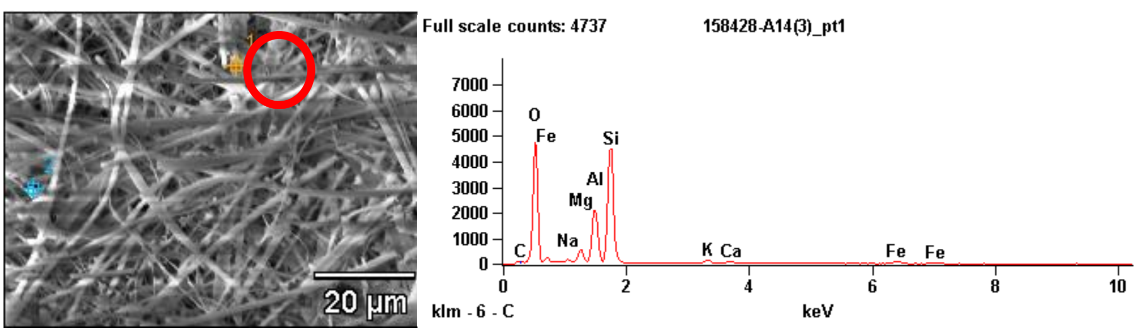
Oxide minerals are identified by high content of O and other elements like Fe, Al with low amount of trace elements. They tend to have sub-spherical shape. Figure 23 shows an oxide mineral which has high Al and O content with trace amount of Na, Mg, K, Ca, and Fe. It likely is aluminum oxide.



Weight	O	Na	Mg	Al	Si	K	Ca	Fe
158518(1)_pt2	50.27S	2.76	0.56	5.49	37.64	0.88	1.28	1.11

SEM ID Number	Mineral Group	Major Elements	Minor Elements	Morphology	Formulas from SEM data
158518(1)_pt2	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	Irregular	158 O, 6 Na, 1 Mg, 10 Al, 67 Si, 1 K 2 Ca, 1 Fe

Figure 22. Particulate matter identification from actual samples (Silicate minerals - aluminosilicates)



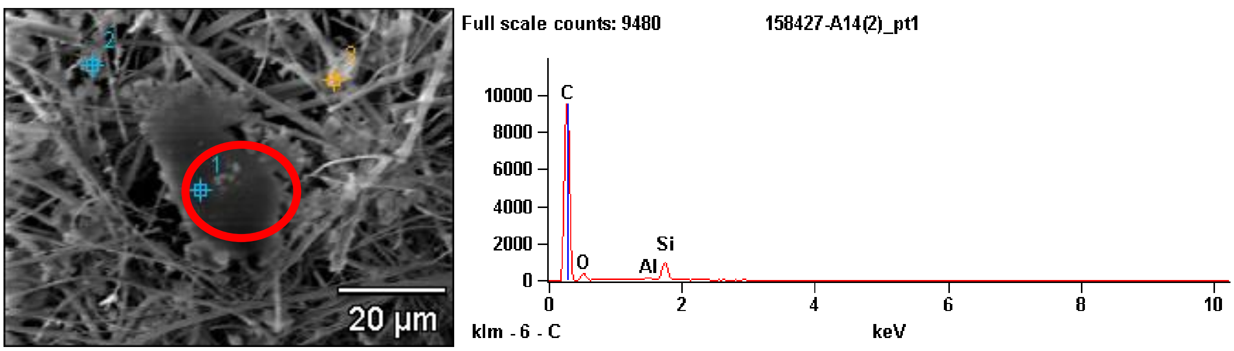
Weight %	O	Na	Mg	Al	K	Ca	Fe
158428-A14(3)_pt1	40.50S	2.35	6.36	31.36	3.02	2.42	13.98

SEM ID Number	Mineral Group	Major Elements	Minor Elements	Morphology	Formulas from SEM data
158428-A14(3)_	Oxides	O, Al	Na, Mg, K, Ca, Fe	Sub-spherical	42 O, 2 Na, 4 Mg, 19 Al, 1 K, 1 Ca, 4 Fe

Figure 23. Particulate matter identification from actual samples (Silicate minerals - oxides)

4.2.2. Anthropogenic particles

Anthropogenic particles include carbonaceous and industrial particles. Among industrial particles, the dominant metalliferous particles contain Cr>40%, Mn>50% and Ni>10% by weight in combination with trace particles. Very few industrial particles were found in this study as the sampling sites were very far from industrial zones. Carbonaceous particles are significant as they contribute highly to the total mass of the particles. In figure 24, soot was identified. It had high carbon content and low oxygen content. This type of particle can be produced from biomass and biofuel burning. Earlier studies show that this spherical particle can scatter and absorb light (Cong et al., 2008). Agricultural burning, tire residue, and waste incineration might be origin of these particles.



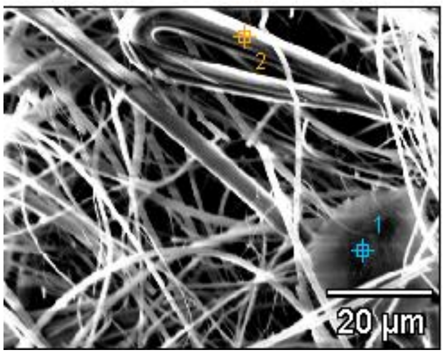
Weight %	C	O	Na	Mg	Al	Si	K	Ca	Fe
158427-A14(2)_pt1	95.66	2.30S			0.13	1.92			

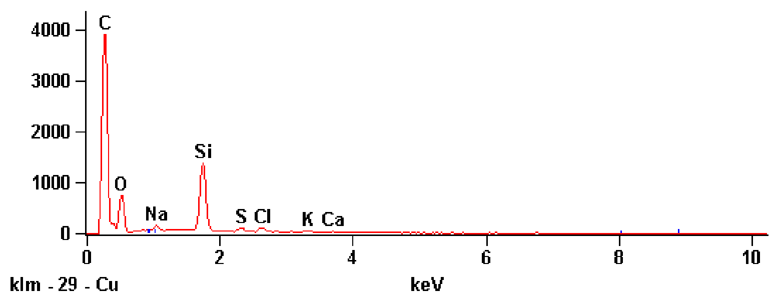
SEM ID Numbe	Mineral Group	Major Elements	Minor Elements	Morphology	Formulas from SEM data
158427-A14(2)_	Soot	C, O	Al, Si	Sub-spherical/irregular	1653 O, 30 O, 1 Al, 14 Si

Figure 24. Particulate matter identification from actual samples (Anthropogenic minerals - soot)

4.2.3. Biogenic particles

Particles of biological origin were quantified by the method used by Matthias-Maser and Jaenicke (Matthias-Maser & Jaenicke, 1994). Both dead and alive biogenic aerosols contain minor amounts of Na, Mg, K, P, Si, Cl, Al and Ca. These elements sum to approximately 10% of the whole weight of the particle. These elements are also essential trace elements present in plants (Artaxo & Hansson, 1995). The rule to identify such particles is: biological aerosols will have combined weight percentage of greater than 75% of carbon and oxygen, and phosphorus, potassium and chlorine will have weight percentage of between 1% and 10% (Coz et al., 2010). S, Si, Zn, and Ca are also tracers of biogenic materials. Figure 25 shows a round shaped outgrowth. It has a high carbon and oxygen content which sums up to more than 75% by weight with trace amounts of K, Na, Cl, and Ca. The silica content is probably from the filter fibers.





Weight, %	C	O	Na	Si	S	Cl	K	Ca
158426-A10(1)_pt1	26.32	71.87S	0.16	1.33	0.10	0.12	0.06	0.04

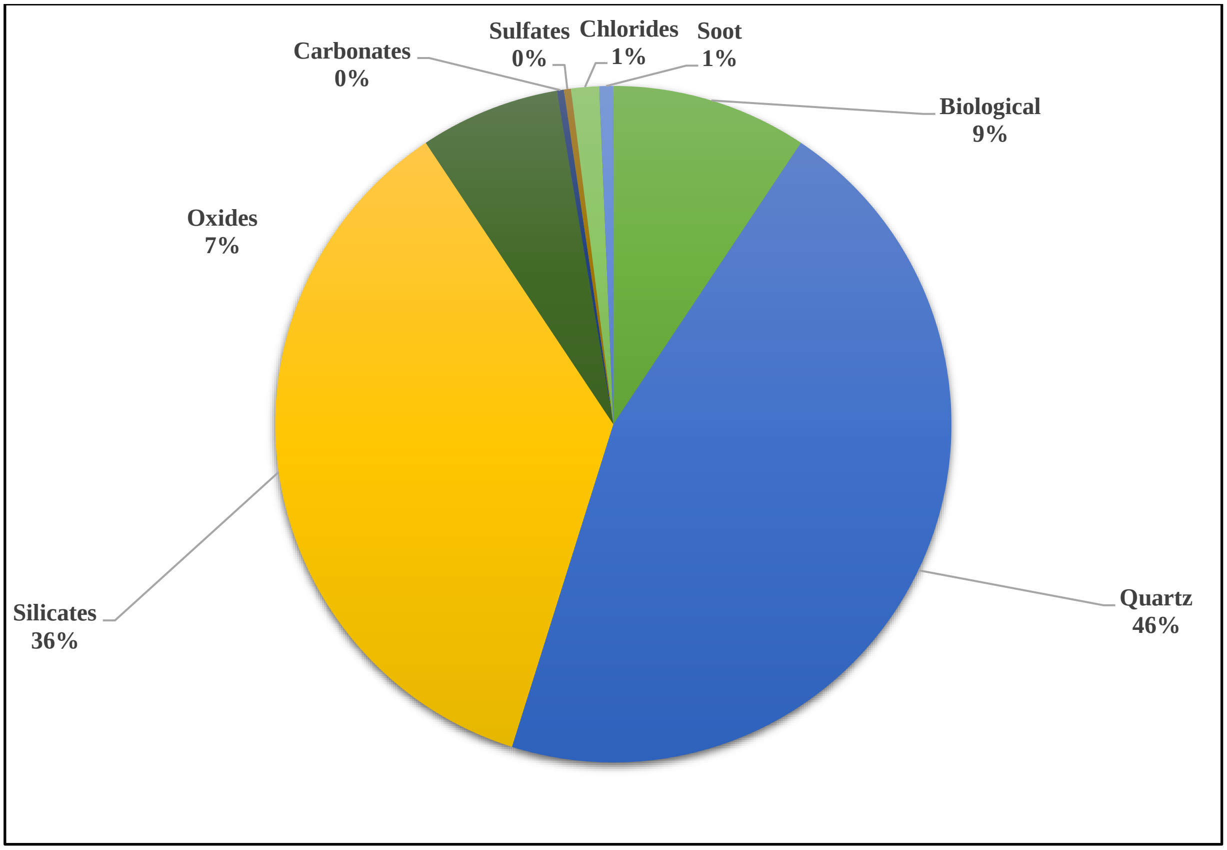
SEM ID Number	Mineral Group	Major Eleme	Minor Eleme	Morphology	Formulas from SEM data
158426-A10(1)	Biological group	C, O	Si, Na, S, Cl, K, Ca	Round/spherical	2195 C, 4500 O, 7 Na, 47 Si, 3 S, 3 Cl, 2 K, 1 Ca

Figure 25. Particulate matter identification (Biological particles)

Such biological particles include microorganisms and fragments of all varieties of living matter like viruses, bacteria, fungal growth, spores, pollen, plant debris, etc. (Cong et al., 2008; Coz et al., 2010; Matthias-Maser & Jaenicke, 2000).

4.2.4. Relative amounts of identified particles

Figure 26(a) shows that out of all particles analyzed, 46% were quartz, 36% were silicates, 9% were of biological origin followed by 7% oxides, 1% soot, and 1% chlorides. At site 1, 53% of the particles were quartz followed by 33% silicates, 9% biological, 3% chlorides, etc. Among PM_{10} particles, majority of particles were silicates (41%), and quartz (39%), biological (12%), etc. in site 1.



(a)

Figure 26. Relative amounts of minerals: (a) at all sites; (b) at site 1; (c) at site 2; (d) at site 1: PM_{10}; (e) at site 1: $PM_{2.5}$; (f) at site 2: PM_{10}; (g) at site 2: $PM_{2.5}$

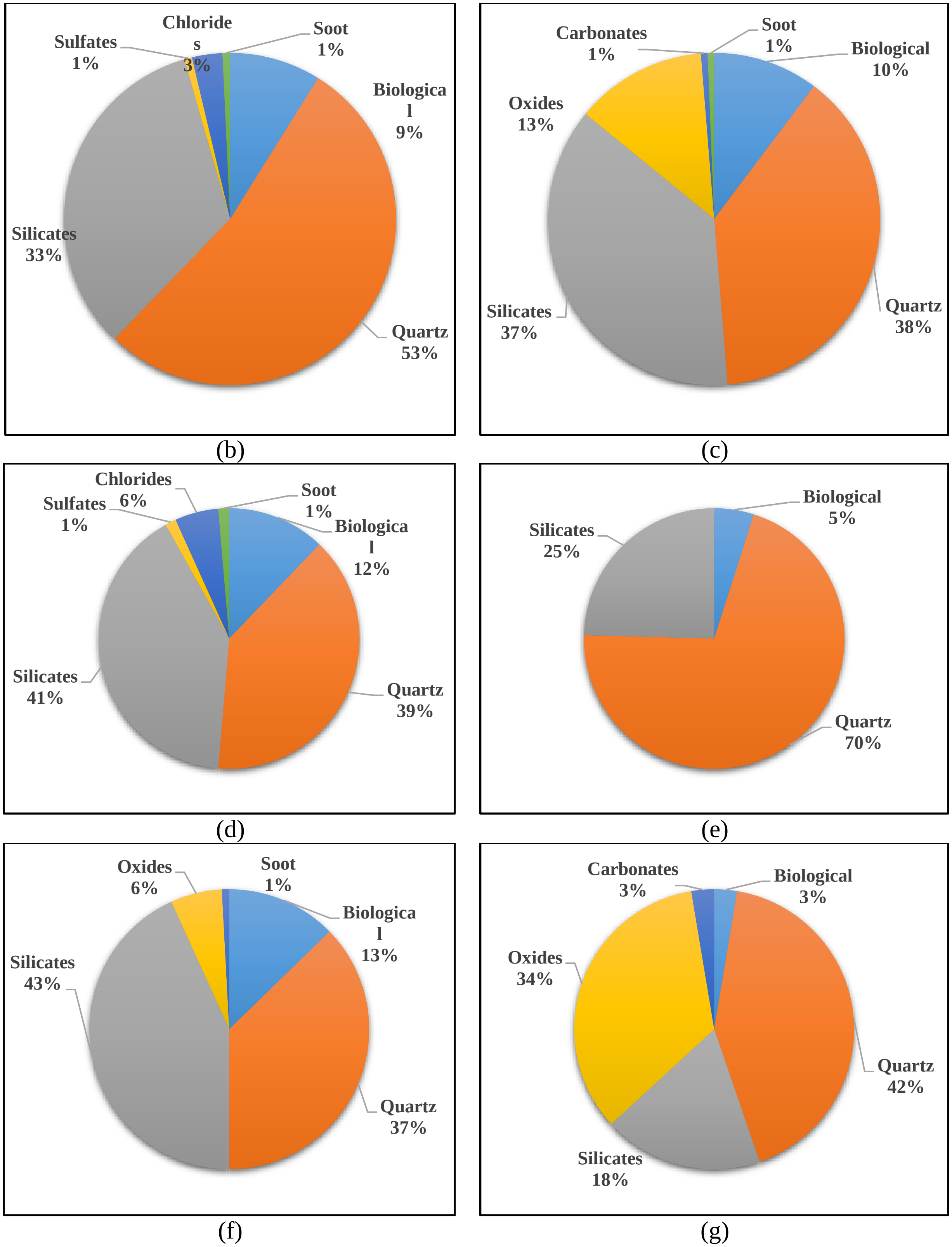
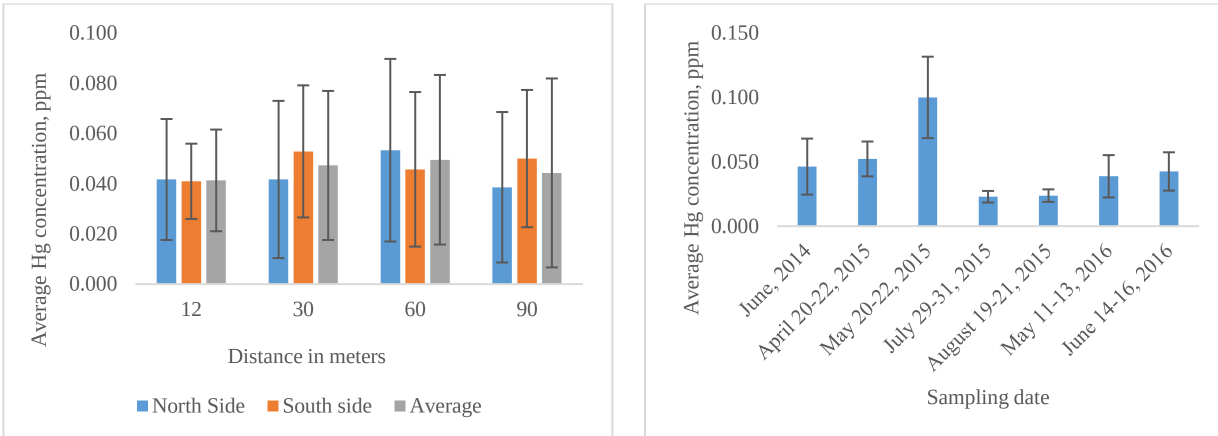


Figure 26. Relative amounts of minerals: (a) at all sites; (b) at site 1; (c) at site 2; (d) at site 1: PM_{10}; (e) at site 1: $PM_{2.5}$; (f) at site 2: PM_{10}; (g) at site 2: $PM_{2.5}$ (continued)

Among $PM_{2.5}$ particles, majority of particles were quartz (70%) followed by 25% silicates and 5 % biological particles at site 1. The prominence of quartz in $PM_{2.5}$ particles is likely due to weathering action in the area by high traffic or transport of particles over long distances. At site 2, majority of particles were quartz (38%) and silicates (37%) followed by 10% biological particles, and 13% oxides, and with traces of carbonate minerals. Among PM_{10} particles in site 2, silicates contributed to 43% followed by quartz (37%), biological particles (13%), oxides (6%), etc. Among $PM_{2.5}$ particles in site 2, majority of particles were quartz (42%) and oxides (34%) followed by 18% silicates, 3% biological and 3% carbonates particles.

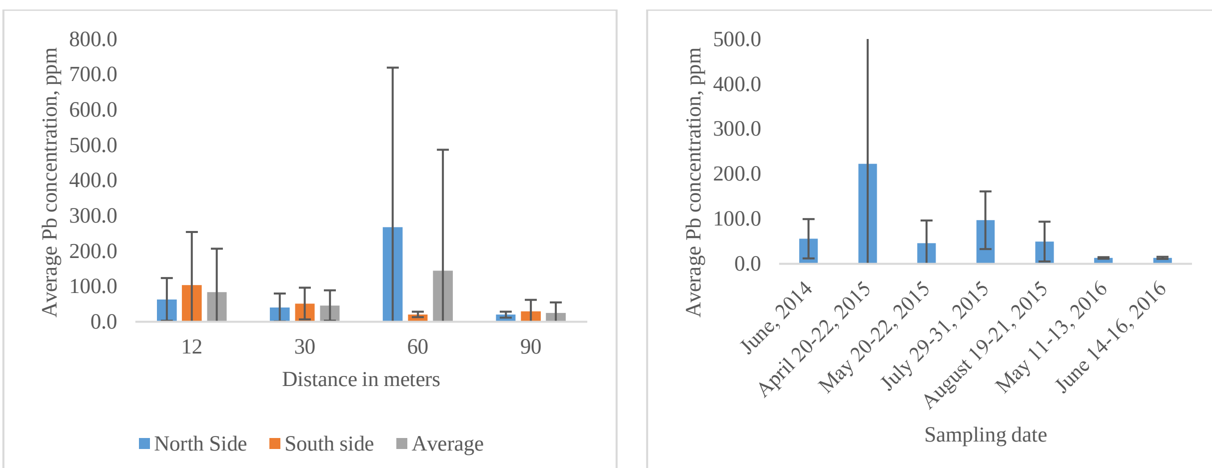
4.3. Elemental analysis of soil samples

The soil samples were analyzed to determine their elemental composition with regard to sixty chemical elements by ICP-MS. Selected metals of interest were chosen because of their potential impact on the local environment and, essentially, crops and human health. There were several studies conducted in early 1980s which depict the elemental compositions of metals and their reference values in the soil (Shacklette & Boerngen, 1984). In this study, concentrations of most of the metals were lower than the reference values. Additional data collected by the United States Geological Survey (USGS) Mineral Resources National Geochemical Survey (NGS) (USGS, 2003) (Sample ID: C – 250179, C – 237228, C-237239) and Smith et al. (2013) (Lab ID: C – 340224) were used to compare the measured values with these previously published values. Evaluation of the analytical data from this study showed few elements that appeared to be potentially influenced by dust from road traffic. However, some anomalies appeared to occur in the data from mercury (Hg), lead (Pb), and nickel (Ni). Thus, these elements were examined more closely. Figure 27 and 28 show the average mercury (Hg), and lead (Pb) concentrations with increasing distances from the center of the road and their concentrations with respect to sampling dates.



(a) (b)

Figure 27. (a) Average mercury (Hg) concentrations in ppm in soil at varying distances from the road (n=8 at 12 m, n=6 at 30 m, 60 m, 90 m); (b) Average mercury (Hg) concentration in ppm with respect to the date of trip (n=8 for all sampling dates except, n=6 for April 20-22, 2015).



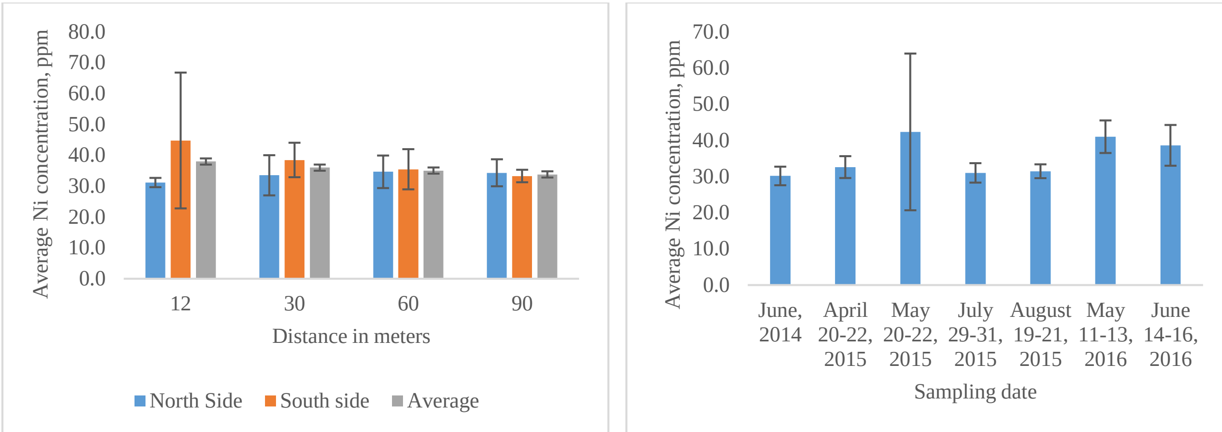
(a) (b)

Figure 28. (a) Average lead (Pb) concentrations in ppm in soil at varying distances from the road (N=8 at 12 m, N=6 at 30 m, 60 m, 90 m); (b) Average lead (Pb) concentration in ppm with respect to the date of trip (n=8 for all sampling dates except, n=6 for April 20-22, 2015).

The pooled average Hg concentration for the 7 sampling dates was 0.046 ± 0.029 ppm sampled over a period of three years. The concentration of Hg varied from 0.020 to 0.10 ppm. The reference value from NGS was found to be 0.020 ppm and 0.07 ppm (Smith et al., 2013). The average Hg concentrations on north side of the road were higher than that on the south side of the road. The mercury concentration is highest in the month of May, 2015 and then decreased significantly. There is a rise in Hg concentration in 2015, but the concentrations during 2014 and 2016 were low. It could be also due to disturbance of soil on the south side of the road as the underground cable/pipe installation activities were going on at that time.

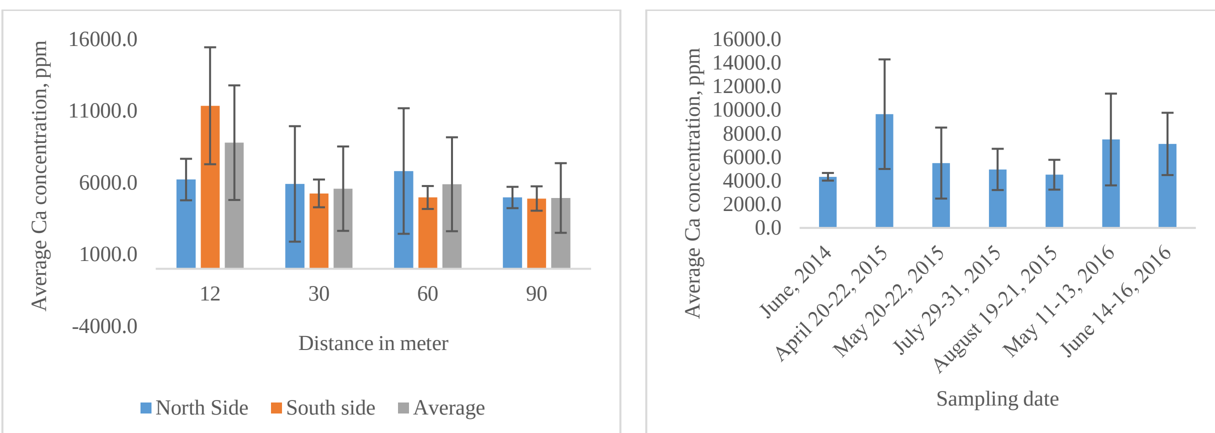
The pooled average Pb concentration was 76.7 ± 168 ppm sampled over a period of three years. The reason of large error range is due to high Pb concentrations on April 20-22, 2015 sampling date (222.3 ± 391.5 ppm), and on July 29-31, 2015 sampling date (97 ± 64.2 ppm). The Pb concentrations varied from 6.4 to 435.9 ppm. The reference value from NGS was found to be 8.3 ± 1.5 ppm and 15.2 ppm (Smith et al., 2013). The average Pb concentrations increased over distance to the 60m sampling point and then dropped at 90 m. The Pb concentrations, like Hg, were much higher in 2015 than that of 2014 and 2016's. The high Pb concentrations during the 2015 sampling period could cause health issues to human working in the area and the animals that are feeding off the site, if the soil is ingested. As the soil pH (5.92) was below 6.50, it could also become available to plants.

Figure 29 and 30 show the average nickel (Ni), and calcium (Ca) concentrations with increasing distances from the center of the road and their concentrations with respect to sampling dates, respectively.



(a) (b)

Figure 29. (a) Average nickel (Ni) concentrations in ppm in soil at varying distances from the road (N=8 at 12 m, N=6 at 30 m, 60 m, 90 m); (b) Average nickel (Ni) concentration in ppm with respect to the date of trip (n=8 for all sampling dates except, n=6 for April 20-22, 2015).



(a) (b)

Figure 30. (a) Average calcium (Ca) concentrations in ppm in soil at varying distances from the road (N=8 at 12 m, N=6 at 30 m, 60 m, 90 m); (b) Average calcium (Ca) concentration in ppm with respect to the date of trip (n=8 for all sampling dates except, n=6 for April 20-22, 2015).

The pooled average Ni concentration was 34.1 ± 9.7 ppm over a three-year sampling period. The Ni concentration values ranged from 18.2 to 97.5 ppm. The USGS NGS reference value of Ni concentration was 27.7 ± 4.0 ppm and 40.9 ppm (Smith et al., 2013). This rise in Ni concentrations may be due to increased oil drilling in the area or due to natural variability in background specific to the sampling site.

The pooled average Ca concentration was 6273.89 ± 6112.43 ppm over a three-year sampling period. The Ca concentration values ranged from 3400 to 17000 ppm. The USGS NGS reference value for Ca concentration was 2529.7 ± 1738.9 ppm and 17000 ppm (Smith et al., 2013). This increase might be due to cable/pipe installation activities near the road which might have exposed lime (calcareous) geologic materials beneath the natural soil surface and brought it to the surface, subjected o displacement by wind or rainfall.

5. CONCLUSIONS AND FUTURE STUDY

5.1. Conclusions

The primary objective of this project was to quantify particulate matter (PM_{10}, $PM_{2.5}$) emissions from unpaved roads (treated vs untreated) in well development area in the Western North Dakota. Airmetrics miniVOL™ Tactical Air Samplers (Springfield, OR, USA) were used to quantify PM_{10}, $PM_{2.5}$, TSP at selected locations. The pooled average PM_{10} and $PM_{2.5}$ concentrations were 30.84 ± 14.19 µg/m^3 and 14.08 ± 6.56 µg/m^3 from a periodically treated road (Site 1), respectively over a two-year sampling period. The PM_{10} emissions at site 1 were found to be weakly correlated with rainfall in 2015 ($r^2 = 0.07$) and moderately correlated with vehicle count, wind speed, wind direction, and rainfall in 2016 ($r^2 = 0.30$) at p=0.15. Likewise, the $PM_{2.5}$ emissions were strongly correlated with wind direction and rainfall in 2015 ($r^2 = 0.51$) and with vehicle count in 2016 ($r^2 = 0.38$). So, most of the time, the PM concentrations were high when the vehicle count was high and PM concentrations were low when there was a rainfall event. However, the average PM concentrations in 2015 were higher than 2016 but they were still below the NAAQS threshold values. In addition, the PM concentrations were low when magnesium chloride was applied on the road surface.

The pooled average PM_{10} and $PM_{2.5}$ concentrations (over a two-year sampling period) were found to be 70.42 ± 38.37 µg/m^3 and 19.60 ± 7.51 µg/m^3 from an untreated loose gravel road (Site 2), respectively. There were some instances when the PM concentrations exceeded NAAQS values which could be due to construction activities on road or high vehicle count or new gravel application on the road or due to the untreated road surface. The PM_{10} concentrations were loosely correlated ($r^2 = 0.10$) with rainfall in 2015 and with wind speed and rainfall ($r^2 = 0.20$) in 2016. The $PM_{2.5}$ concentrations were strongly correlated ($r^2 = 0.58$) with vehicle count and wind direction in 2015 and no correlation was found in 2016 ($p=0.15$). The PM concentrations in 2016 were lower than that of 2015 because of a decrease in oil rigging activities in the sampling area.

Another location (site 3) was selected to determine the effectiveness of different types of treatments on the roads. Out of three treatments (control, brine, magnesium chloride), the most effective form of treatment was magnesium chloride.

Elemental composition, and morphology of samples were analyzed by scanning electron microscopy energy dispersive spectroscopy (SEM/EDS) which revealed there is a wide range of minerals, biological aerosols, and little amount of anthropogenic particles in the area. 46% of the particles analyzed was quartz which could have resulted from weathering processes of rocks, and 36% of the particles were found to be silicates which are basically constituents of roads in the sampling area. There were small amounts of biological particles (9%), and oxides (7%). Very limited amount of anthropogenic particles (Soot, 1%) was found in the area. The relative amount of quartz was higher in site 1 than that of site 2 which could be due to accelerated weathering process from high number of traffic. Quartz and oxides were predominant in $PM_{2.5}$ samples too.

Soil samples were analyzed using inductively coupled plasma – mass spectroscopy (ICP-MS) to find out elemental compositions of metals present in the sampling area. To compare the measured value, elemental compositions of metals from three reference sites were compared with the United States Geological Survey (USGS) – National Geochemical Survey website and (Smith et al., 2013). It was found that the concentrations of most metal decreased with increasing distances from the center of the road to the north and south sides. Concentrations of the metals were higher in some cases which were likely due to increased oil drilling activities, higher traffic, disturbance of soil from underground cable installations, etc. The concentrations of most of the metals were higher in 2015 than that of 2014 and 2016, during which, traffic and oil activities were the highest. However, most of the metal concentrations were lower than the USGS reference values, thus may not pose any concern based on this study.

5.2. Future study

This study provided PM emissions along with their elemental composition of particles in the dust as well as elemental compositions of metals present in the soil in the study area. Further approach could be made to determine emission factor in the Western North Dakota. Another possible work could be a determination of “Emission Potential” for a road surface.

The overall dust distribution across the landscape could be demonstrated using remote sensing or by geographic information system. An air quality modeling could be done using AERMOD to predict the PM concentrations more accurately by taking topography, spatial data into consideration. Since, limited scientific information is available on dust suppressant, different dust mitigation and control techniques could be explored to find an economically viable as well as effective dust reduction method. Also, more studies could be carried out to find impacts of dust on the human living next to the oil development area, as well as the welfare of the animals.

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APPENDIX A

Table A1

Airmetrics sampler calibration constants

Sampler No.	2015		2016	
	Regression slope, m_{vol}	Intersect, b_{vol}	Regression slope, m_{vol}	Intersect, b_{vol}
5941	1.1775	- 0.37940	1.1156	- 0.32850
5939	1.1650	- 0.34250	1.1432	- 0.49800
5942	1.1805	- 0.41300	1.1562	- 0.50470
5940	1.1850	- 0.39650	1.1600	- 0.52130
6786	1.1941	- 0.54200	1.1153	- 0.40920
6785	1.1861	- 0.46850	1.1336	- 0.54560
6784	1.1862	- 0.48690	1.1369	- 0.55520
6787	1.1798	- 0.43530	1.1228	- 0.48320

A2. Particulate matter concentration at site 1

S1-10 means that the sampler is on the south side (N means north) of the road about 38 feet from the center of the road with PM_{10} configuration. S2-10 means the sampler is 100 feet from the center of the road. S1-2.5 means a sampler with $PM_{2.5}$ configuration. N-10 refers to a sampler at about 38 feet from the center of the road to the north side with a PM_{10} configuration. Wind direction is expressed in cardinal degree system which was converted to compass (Atlas).

Table A2

Particulate matter concentration at site 1

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
4/20/2015	146.1	167.3	5941 S1-10	A-1	115	21.2	5.0	4.916	693.144	6.93	16.60	86		
4/20/2015	145.0	166.3	5939 S1-2.5	A-4	75	21.3	5.0	4.916	693.144	6.93	10.82			
4/20/2015	146.5	167.5	5942 S2-10	A-2	143	21.0	5.0	4.916	693.144	6.84	20.91			
4/20/2015	168.6	190.0	5940 N-10	A-3	137	21.4	5.0	4.916	693.144	7.02	19.52			
4/21/2015	167.3	189.3	5941 S1-10	A-11	283	22.0	5.0	2.296	696.659	7.24	39.08	87		
4/21/2015	166.3	188.3	5939 S1-2.5	A-10	110	22.0	5.0	2.296	696.659	7.21	15.26			
4/21/2015	167.5	189.8	5942 S2-10	A-9	273	22.3	5.0	2.296	696.659	7.32	37.31			
4/21/2015	190.0	212.0	5940 N-10	A-12	292	22.0	5.0	2.296	696.659	7.27	40.17			
5/20/2015	189.4	210.1	5941 S1-10	A-18	190	20.7	5.0	14.415	702.676	6.70	28.37	57		
5/20/2015	188.3	209.2	5939 S1-2.5	A-17	51	20.9	5.0	14.415	702.676	6.73	7.58			
5/20/2015	189.7	210.8	5942 S2-10	A-19	184	21.1	5.0	14.415	702.676	6.80	27.04			
5/20/2015	212.0	233.0	5940 N-10	A-20	199	21.0	5.0	14.415	702.676	6.82	29.18			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
5/21/ 2015	209.2	230.6	5939 S1-2.5	A-25	83	21.4	5.0	15.316	700.686	6.87	12.08			
5/21/ 2015	210.8	232.2	5942 S2-10	A-27	208	21.4	5.0	15.316	700.686	6.88	30.23			
5/21/ 2015	233.0	254.5	5940 N-10	A-28	223	21.5	5.0	15.316	700.686	6.96	32.03			
6/9/ 2015	231.5	251.8	5941 S1-10	A-33	277	20.3	5.0	19.03	694.786	6.48	42.75	52		
6/9/ 2015	230.6	250.9	5939 S1-2.5	A-34	39	20.3	5.0	19.03	694.786	6.45	6.05			
6/9/ 2015	232.2	252.5	5942 S2-10	A-35	324	20.3	5.0	19.03	694.786	6.46	50.17			
6/9/ 2015	254.5	275.1	5940 N-10	A-36	214	20.6	5.0	19.03	694.786	6.60	32.42			
6/11/ 2015	251.8	259.9	5941 S1-10	A-41	59	8.1	5.0	19.521	696.449	2.59	22.81	34		
6/11/ 2015	250.9	258.9	5939 S1-2.5	A-42	122	8.0	5.0	19.521	696.449	2.54	47.98			
6/11/ 2015	252.5	260.6	5942 S2-10	A-43	50	8.1	5.0	19.521	696.449	2.58	19.40			
6/11/ 2015	275.1	283.3	5940 N-10	A-44	159	8.2	5.0	19.521	696.449	2.63	60.50			
6/11/ 2015	259.9	273.1	5941 S1-10	A-49	102	13.2	5.0	15.038	695.134	4.24	24.04	24		
6/11/ 2015	258.9	272.1	5939 S1-2.5	A-50	63	13.2	5.0	15.038	695.134	4.22	14.92			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/11/ 2015	260.6	273.7	5942 S2-10	A-51	110	13.1	5.0	15.038	695.134	4.20	26.21			
6/11/ 2015	283.3	296.7	5940 N-10	A-52	125	13.4	5.0	15.038	695.134	4.32	28.91			
6/12/ 2015	273.1	281.5	5941 S1-10	A-57	76	8.4	5.0	23.429	692.207	2.66	28.61	22		
6/12/ 2015	272.1	280.5	5939 S1-2.5	A-58	3	8.4	5.0	23.429	692.207	2.64	1.13			
6/12/ 2015	273.7	282.1	5942 S2-10	A-59	20	8.4	5.0	23.429	692.207	2.65	7.55			
6/12/ 2015	296.7	305.1	5940 N-10	A-60	139	8.4	5.0	23.429	692.207	2.67	52.13			
6/24/ 2015	281.5	301.5	5941 S1-10	A-65	144	20.0	5.0	19.99	698.866	5.57	25.84	89	1.12	180.74
6/24/ 2015	280.5	300.6	5939 S1-2.5	A-66	13	20.1	5.0	19.99	698.866	5.58	2.33			
6/24/ 2015	282.1	302.2	5942 S2-10	A-67	53	20.1	5.0	19.99	698.866	5.44	9.74			
6/24/ 2015	305.1	325.8	5940 N-10	A-68	107	20.7	5.0	19.99	698.866	5.79	18.49			
6/25/ 2015	301.5	322.4	5941 S1-10	A-73	83	20.8	5.0	17.54	700.233	5.83	14.25	63	2.25	195.52
6/25/ 2015	300.6	321.4	5939 S1-2.5	A-74	92	20.8	5.0	17.54	700.233	5.80	15.85			
6/25/ 2015	302.2	323	5942 S2-10	A-75	71	20.8	5.0	17.54	700.233	5.66	12.55			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/25/ 2015	325.8	346.5	5940 N-10	A-76	166	20.7	5.0	17.54	700.233	5.82	28.54			
7/13/ 2015	322.4	342.9	5941 S1-10	A-83	117	20.5	4.4	21.703	694.047	5.68	20.62	62	3.23	85.86
7/13/ 2015	321.4	342	5939 S1-2.5	A-82	40	20.6	4.4	21.703	694.047	5.68	7.04			
7/13/ 2015	323.0	343.6	5942 S2-10	A-81	93	20.6	4.4	21.703	694.047	5.68	16.38			
7/13/ 2015	346.5	367.1	5940 N-10	A-84	145	20.6	4.3	21.703	694.047	5.58	25.98			
7/14/ 2015	342.9	363.9	5941 S1-10	A-89	204	21.0	4.4	22.053	695.244	5.82	35.08	49	2.6	162.43
7/14/ 2015	342	363.1	5939 S1-2.5	A-90	49	21.1	4.4	22.053	695.244	5.82	8.42			
7/14/ 2015	343.6	364.6	5942 S2-10	A-91	166	21.0	4.4	22.053	695.244	5.79	28.67			
7/14/ 2015	367.1	387.9	5940 N-10	A-92	159	20.8	4.3	22.053	695.244	5.64	28.21			
7/29/ 2015	363.9	384.6	5941 S1-10	A-97	131	20.7	4.440	19.06	700.55	5.84	22.43	55	2.938	116.27
7/29/ 2015	363.1	383.7	5939 S1-2.5	A-98	2	20.6	4.456	19.06	700.55	5.81	0.34			
7/29/ 2015	364.6	385.2	5942 S2-10	A-99	84	20.6	4.457	19.06	700.55	5.81	14.45			
7/29/ 2015	387.9	408.7	5940 N-10	A-100	73	20.8	4.427	19.06	700.55	5.87	12.44			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
7/30/ 2015	384.6	406.2	5941 S1-10	A-105	210	21.6	4.439	19.82	701.88	6.09	34.48	41	2.487	129.5
7/30/ 2015	383.7	405.3	5939 S1-2.5	A-106	19	21.6	4.455	19.82	701.88	6.09	3.12			
7/30/ 2015	385.2	406.8	5942 S2-10	A-107	205	21.6	4.456	19.82	701.88	6.09	33.66			
7/30/ 2015	408.7	430.0	5940 N-10	A-108	119	21.3	4.425	19.82	701.88	6.01	19.81			
5/11/ 2016	447.5	469.5	5941 S1-10	A-129	8	22.0	4.600	6.19	698.485	6.47	1.24	23	13.71	81.1
5/11/ 2016	448.6	470.6	5939 S1-2.5	A-130	17	22.0	4.700	6.19	698.485	6.47	2.63			
5/11/ 2016	449.1	471.2	5942 S2-10	A-131	39	22.1	4.600	6.19	698.485	6.50	6.00			
5/11/ 2016	472.4	494.5	5940 N-10	A-132	6	22.1	4.600	6.19	698.485	6.50	0.92			
5/12/ 2016	469.5	491.1	5941 S1-10	A-137	54	21.6	4.700	5.76	701.695	6.40	8.44	44	9.29	92.48
5/12/ 2016	470.6	492.7	5939 S1-2.5	A-138	25	22.1	4.800	5.76	701.695	6.54	3.82			
5/12/ 2016	471.2	492.7	5942 S2-10	A-139	33	21.5	4.800	5.76	701.695	6.37	5.18			
5/12/ 2016	494.5	515.7	5940 N-10	A-140	55	21.2	4.800	5.76	701.695	6.28	8.76			
5/24/ 2016	491.6	512.2	5941 S1-10	A-145	90	20.6	4.600	16.1	694.138	5.82	15.47	52	5.59	114.01

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
5/24/ 2016	491.1	512.7	5939 S1-2.5	A-146	76	21.6	4.700	16.1	694.138	6.10	12.46			
5/24/ 2016	492.7	513.7	5942 S2-10	A-147	102	21.0	4.600	16.1	694.138	5.93	17.20			
5/24/ 2016	515.7	536.8	5940 N-10	A-148	73	21.1	4.600	16.1	694.138	5.96	12.25			
5/25/ 2016	512.2	534.2	5941 S1-10	A-153	5	22.0	4.700	11.87	693.123	6.30	0.79	68	10.267	268.383
5/25/ 2016	512.7	534.7	5939 S1-2.5	A-154	233	22.0	4.800	11.87	693.123	6.30	37.00			
5/25/ 2016	513.7	535.8	5942 S2-10	A-155	108	22.1	4.800	11.87	693.123	6.33	17.07			
5/25/ 2016	536.8	558.9	5940 N-10	A-156	103	22.1	4.800	11.87	693.123	6.33	16.28			
5/26/ 2016	534.2	556.7	5941 S1-10	A-161	160	22.5	4.700	12.65	693.662	6.43	24.89	83	4.428	233.633
5/26/ 2016	534.7	557.2	5939 S1-2.5	A-162	121	22.5	4.800	12.65	693.662	6.43	18.83			
5/26/ 2016	535.8	558.2	5942 S2-10	A-163	144	22.4	4.800	12.65	693.662	6.40	22.51			
5/26/ 2016	558.9	581.2	5940 N-10	A-164	137	22.3	4.800	12.65	693.662	6.37	21.51			
6/14/ 2016	577.8	598.2	5941 S1-10	A-177	71	20.4	4.600	17.66	691.93	5.71	12.43	53	7.626	240.82
6/14/ 2016	577.3	597.7	5939 S1-2.5	A-178	95	20.4	4.700	17.66	691.93	5.71	16.63			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/14/2016	578.8	599.2	5942 S2-10	A-179	70	20.4	4.600	17.66	691.93	5.71	12.25			
6/14/2016	602.1	622.6	5940 N-10	A-180	97	20.5	4.600	17.66	691.93	5.74	16.90			
6/15/2016	598.2	620.1	5941 S1-10	A-185	117	21.9	4.700	20.26	694.02	6.10	19.19	70	12.61	298.67
6/15/2016	597.7	619.6	5939 S1-2.5	A-186	128	21.9	4.800	20.26	694.02	6.10	21.00			
6/15/2016	599.2	621.1	5942 S2-10	A-187	145	21.9	4.800	20.26	694.02	6.10	23.78			
6/15/2016	622.6	644.5	5940 N-10	A-188	161	21.9	4.800	20.26	694.02	6.10	26.41			
6/28/2016	620.1	640.5	5941 S1-10	A-193	418	20.4	4.600	28.34	692.05	5.51	75.85	57	3.4	108
6/28/2016	619.6	640.4	5939 S1-2.5	A-194	42	20.8	4.700	28.34	692.05	5.62	7.47			
6/28/2016	621.1	641.5	5942 S2-10	A-195	370	20.4	4.600	28.34	692.05	5.51	67.14			
6/28/2016	644.5	665.1	5940 N-10	A-196	1455	20.6	4.600	28.34	692.05	5.57	261.45			
6/29/2016	640.5	662	5941 S1-10	A-201	1414	21.5	4.700	25.03	691.96	5.87	240.81	69	6.6	109
6/29/2016	640.4	661.5	5939 S1-2.5	A-202	170	21.1	4.800	25.03	691.96	5.76	29.50			
6/29/2016	641.5	663	5942 S2-10	A-203	834	21.5	4.800	25.03	691.96	5.87	142.03			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/29/ 2016	665.1	686.6	5940 N-10	A-204	385	21.5	4.800	25.03	691.96	5.87	65.57			
7/26/ 2016	682.5	703.9	5941 S1-10	A-209	108	21.4	4.600	18.49	699.645	6.04	17.87	52	4.3	113.59
7/26/ 2016	681.9	703.4	5939 S1-2.5	A-210	38	21.5	4.700	18.49	699.645	6.07	6.26			
7/26/ 2016	683.3	704.9	5942 S2-10	A-211	88	21.6	4.600	18.49	699.645	6.10	14.43			
7/26/ 2016	706.9	728.4	5940 N-10	A-212	102	21.5	4.600	18.49	699.645	6.07	16.80			
7/27/ 2016	703.9	726.8	5941 S1-10	A-217	110	22.9	4.700	18.31	700.94	6.48	16.97	52	4.64	78.176
7/27/ 2016	703.4	726.3	5939 S1-2.5	A-218	96	22.9	4.800	18.31	700.94	6.48	14.81			
7/27/ 2016	704.9	727.8	5942 S2-10	A-219	66.5	22.9	4.800	18.31	700.94	6.48	10.26			
7/27/ 2016	728.4	751.6	5940 N-10	A-220	169	23.2	4.800	18.31	700.94	6.57	25.74			
8/3/ 2016	726.8	749.3	5941 S1-10	A-233	129	22.5	4.600	21.11	694.294	6.25	20.65	49	15.78	142.67
8/3/ 2016	726.3	748.8	5939 S1-2.5	A-234	51	22.5	4.700	21.11	694.294	6.25	8.16			
8/3/ 2016	727.8	750.3	5942 S2-10	A-235	179	22.5	4.600	21.11	694.294	6.25	28.65			
8/3/ 2016	751.6	773.8	5940 N-10	A-236	137	22.2	4.600	21.11	694.294	6.16	22.22			

Table A2. *Particulate matter concentration at site 1 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
8/4/ 2016	749.3	770.4	5941 S1-10	A-241	112	21.1	4.700	17.14	699.27	5.98	18.72	68	7.77	138.4
8/4/ 2016	748.8	769.9	5939 S1-2.5	A-242	34	21.1	4.800	17.14	699.27	5.98	5.68			
8/4/ 2016	750.3	771.4	5942 S2-10	A-243	87	21.1	4.800	17.14	699.27	5.98	14.54			
8/4/ 2016	773.8	795.0	5940 N-10	A-244	85	21.2	4.800	17.14	699.27	6.01	14.14			
8/15/ 2016	770.4	791.4	5941 S1-10	A-249	173	21.0	4.600	21.22	698.08	5.86	29.52	54	3.61	250.74
8/15/ 2016	769.9	790.9	5939 S1-2.5	A-250	28	21.0	4.700	21.22	698.08	5.86	4.78			
8/15/ 2016	771.4	792.4	5942 S2-10	A-251	114	21.0	4.600	21.22	698.08	5.86	19.45			
8/15/ 2016	795.0	816.1	5940 N-10	A-252	119	21.1	4.600	21.22	698.08	5.89	20.21			
8/16/ 2016	791.4	813.3	5941 S1-10	A-257	287	21.9	4.700	22.97	699.007	6.08	47.17	56	3.77	205.15
8/16/ 2016	790.9	812.8	5939 S1-2.5	A-258	75	21.9	4.800	22.97	699.007	6.08	12.33			
8/16/ 2016	792.4	814.3	5942 S2-10	A-259	198	21.9	4.800	22.97	699.007	6.08	32.54			
8/16/ 2016	816.1	837.8	5940 N-10	A-260	198	21.7	4.800	22.97	699.007	6.03	32.84			

A3. Particulate matter concentrations at site 2

S1-10 means sampler on the south side (N means north) of the road about 100 feet from the center of the road with PM_{10} configuration. S2-10 means the sampler is 38 feet from the center of the road. S2-2.5 means a sampler with $PM_{2.5}$ configuration.

Table A3

Particulate matter concentrations at site 2

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
4/20/ 2015	0.5	20.9	6786 S1-10	A-5	564	20.4	5.0	4.916	693.144	6.57	85.84	26		
4/20/ 2015	0.4	20.9	6785 S2-10	A-6	707	20.5	5.0	4.916	693.144	6.64	106.42			
4/20/ 2015	0.2	20.6	6784 S2-2.5	A-7	180	20.4	5.0	4.916	693.144	6.59	27.32			
4/20/ 2015	0.2	20.7	6787 N-10	A-8	211	20.5	5.0	4.916	693.144	6.65	31.75			
4/21/ 2015	20.9	42.9	6786 S1-10	A-13	1090	22	5.0	2.296	696.659	7.14	152.71	23		
4/21/ 2015	20.9	42.8	6785 S2-10	A-14	1813	21.9	5.0	2.296	696.659	7.15	253.60			
4/21/ 2015	20.6	42.5	6784 S2-2.5	A-15	377	21.9	5.0	2.296	696.659	7.13	52.91			
4/21/ 2015	20.7	42.6	6787 N-10	A-16	750	21.9	5.0	2.296	696.659	7.15	104.88			
5/20/ 2015	42.9	63.6	6786 S1-10	A-21	611	20.7	5.0	14.415	702.676	6.60	92.56	4		

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
5/20/ 2015	42.8	63.4	6785 S2-10	A-22	1375	20.6	5.0	14.415	702.676	6.61	208.02			
5/20/ 2015	42.5	63.3	6784 S2-2.5	A-23	161	20.8	5.0	14.415	702.676	6.65	24.20	3		
5/21/ 2015	63.4	84.7	6785 S2-10	A-30	1505	21.3	5.0	15.316	700.686	6.81	220.87			
5/21/ 2015	63.3	84.5	6784 S2-2.5	A-31	210	21.2	5.0	15.316	700.686	6.76	31.07			
5/21/ 2015	63.3	84.6	6787 N-10	A-32	1230	21.3	5.0	15.316	700.686	6.82	180.45			
6/9/ 2015	84.8	105.2	6786 S1-10	A-37	581	20.4	5.0	19.03	694.786	6.42	90.47	24		
6/9/ 2015	84.7	105.1	6785 S2-10	A-38	810	20.4	5.0	19.03	694.786	6.46	125.35			
6/9/ 2015	84.5	104.9	6784 S2-2.5	A-39	189	20.4	5.0	19.03	694.786	6.44	29.34			
6/9/ 2015	84.6	105	6787 N-10	A-40	174	20.4	5.0	19.03	694.786	6.46	26.92			
6/11/ 2015	105.2	113.5	6786 S1-10	A-45	74	8.3	5.0	19.521	696.449	2.61	28.34	11		
6/11/ 2015	105.1	113.4	6785 S2-10	A-46	52	8.3	5.0	19.521	696.449	2.63	19.79			
6/11/ 2015	104.9	113.2	6784 S2-2.5	A-47	80	8.3	5.0	19.521	696.449	2.62	30.55			
6/11/ 2015	105	113.6	6787 N-10	A-48	434	8.6	5.0	19.521	696.449	2.72	159.36			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/11/ 2015	113.5	126.7	6786 S1-10	A-53	8	13.2	5.0	15.038	695.134	4.18	1.91	14		
6/11/ 2015	113.4	126.6	6785 S2-10	A-54	117	13.2	5.0	15.038	695.134	4.21	27.81			
6/11/ 2015	113.2	126.4	6784 S2-2.5	A-55	52	13.2	5.0	15.038	695.134	4.19	12.40			
6/11/ 2015	113.6	126.9	6787 N-10	A-56	688	13.3	5.0	15.038	695.134	4.24	162.27			
6/12/ 2015	126.7	135	6786 S1-10	A-61	38	8.3	5.0	23.429	692.207	2.58	14.71	19		
6/12/ 2015	126.6	134.8	6785 S2-10	A-62	46	8.2	5.0	23.429	692.207	2.57	17.92			
6/12/ 2015	126.4	134.6	6784 S2-2.5	A-63	38	8.2	5.0	23.429	692.207	2.56	14.85			
6/12/ 2015	126.9	135.2	6787 N-10	A-64	513	8.3	5.0	23.429	692.207	2.60	197.34			
6/24/ 2015	135	154.9	6786 S1-10	A-69	149	19.9	4.5	19.99	698.866	5.58	26.71	3	1.17	182.19
6/24/ 2015	134.8	154.7	6785 S2-10	A-70	322	19.9	4.4	19.99	698.866	5.49	58.70			
6/24/ 2015	134.6	154.5	6784 S2-2.5	A-71	92	19.9	4.5	19.99	698.866	5.60	16.42			
6/24/ 2015	135.2	155.2	6787 N-10	A-72	589	20	4.4	19.99	698.866	5.52	106.72			
6/25/ 2015	154.9	175.2	6786 S1-10	A-77	135	20.3	4.4	17.54	700.233	5.58	24.20	1	2.25	196.25

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/25/ 2015	154.7	175	6785 S2-10	A-78	127	20.3	4.3	17.54	700.233	5.48	23.16			
6/25/ 2015	154.5	175.4	6784 S2-2.5	A-79	90	20.9	4.4	17.54	700.233	5.77	15.60			
6/25/ 2015	155.2	175.7	6787 N-10	A-80	127	20.5	4.3	17.54	700.233	5.55	22.90			
7/13/ 2015	175.4	195.7	6786 S1-10	A-85	542	20.3	4.4	21.703	694.047	5.52	98.27	56	3.377	82.82
7/13/ 2015	175.2	195.5	6785 S2-10	A-86	807	20.3	4.4	21.703	694.047	5.56	145.14			
7/13/ 2015	175	195.3	6784 S2-2.5	A-87	141	20.3	4.4	21.703	694.047	5.54	25.45			
7/13/ 2015	175.7	195.8	6787 N-10	A-88	241	20.1	4.4	21.703	694.047	5.51	43.72			
7/14/ 2015	195.7	216.9	6786 S1-10	A-93	718	21.2	4.4	22.053	695.244	5.76	124.63	63	2.582	166.65
7/14/ 2015	195.5	216.6	6785 S2-10	A-94	1439	21.1	4.4	22.053	695.244	5.78	248.93			
7/14/ 2015	195.3	216.5	6784 S2-2.5	A-95	238	21.2	4.4	22.053	695.244	5.79	41.13			
7/14/ 2015	195.8	216.9	6787 N-10	A-96	488	21.1	4.4	22.053	695.244	5.79	84.32			
7/29/ 2015	216.9	237.5	6786 S1-10	A-101	229	20.6	4.515	19.06	700.55	5.81	39.40	25	2.938	116.27
7/29/ 2015	216.6	237.2	6785 S2-10	A-102	518	20.6	4.483	19.06	700.55	5.81	89.12			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
7/29/ 2015	216.5	237.1	6784 S2-2.5	A-103	80	20.6	4.498	19.06	700.55	5.81	13.76			
7/29/ 2015	216.9	237.5	6787 N-10	A-104	407	20.6	4.479	19.06	700.55	5.81	70.02			
7/30/ 2015	237.5	259	6786 S1-10	A-109	625	21.5	4.389	19.82	701.88	6.06	103.10	27	2.487	129.5
7/30/ 2015	237.2	258.7	6785 S2-10	A-110	902	21.5	4.357	19.82	701.88	6.06	148.79			
7/30/ 2015	237.1	258.5	6784 S2-2.5	A-111	120	21.4	4.372	19.82	701.88	6.03	19.89			
7/30/ 2015	237.5	259	6787 N-10	A-112	323	21.5	4.352	19.82	701.88	6.06	53.28			
5/11/ 2016	302.2	324.4	6786 S1-10	A-133	282	22.2	4.600	6.19	698.485	6.53	43.16	48	13.71	81.1
5/11/ 2016	301	323.2	6785 S2-10	A-134	310	22.2	4.700	6.19	698.485	6.53	47.45			
5/11/ 2016	300.9	323.1	6784 S2-2.5	A-135	42	22.2	4.600	6.19	698.485	6.53	6.43			
5/11/ 2016	301	323.6	6787 N-10	A-136	50	22.6	4.600	6.19	698.485	6.65	7.52			
5/12/ 2016	324.4	345.7	6786 S1-10	A-141	500	21.3	4.700	5.76	701.695	6.31	79.28	48	9.29	92.48
5/12/ 2016	323.2	344.2	6785 S2-10	A-142	519	21	4.800	5.76	701.695	6.22	83.47			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
5/12/ 2016	323.1	344.4	6784 S2-2.5	A-143	90	21.3	4.800	5.76	701.695	6.31	14.27			
5/12/ 2016	323.6	344.5	6787 N-10	A-144	32	20.9	4.800	5.76	701.695	6.19	5.17			
5/24/ 2016	345.7	366.7	6786 S1-10	A-149	126	21	4.600	16.1	694.138	5.93	21.24	37	5.59	114.01
5/24/ 2016	344.2	365.2	6785 S2-10	A-150	174	21	4.700	16.1	694.138	5.93	29.34			
5/24/ 2016	344.4	365.5	6784 S2-2.5	A-151	110	21.1	4.600	16.1	694.138	5.96	18.46			
5/24/ 2016	344.5	365.6	6787 N-10	A-152	219	21.1	4.600	16.1	694.138	5.96	36.75			
5/25/ 2016	366.7	388.6	6786 S1-10	A-157	176	21.9	4.700	11.87	693.123	6.27	28.08	43	10.267	268.383
5/25/ 2016	365.2	387.1	6785 S2-10	A-158	367	21.9	4.800	11.87	693.123	6.27	58.55			
5/25/ 2016	365.5	387.4	6784 S2-2.5	A-159	142	21.9	4.800	11.87	693.123	6.27	22.66			
5/25/ 2016	365.6	387.6	6787 N-10	A-160	210	22	4.800	11.87	693.123	6.30	33.35			
5/26/ 2016	388.6	411.1	6786 S1-10	A-165	175	22.5	4.700	12.65	693.662	6.43	27.23	48	4.428	233.633
5/26/ 2016	387.1	409.6	6785 S2-10	A-166	113	22.5	4.800	12.65	693.662	6.43	17.58			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
5/26/ 2016	387.4	409.9	6784 S2-2.5	A-167	176	22.5	4.800	12.65	693.662	6.43	27.38			
5/26/ 2016	387.6	410	6787 N-10	A-168	137	22.4	4.800	12.65	693.662	6.40	21.41			
6/14/ 2016	431.6	452	6786 S1-10	A-181	89	20.4	4.600	17.66	691.93	5.71	15.58	13	7.626	240.82
6/14/ 2016	430.1	450.6	6785 S2-10	A-182	116	20.5	4.700	17.66	691.93	5.74	20.21			
6/14/ 2016	430.3	450.7	6784 S2-2.5	A-183	63	20.4	4.600	17.66	691.93	5.71	11.03			
6/14/ 2016	430.3	450.8	6787 N-10	A-184	161	20.5	4.600	17.66	691.93	5.74	28.05			
6/15/ 2016	452	473.7	6786 S1-10	A-189	126	21.7	4.700	20.26	694.02	6.04	20.86	9	12.61	298.67
6/15/ 2016	450.6	472.3	6785 S2-10	A-190	229	21.7	4.800	20.26	694.02	6.04	37.91			
6/15/ 2016	450.7	472.5	6784 S2-2.5	A-191	70	21.8	4.800	20.26	694.02	6.07	11.53			
6/15/ 2016	450.8	472.5	6787 N-10	A-192	241	21.7	4.800	20.26	694.02	6.04	39.89			
6/28/ 2016	473.7	494.1	6786 S1-10	A-197	209	20.4	4.600	28.34	692.05	5.51	37.92	19	3.4	108
6/28/ 2016	472.3	492.8	6785 S2-10	A-198	995	20.5	4.700	28.34	692.05	5.54	179.66			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
6/28/ 2016	472.5	492.9	6784 S2-2.5	A-199	109	20.4	4.600	28.34	692.05	5.51	19.78			
6/28/ 2016	472.5	493	6787 N-10	A-200	355	20.5	4.600	28.34	692.05	5.54	64.10			
6/29/ 2016	494.1	515.4	6786 S1-10	A-205	223	21.3	4.700	25.03	691.96	5.82	38.33	14	6.6	109
6/29/ 2016	492.8	514.1	6785 S2-10	A-206	476	21.3	4.800	25.03	691.96	5.82	81.82			
6/29/ 2016	492.9	514.2	6784 S2-2.5	A-207	19	21.3	4.800	25.03	691.96	5.82	3.27			
6/29/ 2016	493	514.3	6787 N-10	A-208	153	21.3	4.800	25.03	691.96	5.82	26.30			
7/26/ 2016	535.8	557.2	6786 S1-10	A-213	131	21.4	4.600	18.49	699.645	6.04	21.68	24	4.3	113.59
7/26/ 2016	534.5	556	6785 S2-10	A-214	108	21.5	4.700	18.49	699.645	6.07	17.79			
7/26/ 2016	534.6	556.1	6784 S2-2.5	A-215	40	21.5	4.600	18.49	699.645	6.07	6.59			
7/26/ 2016	534.9	556.3	6787 N-10	A-216	155	21.4	4.600	18.49	699.645	6.04	25.65			
7/27/ 2016	557.2	580.4	6786 S1-10	A-221	72	23.2	4.700	18.31	700.94	6.57	10.96	27	4.64	78.176
7/27/ 2016	556	579	6785 S2-10	A-222	79	23	4.800	18.31	700.94	6.51	12.14			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
7/27/ 2016	556.1	579.1	6784 S2-2.5	A-223	54	23	4.800	18.31	700.94	6.51	8.30			
7/27/ 2016	556.3	579.3	6787 N-10	A-224	168	23	4.800	18.31	700.94	6.51	25.81			
8/3/ 2016	580.4	602.8	6786 S1-10	A-237	323	22.4	4.600	21.11	694.294	6.22	51.93	17	15.78	142.67
8/3/ 2016	579	601.5	6785 S2-10	A-238	420	22.5	4.700	21.11	694.294	6.25	67.22			
8/3/ 2016	579.1	601.6	6784 S2-2.5	A-239	87	22.5	4.600	21.11	694.294	6.25	13.92			
8/3/ 2016	579.3	601.8	6787 N-10	A-240	150	22.5	4.600	21.11	694.294	6.25	24.01			
8/4/ 2016	602.8	623.9	6786 S1-10	A-245	219	21.1	4.700	17.14	699.27	5.98	36.61	15	7.77	138.4
8/4/ 2016	601.5	622.6	6785 S2-10	A-246	301	21.1	4.800	17.14	699.27	5.98	50.32			
8/4/ 2016	601.6	622.7	6784 S2-2.5	A-247	62	21.1	4.800	17.14	699.27	5.98	10.36			
8/4/ 2016	601.8	622.9	6787 N-10	A-248	306	21.1	4.800	17.14	699.27	5.98	51.15			
8/15/ 2016	623.9	644.9	6786 S1-10	A-253	374	21	4.600	21.22	698.08	5.86	63.81	12	3.61	250.74
8/15/ 2016	622.6	643.6	6785 S2-10	A-254	549	21	4.700	21.22	698.08	5.86	93.67			

Table A3. *Particulate matter concentrations at site 2 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
8/15/ 2016	622.7	643.8	6784 S2-2.5	A-255	92	21.1	4.600	21.22	698.08	5.89	15.62			
8/15/ 2016	622.9	643.9	6787 N-10	A-256	426	21	4.600	21.22	698.08	5.86	72.68			
8/16/ 2016	644.9	666.6	6786 S1-10	A-261	324	21.7	4.700	22.97	699.007	6.03	53.74	11	3.77	205.15
8/16/ 2016	643.6	665.4	6785 S2-10	A-262	608	21.8	4.800	22.97	699.007	6.06	100.39			
8/16/ 2016	643.8	665.5	6784 S2-2.5	A-263	190	21.7	4.800	22.97	699.007	6.03	31.52			
8/16/ 2016	643.9	665.7	6787 N-10	A-264	496	21.8	4.800	22.97	699.007	6.06	81.90			

A4. Particulate matter concentrations at site 3

C is for control section, N and S indicate north and south side of the road, respectively. B means brine treated section and M is for magnesium chloride treated section. TSP is for total suspended particulates.

Table A4.

Particulate matter concentrations at site 3

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
8/19/2015	258.5	281.6	C-N-TSP	A-113	4173	23.1	4.530	15.166	701.812	6.62	630.58	35	1.126	261.58
8/19/2015	258.7	281.5	C-S-TSP	A-114	2840	22.8	4.514	15.166	701.812	6.53	434.80			
8/19/2015	405.3	428.3	B-N-TSP	A-115	2738	23.0	4.488	15.166	701.812	6.59	415.54			
8/19/2015	430	453.2	B-S-TSP	A-116	4557	23.2	4.458	15.166	701.812	6.65	685.64			
8/19/2015	406.2	429.3	B-S-PM10	A-117	126	23.1	4.472	15.166	701.812	6.62	19.04			
8/19/2015	406.8	429.9	B-S-PM2.5	A-118	1578	23.1	4.489	15.166	701.812	6.62	238.45			
8/19/2015	259	282	M-N-TSP	A-119	1789	23.0	4.546	15.166	701.812	6.59	271.51			
8/19/2015	259.0	282.1	M-S-TSP	A-120	1854	23.1	4.510	15.166	701.812	6.62	280.16			
8/20/2015	281.6	300.8	C-N-TSP	A-121	1696	19.2	4.499	17.991	698.332	5.42	312.91	10	2.056	137.64
8/20/2015	281.5	301	C-S-TSP	A-122	661	19.5	4.484	17.991	698.332	5.50	120.08			
8/20/2015	428.3	447.4	B-N-TSP	A-123	788	19.1	4.457	17.991	698.332	5.39	146.15			
8/20/2015	453.2	472.2	B-S-TSP	A-124	2056	19.0	4.428	17.991	698.332	5.36	383.33			

Table A4. *Particulate matter concentrations at site 3 (continued)*

Date	Time		Sampler ID	Filter No.	Net Mass	Run Time	Flow Rate	Actual Temp	Actual Pressure	STD Vol	STD Conc.	Vehicle Count	Wind Speed	Wind Direction
	Initial	Final			M_{PM} (µg)	(hrs)	l_{sp} (lpm)	°C	(mm Hg)	(m^3)	(µg/m^3)		mph	Cardinal degree
8/20/2015	429.3	448.4	B-S-PM10	A-125	124	19.1	4.441	17.991	698.332	5.39	23.00			
8/20/2015	429.9	449	B-S-PM2.5	A-126	272	19.1	4.458	17.991	698.332	5.39	50.45			
8/20/2015	282	300.1	M-N-TSP	A-127	801	18.1	4.516	17.991	698.332	5.11	156.77			
8/20/2015	282.1	300.9	M-S-TSP	A-128	506	18.8	4.480	17.991	698.332	5.31	95.34			

APPENDIX B

Table B1

Identification of filters with respect to their locations and sampling date

Filter No.	Site number	Sampling date
A – 9	1	04/21/2015
A – 10	1	04/21/2015
A – 14	2	04/21/2016
A – 15	2	04/21/2015
A – 25	1	05/21/2015
A – 27	1	05/21/2015
A – 30	2	05/21/2015
A – 31	2	05/21/2015
A – 64	2	06/12/2015
A – 94	2	7/14/2015
A – 120	3	8/20/2015
A – 129	1	05/11/2016
A – 150	2	5/24/2016

Table B2

Relative weight percentages of corresponding elements resulting from EDS analysis

SEM sample ID	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Mn	Fe
158426-A9(1)_pt1	49.0	5.8		8.86	33.34					2.9		
158426-A9(1)_pt2	47.9	0.8	1.49	6.61	31.52	0.22			0.2	5.1		5.9
158426-A9(1)_pt3	37.1	0.3	0.74	2.66	13.46	0.32		0.31	0.4	0.6	1.7	42.0
158426-A9(1)_pt4	47.5	1.1	0.61	15.63	26.55		0.7		3.0	1.4		3.3
158426-A9(2)_pt1	46.9	0.9	1.33	6.21	30.12				0.8	3.1		10.4
158426-A9(2)_pt2	50.1	2.4	0.04	6.83	36.67				0.6	2.3		0.8
158426-A9(2)_pt3	53.2			0.03	46.71							
158426-A9(2)_pt4	47.1	2.0	0.35	8.61	31.47				7.4	1.1		1.7

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM sample ID	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe
158426-A9(3)_pt1	53.12	0.37			46.51								
158426-A9(3)_pt2	46.99	1.57	1.63	6.36	31.01		1.00	0.41	1.08	3.66			6.29
158426-A9(3)_pt3	52.22	0.91	0.36	1.58	43.86				0.71	0.37			
158426-A9(4)_pt1	50.50	1.97		0.59	41.07					5.30	0.57		
158426-A9(4)_pt2	51.23	1.12	0.46	2.81	41.05				0.59	1.13			1.62
158426-A9(4)_pt3	53.12	0.37			46.51								
158426-A9(5)_pt1	28.75	39.05			2.43		6.16	10.46	10.65	2.52			
158426-A9(5)_pt2	27.44	24.85		0.83	5.01		6.19	23.17	9.83	2.66			
158426-A9(5)_pt3	32.44	31.04	0.86		9.43		4.98	9.43	9.46	2.35			
158426-A9(5)_pt4	31.69	17.09		0.34	17.51		1.37	15.24	16.76				
158426-A9(6)_pt1	53.26				46.74								
158426-A9(6)_pt2	51.79	0.53	0.54	0.17	40.29	1.03	1.82		2.00	1.83			
158426-A9(6)_pt3	50.79	1.06	0.64	4.46	39.30				1.49	0.54			1.73
158426-A9(6)_pt4	49.45	0.89	0.45	13.13	30.97				1.36	0.62			3.13
158426-A9(7)_pt1	47.87	0.83	1.18	11.64	29.12				3.17	0.85			5.34
158426-A9(7)_pt2	50.24	1.09	0.86	4.66	38.17				1.98	1.18			1.82
158426-A9(8)_pt1	45.77	0.57	2.11	6.39	27.71		0.31	0.55	2.30	5.20			9.09
158426-A9(8)_pt2	51.00	0.92	0.67	2.99	40.43				0.76	0.86			2.36
158426-A9(8)_pt3	53.06	0.54			46.40								
158426-A9(8)_pt4	52.50	0.50	0.11		45.55				0.86	0.48			
158426-A9(8)_pt5	48.79	0.81	1.31	10.89	30.50		0.22		2.01	0.91	0.64		3.92
158426-A9(9)_pt1	45.08	0.75	1.44	2.94	27.02	0.65	0.48		0.48	4.95		0.87	15.34
158426-A9(9)_pt2	43.58		1.55	7.36	22.48			0.32	0.79	1.47			22.45
158426-A9(9)_pt3	47.72			0.14	3.24		22.21			26.69			
158426-A9(9)_pt4	53.24			0.12	46.64								
158426-A9(9)_pt5	53.26				46.74								

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM sample ID	N	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe
158426-A9(10)_pt1			53.02	0.48		0.48	46.02								
158426-A9(10)_pt2			52.68	1.37			45.00	0.68			0.26				
158426-A9(10)_pt3			52.49	0.61	0.42	2.07	43.94				0.47				
158426-A9(11)_pt1			36.08		0.67	2.10	10.86			0.32	0.26	0.46			49.25
158426-A9(11)_pt2			53.26				46.74								
158426-A9(11)_pt3			49.43	1.01	0.64	7.26	35.10				2.63	0.70			3.24
158426-A9(11)_pt4			53.26				46.74								
158426-A9(11)_pt5			53.26				46.74								
158426-A9(2ndDay)(1)_pt1	3.71		55.71	0.66		0.07	38.79		0.35	0.41		0.30			
158426-A9(2ndDay)(1)_pt2			47.30	0.37	2.89	9.20	29.73			0.49	4.87				5.16
158426-A9(2ndDay)(2)_pt1			50.32	0.94	0.47	5.56	37.70				1.59	0.40			3.01

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe
158426-A9(2ndDay)(2)_pt2		47.29	1.07	0.01	8.50	32.66				10.46				
158426-A9(2ndDay)(3)_pt1	6.17	53.28	0.52		6.66	25.57				7.80				
158426-A9(2ndDay)(4)_pt1	2.85	55.29				41.86								
158426-A9(2ndDay)(4)_pt2		49.46	0.49	0.77	3.81	36.34	0.27			0.70	3.56	0.4		4.15
test158426 A9(2)_pt1	9.42	44.91	1.15	0.72	6.34	32.41				1.59	0.67			2.78
158426-A10(1)_pt1	26.3	71.87	0.16			1.33		0.10	0.12	0.06	0.04			
158426-A10(1)_pt2	4.15	56.22		39.63										
158427-A10(2)_pt1	2.31	54.90				42.79								
158427-A10(2)_pt2		47.26	10.68	1.74	1.79	34.44				0.34	3.75			
158427-A10(2)_pt3		45.03				31.29					20.86		1.15	1.67
158427-A10(3)_pt2		50.88	0.48	0.14	0.54	39.19					0.31	7.25		1.21
158427-A10(5)_pt1		46.86	1.30	1.45	11.3	27.03				2.00	3.46			6.63
158427-A10(5)_pt2		53.09	0.41		0.08	46.41								
158427-A10(4)_pt1	18.9	66.52	0.30			13.37	0.47		0.36					
158427-A10(4)_pt2	19.6	65.58	0.44		1.39	8.98	0.20		0.60	0.28	0.53	0.29		2.05
158427-A10(4)_pt3		53.24			0.13	46.63								
158427-A10(46)_pt1		53.25			0.02	46.73								
158427-A10-2ndDay(1)_pt1	2.32	52.02				45.66								

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	Cl	K	Ca	Ti	Mn	Fe	Cu
158427-A10-2ndDay(1)_pt2	6.17	47.68	0.38	0.44	2.01	38.05			0.27	2.82			2.18	
158427-A10-2ndDay(1)_pt3		52.85	0.62		0.09	45.96				0.48				
158427-A10-2ndDay(2)_pt1		45.30	0.37	0.56	1.21	30.63				19.27			2.66	
158427-A10-2ndDay(3)_pt1		51.46	1.07	0.41	1.68	42.34			0.96	0.42			1.67	
158427-A10-2ndDay(3)_pt2		51.33	0.98	0.75	2.30	41.47			0.61	0.67			1.89	
158427-A10-2ndDay(4)_pt1		53.09	0.45		0.02	46.44								
158427-A10-2ndDay(4)_pt2	1.98	52.20				45.82								
158427-A10-2ndDay(4)_pt3		53.17	0.23			46.60								
158427-A10-2ndDay(5)_pt1		48.99	0.82	0.63	8.96	32.76			1.62				6.21	
158427-A10-2ndDay(5)_pt2		53.10	0.43			46.47								
158427-A10-2ndDay(5)_pt3		52.65	0.39			46.09								0.87
158427-A10-2ndDay(5)_pt4		53.12	0.32		0.14	46.42								
158427-A10-2ndDay(6)_pt1		53.07	0.50			46.43								
158427-A10-2ndDay(6)_pt2		53.26				46.74								
158427-A10-2ndDay(6)_pt3		52.99	0.56			45.56	0.60			0.30				

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	Cl	K	Ca	Ti	Mn	Fe
158427-A10-2ndDay(7)_pt1		49.96	0.83	0.82	3.52	37.97			0.68	2.63			3.60
158427-A10-2ndDay(7)_pt2		47.41	0.92	2.27	12.02	27.45			3.09	0.94	0.36		5.55
158427-A10-2ndDay(7)_pt3		45.25	0.23	7.18	15.02	18.66			0.89	0.35	0.69		11.72
158427-A10-2ndDay(7)_pt4		42.57	2.20	1.19	5.03	22.30			0.36	18.40	1.25		6.70
158427-A10-2ndDay(7)_pt5		40.57	0.53	0.84	5.04	18.20			0.43	2.34		1.29	30.76
158427-A10-2ndDay(7)_pt6		52.00	0.52	0.35	2.10	42.93			0.31	0.58			1.19
158427-A10-2ndDay(7)_pt7		50.79	0.31	0.20	1.13	41.40			1.05	1.06			4.05
158427-A10-2ndDay(7)_pt8		53.22			0.28	46.49							
158427-A10-2ndDay(7)_pt9		51.38	0.33	0.77	3.64	40.58			0.50	0.28			2.52
158427-A10-2ndDay(7)_pt10		41.30		0.52	1.09	23.20				32.87			1.03
158427-A14(1)_pt1		49.02	1.16	0.85	8.34	33.17			1.71	1.91	0.36		3.46
158427-A14(2)_pt1	95.66	2.30			0.13	1.92							
158427-A14(2)_pt2	6.31	40.92	0.62	5.08	11.28	17.12			0.82	0.43			17.42
158427-A14(2)_pt3		47.98	1.01	0.58	14.72	28.16			5.11	0.82			1.62
158427-A14(3)_pt1		47.97	0.97	1.70	10.97	29.37			2.42	1.03			5.56

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	O	Na	Mg	Al	Si	P	Cl	K	Ca	Ti	Mn	Fe
158428-A14(5)_pt1	47.65	2.32	0.44	9.12	31.97			7.30				1.20
158428-A14(5)_pt2	49.44	1.06	1.08	6.88	34.71			1.46	0.86	0.46		4.04
158428-A14(5)_pt3	48.92	0.43	1.41	7.12	32.67				0.95	1.08		7.41
158428-A14(5)_pt4	48.94	4.64	0.80	8.59	33.08			0.80	1.78			1.37
158428-A14(5)_pt5	45.75	0.38	7.59	12.33	21.65			1.22	0.66			10.43
158428-A14(5)_pt6	43.64	0.52	6.07	9.08	19.90			0.86	0.60			19.34
158428-A14(5)_pt7	46.70	2.95	1.16	9.68	29.35			6.58	0.95			2.64
158428-A14(6)_pt1	51.97	1.59		2.83	42.63	0.33	0.66					
158428-A14(6)_pt2	53.26				46.74							
158428-A14(6)_pt3	49.26	0.70	0.83	7.38	34.69			3.49	0.81	0.51		2.34
158427-A10-2ndDay(7)_pt1	49.96	0.83	0.82	3.52	37.97			0.68	2.63			3.60
158427-A10-2ndDay(7)_pt2	47.41	0.92	2.27	12.02	27.45			3.09	0.94	0.36		5.55
158427-A10-2ndDay(7)_pt3	45.25	0.23	7.18	15.02	18.66			0.89	0.35	0.69		11.72
158427-A10-2ndDay(7)_pt4	42.57	2.20	1.19	5.03	22.30			0.36	18.40	1.25		6.70
158427-A10-2ndDay(7)_pt5	40.57	0.53	0.84	5.04	18.20			0.43	2.34		1.29	30.76
158427-A10-2ndDay(7)_pt6	52.00	0.52	0.35	2.10	42.93			0.31	0.58			1.19
158427-A10-2ndDay(7)_pt7	50.79	0.31	0.20	1.13	41.40			1.05	1.06			4.05

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	S	Cl	K	Ca	Ti	Mn	Fe
158427-A10-2ndDay(7)_pt8		53.22			0.28	46.49							
158427-A10-2ndDay(7)_pt9		51.38	0.33	0.77	3.64	40.58			0.50	0.28			2.52
158427-A10-2ndDay(7)_pt10		41.30		0.52	1.09	23.20				32.87			1.03
158428-A14(1)_pt1	34.90	27.53	0.95	1.89	3.51	13.37			0.48	13.66	1.89		1.82
158428-A14(1)_pt2	20.22	34.89	1.23	2.73	5.95	17.83			1.31	11.71	1.43		2.70
158428-A14(1)_pt3	67.06	15.35	0.29	0.40	1.20	7.81	0.83		1.04	1.33	4.28		0.41
158428-A14(1)_pt4	18.94	33.27	2.66	3.85	24.44		1.50		2.78	4.63			7.93
158428-A14(2)_pt1		40.55	1.67	1.33	38.62				12.94				4.89
158428-A14(2)_pt2		40.46	13.41	5.10	32.74					8.30			
158428-A14(3)_pt1		40.50	2.35	6.36	31.36				3.02	2.42			13.98
158428-A14(3)_pt2		38.11	18.53		29.29					14.07			
158428-A14(4)_pt1		39.23	6.50	5.13	24.04				4.13	9.83	11.15		
158428-A14(4)_pt2		36.68	11.93	5.32	23.43				6.22	4.76			11.68
158429-A15(1)_pt1		100.00											
158429-A15(1)_pt2		38.60			28.75					32.65			
158429-A15(1)_pt3		47.07			52.93								
158429-A15(2)_pt1	76.56	9.24	6.27		7.93								
158429-A15(2)_pt2	40.49	17.92	0.56	0.29	2.60					38.15			
158429-A15(3)_pt1		38.54	8.21	6.37	22.85					5.07	4.17		14.79
158429-A15(3)_pt2		35.27	41.19		23.54								
158429-A15(4)_pt1	80.79	8.69	0.49	0.03	9.38			0.14	0.17	0.32			
158429-A15(4)_pt2		37.71	15.68	8.59	23.29					14.73			

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	S	Cl	K	Ca	Ti	Mn	Fe
158429-A15(5)_pt1		29.90								7.32			62.78
158429-A15(5)_pt2		33.78	32.34		18.37					15.51			
158429-A15(5)_pt3		38.16	9.81	6.28	26.54				4.68	6.58			7.96
158429-A15(5)_pt4		39.73	6.84	4.69	32.42				6.53	3.61			6.17
158429-A15(6)_pt1		37.71	21.32		28.43					12.55			
158429-A15(6)_pt2		40.46	6.04	3.53	32.18					7.42			10.37
158429-A15(6)_pt3		100.0											
158429-A15(6)_pt4		37.75			36.52				25.73				
158503(1)_pt1	5.67	53.59	0.33	0.96	2.37	27.99			0.37	0.75		0.43	7.53
158503(2)_pt1		50.93	1.85	0.22	2.94	41.08			2.39	0.58			
158503(2)_pt2		48.83	5.89	1.20	1.36	37.62			0.57	4.52			
158503(3)_pt1		51.47	0.67		5.09	40.60			2.17				
158503(4)_pt1		53.01	0.60	0.11		46.28							
158503(4)_pt2		50.94	0.46	0.41	1.27	41.42			0.29	3.48			1.73
158503(4)_pt3		53.03	0.48		0.47	46.03							
158503(4)_pt4		52.30		0.45	1.24	43.21	0.50		0.23	0.35			1.73
158503(4)_pt5		53.15	0.30			46.56							
158503(4)_pt6		50.66	0.60	0.22	0.14	41.71				6.66			
158503(5)_pt1		51.50	1.09	0.26	2.67	41.71			0.48	0.86			1.42
158503(5)_pt2		53.26				46.74							
158503(5)_pt3		53.26				46.74							
158503(5)_pt4		48.95	0.23	3.44	4.51	34.54			1.23	2.14			4.97
158503(5)_pt5		52.97	0.30		0.66	45.85			0.23				
158503(5)_pt6		50.18	0.47	0.17	0.73	40.08				0.35			8.02
158503(5)_pt7		51.56	0.74	0.58	3.13	41.36			0.48	0.60			1.55

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	S	Cl	K	Ca	Ti	Fe
158504(1)_pt1		51.55	0.41	0.34	2.70	41.78			0.90			2.31
158504(1)_pt2		51.02	0.19	0.21	0.30	42.16				4.11		2.00
158504(1)_pt3		49.88	0.26	2.12	10.04	32.49	0.36		0.75			4.10
158504(1)_pt4	10.20	56.34	0.27	3.41	0.70	19.57	0.13		0.30	8.16		0.93
158504(2)_pt1		53.13	0.35		46.52							
158504(2)_pt2		51.3	0.54	2.65	42.26	3.19						
158504(2)_pt3		52.8	0.84	0.13	45.97	0.21						
158504(3)_pt1		48.0	0.45	3.90	0.98	34.42	0.74			9.88		1.24
158504(3)_pt2		52.05	0.87		1.71	43.05	0.38		0.85	1.09		
158504(3)_pt3		50.36	0.70	0.83	1.94	38.85	0.47		0.20	0.59		6.06
158504(3)_pt4		48.99	0.46	3.27	1.85	36.05			0.28	4.95	0.58	3.56
158504(3)_pt5		53.07	0.49			46.43						
158504(3)_pt6		53.26				46.74						
158504(3)_pt7		53.00	0.61	0.12		46.26						
158504(3)_pt8		52.07	0.62	0.31	0.64	43.60			0.31	0.38	1.24	0.83
158504(3)_pt9		51.33	3.09	0.30	3.06	41.22			0.25			0.76
158504(3)_pt10		53.11	0.41			46.49						
158507 A-27 (A)(1)_pt1	27.12	29.23	0.28	0.19	0.37	15.64				26.65		0.54
158507 A-27 (A)(1)_pt2	8.30	46.29	0.48	1.50	4.41	34.49			0.33	0.68	0.25	3.26
158507 A-27 (A)(1)_pt3	5.42	45.90	0.95	2.10	7.00	30.61			1.58			6.44
158507 A-27 (A)(1)_pt4	19.33	35.96	0.40	4.40	6.81	18.27	0.11	0.14	2.06	1.34	0.64	10.54
158509 A-27 (C)(1)_pt1	38.50	24.76	0.34	7.25	0.49	10.69				15.42		2.56
158509 A-27 (C)(1)_pt2	6.51	46.44	4.33		7.33	32.87			0.21	2.30		
158509 A-27 (C)(1)_pt3	5.98	49.42	0.39	0.15	1.87	41.61			0.58			
158509 A-27 (C)(1)_pt4	21.00	40.66	0.27	0.40	1.33	33.24			0.19	1.37		1.53

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Cu
158510 A-27 (D)(1)_pt1	6.26	46.23	0.79	0.99	6.63	32.19				1.36	0.45	0.36	4.75	
158510 A-27 (D)(1)_pt2	8.52	44.44	0.56	0.56	10.32	28.91				4.97			1.73	
158510 A-27 (D)(1)_pt3	63.12	16.98		0.42	1.96	10.85				0.54	4.70		1.44	
158510 A-27 (D)(1)_pt4	4.05	50.67	0.46			44.06					0.77			
158506(5)_pt1	35.89	31.80	0.69	0.45	1.57	24.07		0.70	0.67	0.92	0.83	0.27	1.43	0.71
158506(2)_pt1		37.63	0.98	1.06	3.66	12.52		0.23	0.49	0.39	1.02	0.75	41.27	
158506(2)_pt2		52.48	1.10	0.34	0.76	44.72					0.60			
158506(2)_pt3		50.34	1.13	0.87	5.23	37.84				1.40	1.66		1.53	
158506(2)_pt4		52.97	0.54	0.23	0.33	45.93								
158506(2)_pt5		52.48	0.79	0.25	0.45	45.25								0.78
158506(2)_pt6		52.68	0.73	0.16	0.68	45.26				0.23	0.26			
158506(3)_pt1		50.21	0.95	1.06	7.17	36.11				1.11	0.58		2.81	
158506(3)_pt2		46.95	0.54	1.12	6.34	17.20		8.91		1.30	12.72		4.91	
158506(3)_pt4		51.34	1.04	0.30	4.08	40.40				0.38	0.53		1.91	
158506(4)_pt1		51.55	0.86	0.38	1.46	40.69		1.38	0.31	0.59	1.38		1.39	
158506(4)_pt2		51.34	0.59	0.50	1.74	41.29	0.51			0.54	1.42		2.07	
158506(4)_pt3		51.21	0.69	0.62	3.35	39.71		0.50		0.65	1.25	0.41	1.61	
158506(4)_pt4		53.11	0.39		0.03	46.47								
158506(6)_pt1		50.84	0.82	0.78	8.64	36.33				0.60	0.45		1.55	
158506(6)_pt2		49.05	1.50	0.80	7.40	34.38				2.91	1.71		2.26	
158506(6)_pt3		52.71	0.61	0.22	0.71	45.26				0.26	0.23			
158506(6)_pt4		53.23			0.24	46.53								

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe
158506(7)_pt1		51.52	1.12	0.53	2.98	41.44				0.34	1.29		0.78
158506(7)_pt2		49.72	0.43	3.28	2.16	34.94		1.40		0.27	1.57	0.97	5.26
6-8-15(1)_pt1	11.73	57.68	0.78	0.71	3.75	16.66				0.76	5.75		2.18
6-8-15(1)_pt2		52.45			0.42	44.93					2.20		
6-8-15(1)_pt3		52.50	0.65		1.17	44.59					1.09		
6-8-15(1)_pt4	4.51	52.33	1.51	0.16	7.35	27.48				4.28	1.72		0.66
158514(2)_pt1		53.05	0.33	0.17	0.42	46.03							
158514(2)_pt2		50.58	0.42	0.86	3.14	39.37				0.75	0.93		3.95
158514(2)_pt3		49.90	1.17	1.79	8.57	34.51				1.58	0.79		1.70
158514(2)_pt4		48.18	3.94	0.27	8.65	31.32		0.74		3.29	2.39		1.21
158514(2)_pt5		51.71	0.41	0.51	3.04	41.92				1.19			1.22
158515(1)_pt1		52.60	0.71		0.66	45.25				0.50	0.27		
158515(1)_pt2		52.51	0.61	0.56	2.00	43.96				0.36			
158515(1)_pt3		47.74	0.86	0.75	3.54	32.94				0.28	1.44	1.22	11.24
158515(1)_pt4		50.24	0.52	1.33	0.91	39.79				0.24			6.97
158515(1)_pt5		53.08	0.43		0.10	46.38							
158515(1)_pt6		52.59	1.11	0.31	0.33	45.24					0.42		
158516(1)_pt1		53.10	0.39		0.08	46.43							
158516(1)_pt2		53.05	0.34			46.38					0.22		
158516(1)_pt3		52.52	0.55	0.19	0.85	44.80				0.23	0.24	0.62	
158517(1)_pt1		53.19		0.17	0.22	46.42							
158517(1)_pt2		50.09	0.36	0.61	1.82	39.18				0.48			7.45
158517(1)_pt3		48.85	1.30	0.97	5.22	33.73		0.64		0.65	3.63		5.01
158517(1)_pt4		52.78	0.30			45.87					1.05		
158518(1)_pt1		50.50	0.67	0.64	2.36	39.71				0.51	0.43		5.18
158518(1)_pt2		50.27	2.76	0.56	5.49	37.64				0.88	1.28		1.11
158518(1)_pt3		50.34	0.93	0.25	3.43	39.78				3.38	0.62		1.26
158518(1)_pt4		52.31	1.24	0.51	0.29	44.67					0.99		
158518(1)_pt5		49.44	1.59	0.85	4.32	36.40				0.57	1.43		5.40

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	F	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe
158726 A-64(5)_pt1	12.62	60.52		0.40	0.54	0.12	20.51	1.10	0.28	0.27	1.83	1.81		
158726 A-64(5)_pt2	5.41	52.87		1.14	1.83	9.14	23.09				1.67	1.76	0.22	2.87
158726 A-64(1)_pt1	16.27	40.41		0.51	1.64	5.57	27.60				2.79	1.93		3.27
158726 A-64(1)_pt2	6.51	56.17		2.26	0.13	2.90	30.71				0.79	0.52		
158726 A-64(1)_pt3	4.16	55.06	0.63	0.71	0.33	1.80	36.60				0.36	0.34		
158726 A-64(2)_pt1		50.75		1.01	0.73	7.88	36.94				1.48			1.22
158726 A-64(2)_pt2		51.70		1.28	0.42	1.95	42.48				0.35	0.36		1.45
158726 A-64(2)_pt3		52.66		0.68	0.41	1.28	44.73				0.23			
158726 A-64(2)_pt4		49.48		0.74	1.13	3.87	36.16	0.47			0.53	5.16		2.46
158726 A-64(2)_pt5		48.08		0.80	1.19	9.79	24.21		4.48		3.25	5.46		2.75
158726 A-64(3)_pt1		46.75					16.11		16.2	10.63		10.28		
158726 A-64(3)_pt2		52.96					25.81		13.7			7.50		
158726 A-64(4)_pt1	6.56	53.14		1.92	1.01	8.01	21.47	0.09			3.34	0.73	0.24	3.48
158726 A-64(4)_pt2	14.53	63.51		0.27			21.70							
158727 A-94(1)_pt1		49.41		1.62	0.93	13.65	30.92				2.71	0.29		0.46

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Mo
158727 A-94(1)_pt2	51.20	1.75	1.47	5.11	39.17				0.40	0.39		0.52	
158727 A-94(1)_pt3	48.45	7.99	0.44	9.60	31.73				0.22	0.84		0.72	
158727 A-94 (1)_pt1	53.03	0.21		0.30	46.13					0.35			
158727 A-94 (1)_pt2	53.05	0.55			46.40								
158727 A-94 (1)_pt3	49.91	0.32	2.35	0.98	38.90					5.76		1.78	
158727 A-94 (2)_pt1	46.79	1.92	2.19	8.41	29.51			1.63	2.56	1.52	0.40	5.08	
158727 A-94 (2)_pt2	53.14	0.21		0.31	46.34								
158727 A-94 (3)_pt1	48.58		2.27	1.41	8.86	31.28	0.25		0.98	1.69	0.58	4.10	
158727 A-94 (3)_pt2	41.01	0.32	0.51	13.86	1.84	14.43		2.30	0.42	25.31			
158727 A-94 (3)_pt3	53.08		0.45		0.08	46.39							
158727 A-94 (3)_pt4	40.15		0.61	0.75	1.39	20.88			0.28	35.33		0.62	
158727 A-94 (3)_pt5	30.06											69.94	
158727 A-94 (4)_pt1	53.02	0.56		0.23	46.19								
158727 A-94 (4)_pt2	50.85	0.53	0.79	2.18	41.05			0.24	0.25	2.01		1.37	0.74

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe
158727 A-94 (4)_pt3	50.05	1.39	0.75	7.53	35.96				1.90	0.50		1.91
158727 A-94 (4)_pt4	49.90	0.82	0.76	3.86	37.49				0.95	0.99	0.53	4.69
158727 A-94 (5)_pt1	44.91	1.28	3.88	2.69	28.76		0.78	3.39	1.10	10.43		2.81
158727 A-94 (5)_pt2	47.99	0.75	3.06	5.49	32.43				1.45	6.70		2.11
158727 A-94 (5)_pt3	48.28	0.62	1.13	12.59	29.99				5.34	0.67		1.38
158727 A-94 (5)_pt4	51.55	0.51	0.81	1.74	42.21				0.54	1.10		1.55
158727 A-94 (6)_pt1	50.51	0.26	1.62	0.80	40.39					4.34		2.08
158727 A-94 (6)_pt2	52.42	0.42	0.45	0.81	44.49					1.41		
158727 A-94 (6)_pt3	51.02		0.79	2.53	40.71				0.99	1.19		2.77
158727 A-94 (6)_pt4	51.82	0.39	0.17	3.76	41.90				1.52	0.43		
A-120 (2)_pt1	50.99	0.44		0.64	41.75					5.27	0.91	
A-120 (2)_pt2	49.22	1.00	4.25	3.70	34.34		0.82	0.26	0.94	3.33		2.16
A-120 (2)_pt3	48.57	0.70	1.84	6.02	33.92			0.85	1.43	1.33		5.33
A-120 (2)_pt4	50.18	0.84	0.87	4.95	37.80				1.88	1.28		2.21

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe
A-120 (1)_pt1		52.01	0.35	0.30	2.50	42.93				1.06	0.84		
A-120 (1)_pt2		49.83	0.83	0.60	4.86	36.71				1.19	0.68	0.88	4.42
A-120 (1)_pt3		53.26				46.74							
A-120 (1)_pt4		50.96	0.87	0.65	3.66	39.92				0.69	1.58		1.65
A-129(1)_pt2	55.26	20.66	0.73		0.20	16.47		0.37	2.42	3.27	0.60		
A-129(2)_pt1	78.76	10.97	0.20			8.42		0.70	0.22	0.17	0.55		
A-129(2)_pt2	81.92	9.45	0.18			7.66		0.39	0.17	0.09	0.15		
A-129(5)_pt1	65.44	17.25	0.66		0.18	13.27		0.92	0.87	1.07	0.36		
A-129(5)_pt2	60.15	20.67	0.56			17.47		0.27	0.27	0.40	0.20		
A-129(6)_pt1	87.56	6.23	0.23	0.16		4.34		0.60	0.27	0.20	0.41		
A-129(7)_pt1	84.24	6.25	0.32	0.07		4.36			1.59	0.72	2.44		
A-129(7)_pt2	6.18	49.74	0.53	0.12		43.43							
A-129(11)_pt4	54.17	24.09	0.51	0.19	0.28	20.13	0.41				0.23		
A-129(12)_pt1	71.20	14.31	0.71			11.75		0.32	0.90	0.63	0.18		
A-129(12)_pt2	6.69	49.69				43.61							
A-150(1)_pt1	74.26	13.57	0.69			9.76	1.72						
A-150(1)_pt2	66.77	17.11	0.88	0.21	0.03	13.15	1.24		0.08	0.22	0.31		
A-150(4)_pt1	61.13	20.60	0.20			17.61		0.26			0.19		
A-150(4)_pt2	68.89	16.48	0.21		0.09	13.89		0.29			0.15		
A-150(4)_pt3	78.28	11.45	0.15			9.64		0.20			0.28		

Table B2. *Relative weight percentages of corresponding elements resulting from EDS analysis (continued)*

SEM Sample ID	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe
A-150(9)_pt1	60.59	13.90	0.55	0.54	0.24	8.57		1.12	6.21	8.28			
A-150(13)_pt1	77.22	11.83	0.21			9.14		0.76	0.35		0.49		
A-150(13)_pt2	9.86	47.86	0.38			41.90							
A-150(14)_pt1	90.95	4.82				4.23							
A-150(15)_pt1	54.88	23.75	0.16		0.03	20.73			0.23	0.23			

Table B3

Particulate matter type with respect to filters

Filter No.	Particulate matter type
A – 9	PM_{10}
A – 10	$PM_{2.5}$
A – 14	PM_{10}
A – 15	$PM_{2.5}$
A – 25	$PM_{2.5}$
A – 27	PM_{10}
A – 30	PM_{10}
A – 31	$PM_{2.5}$
A – 64	PM_{10}
A – 94	PM_{10}
A – 120	TSP
A – 129	PM_{10}
A – 150	PM_{10}

Table B4

Particulate matter identification

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A9(1)_pt1	1	PM_{10}	Silicates	Si, O, Al, Na	Ca	42 O, 16 Si, 4 Al, 3 Na, 1 Ca
158426-A9(1)_pt2	1	PM_{10}	Silicates	Si, O, Al	Na, Ca, P, K	434 O, 163 Si, 35 Al, 9 Na, 18 Ca, 1 P, 1 K
158426-A9(1)_pt3	1	PM_{10}	Silicates	Si, O, Al, Fe	Na, Mg, P, Cl, K, Ca, Mn	266 O, 55 Si, 11 Al, 2 Na, 3 Mg, 1 P, 1 Cl, 1 K, 2 Ca, 4 Mn, 86 Fe
158426-A9(1)_pt4	1	PM_{10}	Silicates	Si, Al, O	Na, Mg, S, K, Ca, Fe	136 O, 43 Si, 27 Al, 2 Na, 1 Mg, 1 S, 4 K, 2 Ca, 3 Fe
158426-A9(2)_pt1	1	PM_{10}	Silicates	Si, O, Al	Na, Mg, K, Ca, Fe	142 O, 52 Si, 11 Al, 2 Na, 3 Mg, 1 K, 4 Ca, 9 Fe
158426-A9(2)_pt2	1	PM_{10}	Silicates	Si, O, Al, Mg	Na, K, Ca	201 O, 84 Si, 16 Al, 7 Na, 26 Mg, 1 K, 4 Ca
158426-A9(2)_pt3	1	PM_{10}	Quartz	Si, O	Al	2993 O, 1496 Si, 1 Al
158426-A9(2)_pt4	1	PM_{10}	Silicates	Si, O, Al, K	Na, Mg, Ca, Fe	205 O, 78 Si, 22 Al, 6 Na, 1 Mg, 13 K, 2 Ca, 2 Fe
158426-A9(3)_pt1	1	PM_{10}	Quartz	Si, O	Na	206 O, 103 Si, 1 Na
158426-A9(3)_pt2	1	PM_{10}	Silicates	Si, O, Al, Fe	Na, Mg, S, K, Cl	254 O, 6 Na, 6 Mg, 20 Al, 95 Si, 3 S, 1 Cl, 2 K, 8 Ca, 10 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A9(3)_pt3	1	PM_{10}	Silicates	Si, O, Na	Mg, Al, K, Ca	353 O, 429 Na, 2 Mg, 6 Al, 169 Si, 2 K, 1 Cl
158426-A9(4)_pt1	1	PM_{10}	Quartz	Si, O	Na, Al, Ca, Ti	265 O, 7 Na, 2 Al, 123 Si, 11 Ca, 1 Ti
158426-A9(4)_pt2	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Ti, Fe	269 O, 4 Na, 2 Mg, 9 Al, 123 Si, 1 K, 2 Ca, 1 Ti, 2 Fe
158426-A9(4)_pt3	1	PM_{10}	Quartz	Si, O	Na	206 O, 119 Si, 1 Na
158426-A9(5)_pt1	1	PM_{10}	Chlorides	Na, Cl	O, S, K, Ca, Si	27 Na, 3 O, 1 Si, 3 S, 5 Cl, 4 K, 1 Ca
158426-A9(5)_pt2	1	PM_{10}	Chlorides	O, Na, Cl	Al, Si, S, K, Ca	55 O, 35 Na, 1 Al, 6 Si, 6 S, 21 Cl, 8 K, 2 Ca
158426-A9(5)_pt3	1	PM_{10}	Chlorides	Na, O, Cl	Mg, Al, Si, S K, Ca	65 O, 44 Na, 1 Mg, 1 Al, 11 Si, 5 S, 9 Cl, 8 K, 2 Ca
158426-A9(5)_pt4	1	PM_{10}	Chlorides	Na, O, Si, Cl, K	Al, S	157 O, 59 Na, 1 Al, 49 Si, 3 S, 34 Cl, 34 K
158426-A9(6)_pt1	1	PM_{10}	Quartz	Si, O		2 O, 1 Si
158426-A9(6)_pt2	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, P, S, K, Cl	514 O, 4 Na, 4 Mg, 1 Al, 228 Si, 5 P, 9 S, 8 K, 7 Ca

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A9(6)_pt3	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, P, S, K, Ca	236 O, 3 Na, 2 Mg, 12 Al, 104 Si, 2 P, 4 S, 3 K, 1 Ca
158426-A9(6)_pt4	1	PM_{10}	Silicates	Si, Al, O	Na, Mg, K, Ca, Fe	200 O, 3 Na, 1 Mg, 31 Al, 71 Si, 2 K, 1 Ca, 4 Fe
158426-A9(7)_pt1	1	PM_{10}	Silicates	Si, Al, O	Na, Mg, K, Ca, Fe	141 O, 2 Na, 2 Mg, 20 Al, 49 Si, 4 K, 1 Ca, 5 Fe
158426-A9(7)_pt2	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	107 O, 2 Na, 1 Mg, 6 Al, 46 Si, 2 K, 1 Ca, 1 Fe
158426-A9(8)_pt1	1	PM_{10}	Silicates	O, Al, Si, Ca, Fe	Na, Mg, S, Cl, K	293 O, 3 Na, 9 Mg, 24 Al, 102 Si, 1 S, 2 Cl, 6 K, 13 Ca, 17 Fe
158426-A9(8)_pt2	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, K Ca, Fe	164 O, 2 Na, 1 Mg, 6 Al, 74 Si, 1 K, 1 Ca, 2 Fe
158426-A9(8)_pt3	1	PM_{10}	Quartz	Si, O	Na	141 O, 1 Na, 70 Si
158426-A9(8)_pt4	1	PM_{10}	Quartz	Si, O	Na, Mg, K	725 O, 5 Na, 1 Mg. 358 Si, 5 K
158426-A9(9)_pt2	1	PM_{10}	Silicates	O, Al, Si, Fe	Mg, Cl, K, Ca	302 O, 7 Mg, 30 Al, 89 Si, 1 Cl, 2 K, 4 Ca, Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A9(8)_pt5	1	PM_{10}	Silicates	O, Si, Al	Na, Mg, S, K Ca, Ti, Fe	444 O, 5 Na, 8 Mg, 59 Al, 158 Si, 1 S, 7 K, 3 Ca, 2 Ti, 10 Fe
158426-A9(9)_pt1	1	PM_{10}	Silicates	O, Si, Ca, Fe	Na, Mg, Al, P, S, K, Ca, Ti	229 O, 3 Na, 5 Mg, 9 Al, 78 Si, 2 P, 1 S, 1 K, 10 Ca, 1 Ti, 22 Fe
158426-A9(9)_pt3	1	PM_{10}	Sulfates	O, S, Ca	Si, Al	575 O, 1 Al, 22 Si, 133 S, 128 Ca
158426-A9(9)_pt4	1	PM_{10}	Quartz	Si, O	Al	748 O, 1 Al, 373 Si
158426-A9(9)_pt5	1	PM_{10}	Quartz	Si, O		2 O, 1 Si
158426-A9(10)_pt1	1	PM_{10}	Quartz	Si, O	Na, Al	186 O, 1 Na, 1 Mg, 92 Si
158426-A9(10)_pt2	1	PM_{10}	Quartz	Si, O	Na, P, K	495 O, 9 Na, 241 Si, 1 K
158426-A9(10)_pt3	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, K	273 O, 2 Na, 1 Mg, 6 Al, 130 Si, 1 K
158426-A9(11)_pt1	1	PM_{10}	Silicates	O, Si, Al, Fe	Mg, Cl, K, Ca	339 O, 4 Mg, 12 Al, 58 Si, 1 Cl, 1 K, 2 Ca, 133 Fe
158426-A9(11)_pt2	1	PM_{10}	Quartz	Si, O		2 O, 1 Si
158426-A9(11)_pt3	1	PM_{10}	Silicates	O, Al, Si	Na, Mg, K, Ca, Fe	177 O, 3 Na, 2 Mg, 15 Al, 72 Si, 4 K, 1 Ca, Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A9(11)_pt4	1	PM_{10}	Quartz	Si, O		2 O, 1 Si
158426-A9(11)_pt5	1	PM_{10}	Quartz	Si, O		2 O, 1 Si
158426-A9(2ndDay)(1)_pt1	1	PM_{10}	Quartz	Si, O	N, Na, Al, S, Cl, Ca	102 N, 1342 O, 11 Na, 1 Al, 532 Si, 4 S, 4 Cl, 3 Ca
158426-A9(2ndDay)(1)_pt2	1	PM_{10}	Silicates	Si, Al, O	Na, Mg, Cl, K, Fe	214 O, 1 Na, 9 Mg, 25 Al, 77 Si, 1 Cl, 9 K, Fe
158426-A9(2ndDay)(3)_pt1	1	PM_{10}	K-feldspars	Si, O, K, Al	C, Na	23 C, 147 O, 1 Na, 11 Al, 40 Si, 9 K
158426-A9(2ndDay)(2)_pt1	1	PM_{10}	Silicates	Si, Al, O	Na, Mg, K, Ca Fe	315 O, 4 Na, 2 Mg, 21 Al, 134 Si, 4 K, 1 Ca, 5 Fe
158426-A9(2ndDay)(2)_pt2	1	PM_{10}	Silicates	Si, Al, O, K	Na, Mg	72 O, 1 Na, 1 Mg, 8 Al, 28 Si, 7 K
158426-A9(2ndDay)(4)_pt1	1	PM_{10}	Quartz	Si, O	C	1 C, 15 O, 6 Si
158426-A9(2ndDay)(4)_pt2	1	PM_{10}	Quartz	Si, O	Na, Mg, Al, P, K, Ca, Ti, Fe	355 O, 2 Na, 4 Mg, 16 Al, 148 Si, 1 P, 2 K, 10 Ca, 1 Ti, 9 Fe
test158426 A9(2)_pt1	1	PM_{10}	Quartz	Si, O, C	C, Na, Mg, Al, K, Ca, Fe	47 C, 168 O, 3 Na, 2 Mg, 14 Al, 69 Si, 2 K, 1 Ca, 3 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158426-A10(1)_pt1	1	$PM_{2.5}$	Biological group	C, O	Na, Si, S, Cl, K, Ca	2195 C, 4500 O, 7 Na, 47 Si, 3 S, 3 Cl, 2 K, 1 Ca
158426-A10(1)_pt2	1	$PM_{2.5}$	Quartz	Si, O	C	1 C, 10 O, 4 Si
158427-A10(2)_pt1	1	$PM_{2.5}$	Quartz	Si, O	C	1 C, 18 O, 8 Si
158427-A10(2)_pt2	1	$PM_{2.5}$	Silicates	Si, O, Na	Mg, Al, K, Ca	340 O, 53 Na, 8 Mg, 8 Al, 141 Si, 1 K, 11 Ca
158427-A10(2)_pt3	1	$PM_{2.5}$	Silicates	Si, O, Ca	Mn, Fe	135 O, 53 Si, 25 Ca, 1 Mn, 1 Fe
158427-A10(3)_pt2	1	$PM_{2.5}$	Quartz	Si, O	Na, Mg, Al, Ca, Ti, Fe	552 O, 4 Na, 1 Mg, 3 Al, 242 Si, 1 Ca, 26 Si, 4 Fe
158427-A10(5)_pt1	1	$PM_{2.5}$	Silicates	Si, O, Al	Na, Mg, K, Ca, Fe	57 O, 1 Na, 1 Mg, 8 Al, 19 Si, 1 K, 2 Ca, 2 Fe
158427-A10(5)_pt2	1	$PM_{2.5}$	Quartz	Si, O	Na, Al	1119 O, 6 Na, 1 Al, 557 Si
158427-A10(4)_pt1	1	$PM_{2.5}$	Biological group	C, O, Si	Na, P, Cl	156 C, 409 O, 1 Na, 47 Si, 1 P, 1 Cl
158427-A10(4)_pt2	1	$PM_{2.5}$	Biological group	C, O, Si	Na, Al, P, Cl, K, Ca, Ti, Fe	270 C, 677 O, 3 Na, 9 Al, 53 Si, 1 P, 3 Cl, 1 K, 2 Ca, 1 Ti, 6 Fe
158427-A10-2ndDay(1)_pt1	1	$PM_{2.5}$	Quartz	Si, O	Al	1 C, 17 O, 8 Si

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158427-A10-2ndDay(1)_pt2	1	$PM_{2.5}$	Quartz	Si, O	C, Na, Mg, Al, K, Ca, Fe	74 C, 431 O, 2 Na, 3 Mg, 11 Al, 196 Si, 1 K, 10 Ca, 6 Fe
158427-A10-2ndDay(1)_pt3	1	$PM_{2.5}$	Quartz	Si, O	Na, Al, Ca	990 O, 8 Na, 1 Al, 491 Si, 4 Ca
158427-A10-2ndDay(2)_pt1	1	$PM_{2.5}$	Silicates	O, Si, Ca	Na, Mg, Al, Fe	176 O, 1 Na, 1 Mg, 3 Al, 68 Si, 30 Ca, 3 Fe
158427-A10-2ndDay(3)_pt1	1	$PM_{2.5}$	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	307 O, 4 Na, 2 Mg, 6 Al, 144 Si, 2 K, 1 Ca, 3 Fe
158427-A10-2ndDay(3)_pt2	1	$PM_{2.5}$	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	206 O, 3 Na, 2 Mg, 5 Al, 95 Si, 1 K, 1 Ca, 2 Fe
158427-A10-2ndDay(4)_pt1	1	$PM_{2.5}$	Quartz	Si, O	Na, Al	4476 O, 26 Na, 1 Al, 2231 Si
158427-A10-2ndDay(4)_pt2	1	$PM_{2.5}$	Quartz	Si, O	C	1 C, 20 O, 10 Si
158427-A10-2ndDay(4)_pt3	1	$PM_{2.5}$	Quartz	Si, O	Na	332 O, 1 Na, 166 Si
158427-A10-2ndDay(5)_pt1	1	$PM_{2.5}$	Silicates	Si, O, Al	Na, Mg, K, Fe	118 O, 1 Na, 1 Mg, 13 Al, 45 Si, 2 K, 4 Fe
158427-A10-2ndDay(5)_pt2	1	$PM_{2.5}$	Quartz	Si, O	Na	177 O, 1 Na, 88 Si
158427-A10-2ndDay(5)_pt3	1	$PM_{2.5}$	Quartz	Si, O	Na, Cu	240 O, 1 Na, 120 Si, 1 Cu
158427-A10-2ndDay(5)_pt4	1	$PM_{2.5}$	Quartz	Si, O	Na, Al	640 O, 3 Na, 1 Al, 319 Si

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158427-A10-2ndDay(6)_pt1	1	$PM_{2.5}$	Quartz	Si, O	Na	152 O, 1 Na, 76 Si
158427-A10(4)_pt3	1	$PM_{2.5}$	Quartz	Si, O	Al	691 O, 1 Al, 345 Si
158427-A10(46)_pt1	1	$PM_{2.5}$	Quartz	Si, O	Al	4490 O, 1 Al, 2245 Si
158427-A10-2ndDay(6)_pt2	1	$PM_{2.5}$	Quartz	Si, O		2 O, 1 Si
158427-A10-2ndDay(6)_pt3	1	$PM_{2.5}$	Quartz	Si, O	Na, P, Ca	442 O, 3 Na, 217 Si, 3 P, 1 Ca
158427-A14-2ndDay(7)_pt1	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	179 O, 2 Na, 2 Mg, 7 Al, 78 Si, 1 K, 4 Ca, 4 Fe
158427-A14-2ndDay(7)_pt2	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Ti, Fe	394 O, 5 Na, 12 Mg, 59 Al, 130 Si, 11 K, 3 Ca, 1 Ti, 13 Fe
158427-A14-2ndDay(7)_pt3	2	PM_{10}	Silicates	Si, O, Mg, Al, Fe	Na, K, Ca, Ti	324 O, 1 Na, 34 Mg, 64 Al, 76 Si, 3 K, 1 Ca, 2 Ti, 24 Fe
158427-A14-2ndDay(7)_pt4	2	PM_{10}	Silicates	O, Al, Si, Ca	Na, Mg, K, Mn	289 O, 10 Na, 5 Mg, 20 Al, 86 Si, 1 K, 50 Ca, 3 Mn
158427-A14-2ndDay(7)_pt5	2	PM_{10}	Silicates	O, Si, Fe	Na, Mg, Al, K, Ca	231 O, 2 Na, 3 Mg, 17 Al, 59 Si, 1 K, 5 Ca, 50 Fe
158427-A14-2ndDay(7)_pt6	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K Ca, Fe	410 O, 3 Na, 2 Mg, 10 Al, 193 Si, 1 K, 2 Ca, 3 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158427-A14-2ndDay(7)_pt7	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	386 O, 2 Na, 1 mg, 5 Al, 179 Si, 3 K, 3 Ca, 9 Fe
158427-A14-2ndDay(7)_pt8	2	PM_{10}	Quartz	Si, O	Al	321 O, 1 Al, 160 Si
158427-A14-2ndDay(7)_pt9	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	460 O, 2 Na, 5 Mg, 19 Al, 207 Si, 2 K, 1 Ca, 6 Fe
158427-A14-2ndDay(7)_pt10	2	PM_{10}	Silicates	Ca, Si, O	Mg, Al, Fe	140 O, 1 Mg, 2 Al, 45 Si, 44 Ca, 1 Fe
158427-A14(1)_pt1	2	PM_{10}	Silicates	Si, O, Al	Na, Mg, K, Ca, Ti, Fe	407 O, 7 Na, 5 mg, 41 Al, 157 Si, 4 K, 6 Ca, 1 Ti, 8 Fe
158427-A14(2)_pt1	2	PM_{10}	Soot	C, O	Al, Si	1653 O, 30 O, 1 Al, 14 Si
158427-A14(2)_pt2	2	PM_{10}	Silicates	C, O, Al, Si, Fe	Na, Mg, K, Ca	49 C, 238 O, 3 Na, 19 Mg, 39 Al, 57 Si, 2 K, 1 Ca, 29 Fe
158427-A14(2)_pt3	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, K, Ca, Fe	147 O, 2 Na, 1 Mg, 27 Al, 49 Si, 6 K, 1 Ca, 1 Fe
158427-A14(3)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	117 O, 2 Na, 3 Mg, 16 Al, 41 Si, 2 k, 1 Ca, 4 Fe
158428-A14(5)_pt1	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, K, Fe	164 O, 6 Na, 1 Mg, 19 Al, 63 Si, 10 k, 1 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158428-A14(5)_pt2	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, K, Ca, Ti, Fe	322 O, 5 Na, 5 Mg, 27 Al, 129 Si, 4 K, 2 Ca, 1 Ti, 8 Fe
158428-A14(5)_pt3	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, Ca, Ti, Fe	163 O, 1 Na, 3 Mg, 14 Al, 62 Si, 1 Ca, 1 Ti, 7 Fe
158428-A14(5)_pt4	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, Ca, K, Fe	149 O, 10 Na, 2 Mg, 16 Al, 58 Si, 1 K, 2 Ca, 8 Fe
158428-A14(5)_pt5	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, Ca, K, Fe	174 O, 1 Na, 19 Mg, 28 Al, 47 Si, 2 K, 1 Ca, 11 Fe
158428-A14(5)_pt6	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, Ca, K, Fe	182 O, 2 Na, 17 Mg, 22 Al, 47 Si, 1 K, 1 Ca, 23 Fe
158428-A14(5)_pt7	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, Ca, K, Fe	123 O, 5 Na, 2 Mg, 15 Al, 44 Si, 7 K, 1 Ca, 2 Fe
158428-A14(6)_pt1	2	PM_{10}	Quartz	Si, O	Na, Al, K, Ca	385 O, 8 Na, 12 Al, 180 Si, 1 K, 2 Ca
158428-A14(6)_pt2	2	PM_{10}	Quartz	Si, O		2 O, 1 Si

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158428-A14(6)_pt3	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Ti, Fe	289 O, 3 Na, 3 Mg, 26 Al, 116 Si, 8 K, 2 Ca, 1 Ti, 4 Fe
158427-A10-2ndDay(7)_pt1	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	239 O, 3 Na, 3 Mg, 1 Al, 104 Si, 1 K, 5 Ca, 5 Fe
158427-A10-2ndDay(7)_pt2	2	PM_{10}	Silicates	Si, O, Al	Na, Mg, K, Ca, Ti, Fe	394 O, 5 Na, 12 Mg, 59 Al, 130 Si, 11 K, 3 Ca, 1 Ti, 9 Fe
158427-A10-2ndDay(7)_pt3	2	PM_{10}	Silicates	O, Mg, Al, Si, Fe	Na, K, Ca, Ti	324 O, 1 Na, 34 Mg, 64 Al, 76 Si, 3 K, 1 Ca, 2 Ti, 24 Fe
158427-A10-2ndDay(7)_pt4	2	PM_{10}	Silicates	O, Al, Si, Ca	Na, Mg, K, Ti, Fe	289 O, 10 Na, 5 Mg, 20 Al, 86 Si, 1 K, 50 Ca, 3 Ti, 13 Fe
158427-A10-2ndDay(7)_pt5	2	PM_{10}	Silicates	O, Al, Si, Fe	Na, Mg, K, Ca, Mn	231 O, 2 Na, 3 Mg, 17 Al, 59 Si, 1 K, 5 Ca, 2 Mn, 50 Fe
158427-A10-2ndDay(7)_pt6	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	410 O, 3 Na, 2 Mg, 10 Al, 193 Si, 1 K, 2 Ca, 3 Fe
158427-A10-2ndDay(7)_pt7	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	386 O, 2 Na, 1 Mg, 5 Al, 179 Si, 3 K, 3 Ca, 9 Fe
158427-A10-2ndDay(7)_pt8	2	PM_{10}	Quartz	Si, O	Al	321 O, 1 Al, 160 Si

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158427-A10-2ndDay(7)_pt9	2	PM_{10}	Quartz	Si, O	Na, Mg, Al, K, Ca, Fe	460 O, 2 Na, 5 Mg, 19 Al, 207 Si, 2 K, 1 Ca, 6 Fe
158427-A10-2ndDay(7)_pt10	2	PM_{10}	Silicates	Ca, Si, O	Mg, Al, Fe	140 O, 1 Mg, 2 Al, 45 Si, 44 Ca, 1 Fe
158428-A14(1)_pt1	2	PM_{10}	Biological group	C, Si, O, Ca	Na, Mg, Al, K, Ti, Fe	237 C, 140 O, 3 Na, 6 Mg, 11 Al, 39 Si, 1 K, 28 Ca, 3 Ti, 3 Fe
158428-A14(1)_pt2	2	PM_{10}	Biological group	C, Si, O, Ca	Na, Mg, Al, K, Ti, Fe	56 C, 73 O, 2 Na, 4 Mg, 7 Al, 21 Si, 1 K, 10 Ca, 1 Ti, 2 Fe
158428-A14(1)_pt3	2	PM_{10}	Biological group	C, Si, O	Na, Mg, Al, K, Ti, Fe, Ca, S	760 C, 131 O, 2 Na, 2 Mg, 6 Al, 38 Si, 4 S, 4 K, 5 Ca, 12 Ti, 1 Fe
158428-A14(1)_pt4	2	PM_{10}	Biological group	C, O, Al	Na, Mg, S, K, Ca	34 C, 44 O, 2 Na, 3 Mg, 19 Al, 1 S, 2 K, 2 Ca
158428-A14(2)_pt2	2	PM_{10}	Oxides	O, Na, Al	Mg, Ca	12 O, 3 Na, 1 Mg, 6 Al, 1 Ca
158428-A14(3)_pt1	2	PM_{10}	Oxides	O, Al	Na, Mg, K, Ca, Fe	42 O, 2 Na, 4 Mg, 19 Al, 1 K, 1 Ca, 4 Fe
158428-A14(3)_pt2	2	PM_{10}	Oxides	O, Na, Al, Ca		7 O, 2 Na, 3 Al, 1 Ca

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158428-A14(4)_pt1	2	PM_{10}	Oxides	O, Na, Al, Ti	Mg, K, Ca	23 O, 3 Na, 2 Mg, 9 Al, 1 K, 2 Ca, 2 Ti
158428-A14(4)_pt2	2	PM_{10}	Oxides	O, Na, Al, Fe	Mg, K, Ca	19 O, 4 Na, 2 Mg, 7 Al, 1 K, 1 Ca, 2 Fe
158429-A15(1)_pt2	2	$PM_{2.5}$	Oxides	O, Al, Ca		3 O, 1 Al, 1 Ca
158429-A15(1)_pt3	2	$PM_{2.5}$	Oxides	O, Al		1 O, 1 Al
158429-A15(2)_pt1	2	$PM_{2.5}$	Biological group	C, O, Na, Al		23 O, 2 O, 1 Na, 1 Al
158429-A15(2)_pt2	2	$PM_{2.5}$	Carbonates	C, O, Ca	Na, Mg, Al	282 C, 94 O, 2 Na, 1 Mg, 8 Al, 80 Ca
158429-A15(3)_pt1	2	$PM_{2.5}$	Oxides	O, Na, Al, Fe	Mg, Ca, Ti	28 O, 4 Na, 3 Mg, 10 Al, 1 Ca, 1 Ti, 3 Fe
158429-A15(3)_pt2	2	$PM_{2.5}$	Oxides	O, Na, Al		3 O, 2 Na, 1 Al
158429-A15(4)_pt1	2	$PM_{2.5}$	Oxides	C, O, Al	Na, Mg, Cl, K, Ca	5449 O, 440 O, 17 Na, 1 Mg, 282 Al, 3 Cl, 4 K, 6 Ca
158429-A15(4)_pt2	2	$PM_{2.5}$	Oxides	O, Na, Mg, Al Ca		7 O, 2 Na, 1 Mg, 2 Al, 1 Ca
158429-A15(5)_pt1	2	$PM_{2.5}$	Oxides	O, Ca, Fe		10 O, 1 Ca, 6 Fe
158429-A15(5)_pt2	2	$PM_{2.5}$	Oxides	O, Na, Al, Ca		5 O, 4 Na, 2 Al, 1 Ca
158429-A15(5)_pt3	2	$PM_{2.5}$	Oxides	O, Na, Al	Mg, K, Ca, Fe	20 O, 4 Na, 2 Mg, 8 Al, 1 K, 1 Ca, 1 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158428-A14(2)_pt1	2	PM_{10}	Oxides	O, Al, K	Na, Mg, K, Fe	46 O, 1 Na, 1 Mg, 26 Al, 6 K, 2 Fe
158429-A15(5)_pt4	2	$PM_{2.5}$	Oxides	O, Al	Na, Mg, K, Ca, Fe	28 O, 3 Na, 2 Mg, 13 Al, 2 K, 1 Ca, 1 Fe
158429-A15(6)_pt1	2	$PM_{2.5}$	Oxides	O, Na, Al, Ca		8 O, 3 Na, 3 Al, 1 Ca
158429-A15(6)_pt2	2	$PM_{2.5}$	Oxides	O, Na, Al, Fe	Mg, Ca	17 O, 2 Na, 1 Mg, 8 Al, 1 Ca, 1 Fe
158429-A15(6)_pt4	2	$PM_{2.5}$	Oxides	O, Al, K		4 O, 2 Al, 1 K
158503(1)_pt1	1	$PM_{2.5}$	Silicates	O, Si, Fe, C	Na, Mg, Al, K, Ca, Mn	60 C, 428 O, 2 Na, 5 Mg, 11 Al, 127 Si, 1 K, 2 Ca, 1 Mn, 17 Fe
158503(2)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca	352 O, 9 Na, 1 Mg, 12 Al, 162 Si, 7 K, 2 Ca
158503(2)_pt2	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca	209 O, 18 Na, 3 Mg, 3 Al, 92 Si, 1k, 8 Ca
158503(3)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na, Al, K	110 O, 1 Na, 6 Al, 50 Si, 2 K
158503(4)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg	732 O, 6 Na, 1 Mg, 364 Si
158503(4)_pt2	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	429 O, 3 Na, 2 Mg, 6 Al, 199 Si, 1 K, 12 Ca, 4 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158503(4)_pt3	1	$PM_{2.5}$	Quartz	O, Si	Na, Al	190 O, 1 Na, 1 Mg, 94 Si
158503(4)_pt4	1	$PM_{2.5}$	Quartz	O, Si	Mg, Al, S, K, Ca, Fe	556 O, 3 Mg, 8 Al, 262 Si, 3 S, 1 K, 1 Ca, 5 Fe
158503(4)_pt5	1	$PM_{2.5}$	Quartz	O, Si	Na	254 O, 1 Na, 127 Si
158503(4)_pt6	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, Ca	610 O, 5 Na, 2 Mg, 1 Al, 286 Si, 32 Ca
158503(5)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	301 O, 4 Na, 1 Mg, 9 Al, 139 Si, 1 K, 2 Ca, 2 Fe
158503(5)_pt2	1	$PM_{2.5}$	Quartz	O, Si,		2 O, 1 Si
158503(5)_pt3	1	$PM_{2.5}$	Quartz	O, Si,		2 O, 1 Si
158503(5)_pt4	1	$PM_{2.5}$	Silicates	O, Si, Mg, Al	Na, K, Ca, Fe	306 O, 1 Na, 14 Mg, 17 Al, 123 Si, 3 K, 5 Ca, 9 Fe
158503(5)_pt5	1	$PM_{2.5}$	Quartz	O, Si	Na, Al, K	563 O, 2 Na, 4 Al, 278 Si, 1 K
158503(5)_pt6	1	$PM_{2.5}$	Silicates	O, Si, Fe	Na, Mg, Al, Ca	448 O, 3 Na, 1 Mg, 4 Al, 204 Si, 1 Ca, 21 Fe
158503(5)_pt7	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	263 O, 3 Na, 2 Mg, 9 Al, 120 Si, 1 K, 1 Ca, 2 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158504(1)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Fe	230 O, 1 Na, 1 Mg, 7 Al, 106 Si, 2 K, 3 Fe
158504(1)_pt2	1	$PM_{2.5}$	Silicates	O, Si, Ca	Na, Mg, Al, Fe	386 O, 1 Na, 1 Mg, 1 Al, 182 Si, 12 Ca, 4 Fe
158504(1)_pt3	1	$PM_{2.5}$	Silicates	O, Si, Al	Na, Mg, S, K, Fe	278 O, 1 Na, 8 Mg, 103 Si, 1 S, 2 K, 7 Fe
158504(1)_pt4	1	$PM_{2.5}$	Silicates	O, C, Si, Mg, Ca	Na, Al, S, K, Fe	209 C, 869 O, 3 Na, 35 Mg, 6 Al, 172 Si, 1 2 K, 50 Ca, 4 Fe
158504(2)_pt1	1	$PM_{2.5}$	Quartz	O, Si	Na	218 O, 1 Na, 109 Si
158504(2)_pt2	1	$PM_{2.5}$	Quartz	O, Si	Na, Al, K	217 O, 1 Na, 7 Al, 102 Si, 6
158504(2)_pt3	1	$PM_{2.5}$	Quartz	O, Si	Na, Al, K	685 O, 8 Na, 1 Al, 340 Si, 1 K
158504(3)_pt1	1	$PM_{2.5}$	Silicates	O, Si, Ca	Na, Mg, Al, S, Fe	154 O, 1 Na, 8 Mg, 2 Al, 63 Si, 1 S, 13 Ca, 1 Fe
158504(3)_pt2	1	$PM_{2.5}$	Quartz	O, Si	Na, Al, S, K, Ca	275 O, 3 Na, 5 Al, 129 Si, 1 S, 2 K, 2 Ca

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158504(3)_pt3	1	$PM_{2.5}$	Silicates	O, Si	Na, Mg, Al, S, K, Ca, Fe	615 O, 6 Na, 7 Mg, 14 Al, 270 Si, 3 S, 1 K, 3 Ca, 21 Fe
158504(3)_pt4	1	$PM_{2.5}$	Silicates	O, Si, Al, Mg, Ca	Na, K, Ti, Fe	427 O, 3 Na, 19 Mg, 10 Al, 1 K, 17 Ca, 2 Ti, 9 Fe
158504(3)_pt5	1	$PM_{2.5}$	Quartz	O, Si		2 O, 1 Si
158504(3)_pt6	1	$PM_{2.5}$	Quartz	O, Si		2 O, 1 Si
158504(3)_pt7	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg	671 O, 5 Na, 1 Mg, 334 Si
158504(3)_pt8	1	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Ti, Fe	410 O, 3 Na, 2 Mg, 3 Al, 196 Si, 1 K, 1 Ca, 3 Ti, 2 Fe
158504(3)_pt9	1	$PM_{2.5}$	Silicates	O, Si, Na, Al	Mg, K, Fe	502 O, 21 Na, 2 Mg, 18 Al, 230 Si, 1 K, 2 Fe
158504(3)_pt10	1	$PM_{2.5}$	Quartz	O, Si	Na	186 O, 1 Na, 93 Si
158507 A-27 (A)(1)_pt1	1	PM_{10}	Silicates	C, O, Si, Ca	Na, Mg, Al, Fe	289 C, 234 O, 2 Na, 1 Mg, 2 Al, 71 Si, 85 Ca, 1 Fe
158507 A-27 (A)(1)_pt2	1	PM_{10}	Silicates	C, Si, O, Al	Na, Mg, K, Ca, Ti, Fe	132 C, 554 O, 4 Na, 12 Mg, 31 Al, 235 Si, 2 K, 3 Ca, 1 Ti, 11 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158507 A-27 (A)(1)_pt3	1	PM_{10}	Silicates	C, O, Si, Al	Na, Mg, K, Fe	11 C, 71 O, 1 Na, 2 Mg, 6 Al, 27 Si, 1 K, 1 Fe
158507 A-27 (A)(1)_pt4	1	PM_{10}	Silicates	C, O, Si, Mg, . Fe	Na, P, Cl, K, Ca, Ti	453 C, 633 Si, 5 Na, 51 Mg, 71 Al, 183 Si, 1 P, 1 Cl, 15 K, 9 Ca, 4 Ti, 53 Fe
158509 A-27 (C)(1)_pt1	1	PM_{10}	Silicates	C, O, Mg, Si, Ca	Na, Al, Fe	217 C, 105 O, 1 Na, 20 Mg, 1 Al, 26 Si, 26 3 Fe
158509 A-27 (C)(1)_pt2	1	PM_{10}	Silicates	C, O, Si	Na, Al, K, Ca	101 C, 540 O, 35 Na, 51 Al, 218 Si, 1 K, 11 Ca
158509 A-27 (C)(1)_pt3	1	PM_{10}	Quartz	O, Si	C, Na, Mg, Al, K	81 C, 500 O, 3 Na, 1 Mg, 11 Al, 240 Si, 2 K
158509 A-27 (C)(1)_pt4	1	PM_{10}	Silicates	C, O, Si	Na, Mg, Al, K, Ca, Fe	360 C, 523 O, 2 Na, 3 Mg, 10 Al, 244 Si, 1 K, 7 Ca, 6 Fe
158510 A-27 (D)(1)_pt1	1	PM_{10}	Silicates	C, O, Si, Al	Na, Mg, K, Ca, Ti, Fe	69 C, 384 O, 5 Na, 5 Mg, 33 Al, 152 Si, 5 K, 1 Ca, 1 Ti, 11 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158510 A-27 (D)(1)_pt2	1	PM_{10}	Silicates	C, Si, Al, O	Na, Mg, K, Fe	31 C, 121 O, 1 Na, 1 Mg, 17 Al, 45 Si, 6 K, 1 Fe
158510 A-27 (D)(1)_pt3	1	PM_{10}	Biological Group	C, O, Si	Mg, Al, K, Ca, Fe	380 C, 77 O, 1 Mg, 5 Al, 28 Si, 1 K, 8 Ca, 2 Fe
158510 A-27 (D)(1)_pt4	1	PM_{10}	Quartz	C, O, Si	Na, Ca	18 C, 165 O, 1 Na. 82 Si, 1 Ca
158506(5)_pt1	2	PM_{10}	Silicates	C, O, Si	Na, Mg, Al, S, Cu, Cl, K, Ca, Ti, Fe	530 C, 352 O, 5 Na, 3 Mg, 10 Al, 152 Si, 4 S, 3 Cl, 4 K, 4 Ca, 1 Ti, 5 Fe, 2 Cu
158506(2)_pt1	2	PM_{10}	Silicates	O, Al, Si, Fe	Na, Mg, S, Cl, K, Ca, Ti, Fe	328 O, 6 Na, 6 Mg, 19 Al, 62 Si, 1 S, 2 Cl, 1 K, 4 Ca, 2 Ti, 103 Fe
158506(2)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, Ca	234 O, 3 Na, 1 Mg, 2 Al, 114 Si, 1 Ca
158506(2)_pt3	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca	88 O, 1 Na, 1 Mg, 5 Al, 38 Si, 1 K, 1 Ca
158506(2)_pt4	2	PM_{10}	Quartz	O, Si	Na, Mg, Al	388 O, 3 Na, 1 Mg, 1 Al, 192 Si
158506(2)_pt5	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, Cu	350 O, 2 Na, 1 Mg, 1 Al, 173 Si, 1 Cu

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158506(2)_pt6	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca	560 O, 5 Na, 1 Mg, 4 Al, 274 Si, 1 K, 1 Ca
158506(3)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	217 O, 3 Na, 3 Mg, 18 Al, 89 Si, 2 K, 1 Ca, Fe
158506(3)_pt2	2	PM_{10}	Silicates	O, Al, Si, S, Ca	Na, Mg, K, Fe	125 O, 1 Na, 2 Mg, 10 Al, 26 Si, 12 S, 1 K, 14 Ca, 4 Fe
158506(3)_pt4	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	330 O, 5 Na, 1 Mg, 16 Al, 148 Si, 1 K, 1 Ca, 4 Fe
158506(4)_pt1	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, S, Cl, K, Ca, Fe	368 O, 4 Na, 2 Mg, 6 Al, 166 Si, 5 S, 1 Cl, 2 K, 4 Ca, 3 Fe
158506(4)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, P, K, Ca, Fe	232 O, 2 Na, 1 Mg, 5 Al, 106 Si, 1 P, 1 K, 3 Ca, 3 Fe
158506(4)_pt3	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, S, K, Ca, Ti, Fe	374 O, 4 Na, 3 Mg, 14 Al, 164 Si, 2 S, 2 K, 4 Ca, 1 Ti, 3 Fe
158506(4)_pt4	2	PM_{10}	Quartz	O, Si	Na, Al	2985 O, 15 Na, 1 Al, 1488 Si
158506(6)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	283 O, 3 Na, 3 Mg, 29 Al, 115 Si, 1 K, 1 Ca, 2 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158506(6)_pt2	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	93 O, 2 Na, 1 Mg, 8 Al, 37 Si, 2 K, 1 Ca, 1 Fe
158506(6)_pt3	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca	574 O, 5 Na, 2 Mg, 5 Al, 281 Si, 1 K, 1 Ca
158506(6)_pt4	2	PM_{10}	Quartz	O, Si	Al	374 O, 1 Al, 186 Si
158506(7)_pt1	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	370 O, 6 Na, 3 Mg, 13 Al, 170 Si, 1 K, 4 Ca, 2 Fe
158506(7)_pt2	2	PM_{10}	Silicates	O, Si, Mg, Al	Na, S, K, Ca, Ti, Fe	450 O, 3 Na, 20 Mg, 12 Al, 180 Si, 6 S, 1 K, 6 Ca, 3 Ti, 2 Fe
6-8-15(1)_pt1	2	PM_{10}	Silicates	C, O, Si, Al, Fe	Na, Mg, S, K, Ca, Ti	141 C, 522 O, 5 Na, 4 Mg, 20 Al, 180 Si, 6 S, 1 K, 6 Ca, 3 Ti, 14 Fe
6-8-15(1)_pt2	2	PM_{10}	Quartz	O, Si	Al, Ca	211 O, 1 Al, 103 Si, 4 Ca
158515(1)_pt1	2	$PM_{2.5}$	Quartz	O, Si	Na, Al, K, Ca,	488 O, 5 Na, 4 Al, 239 Si, 2 K, 1 Ca
158515(1)_pt2	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K	356 O, 3 Na, 3 Mg, 8 Al, 170 Si, 1 K

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158515(1)_pt3	2	$PM_{2.5}$	Silicates	O, Si, Al, Fe	Na, Mg, K, Ca, Ti	417 O, 5 Na, 4 Mg, 18 Al, 164 Si, 1 K, 5 Ca, 4 Ti, 28 Fe
158515(1)_pt4	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Fe	511 O, 4 Na, 9 Mg, 5 Al, 231 Si, 1 K, 20 Fe
158515(1)_pt5	2	$PM_{2.5}$	Quartz	O, Si	Na, Al	895 O, 5 Na, 1 Al, 446 Si
158515(1)_pt6	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, Ca	314 O, 5 Na, 1 Mg, 1 Al, 154 Si, 1 Ca
158516(1)_pt1	2	$PM_{2.5}$	Quartz	O, Si	Na, Al	1119 O, 6 Na, 1 Al, 558 Si
158516(1)_pt2	2	$PM_{2.5}$	Quartz	O, Si	Na	224 O, 1 Na, 112 Si
158516(1)_pt3	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	558 O, 4 Na, 1 Mg, 5 Al, 271 Si, 1 K, 1 Ca, 2 Fe
158517(1)_pt1	2	$PM_{2.5}$	Quartz	O, Si	Mg, Al	475 O, 1 Mg, 1 Al, 236 Si
158517(1)_pt2	2	$PM_{2.5}$	Silicates	O, Si, Fe	Na, Mg, Al, K	255 O, 1 Na, 2 Mg, 5 Al, 114 Si, 1 K, 11 Fe
158517(1)_pt3	2	$PM_{2.5}$	Silicates	O, Si, Al, Fe, Ca	Na, Mg, S, K	184 O, 3 Na, 2 Mg, 12 Al, 72 Si, 1 S, 1 K, 5 Ca, 5 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158517(1)_pt4	2	$PM_{2.5}$	Quartz	O, Si	Na, Ca	253 O, 1 Na, 125 Si, 2 Ca
158518(1)_pt1	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	294 O, 3 Na, 2 Mg, 8 Al, 132 Si, 1 K, 1 Ca, 9 Fe
158518(1)_pt2	2	$PM_{2.5}$	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	158 O, 6 Na, 1 Mg, 10 Al, 67 Si, 1 K, 2 Ca, 1 Fe
158518(1)_pt3	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	306 O, 4 Na, 1 Mg, 12 Al, 138 Si, 8 K, 2 Ca, 2 Fe
6-8-15(1)_pt3	2	PM_{10}	Quartz	O, Si	Na, Al, Ca	121 O, 1 Na, 2 Al, 58 Si, 1 Ca
6-8-15(1)_pt4	2	PM_{10}	Silicates	O, Si, C, Al, K	Na, Mg, Ca, Fe	57 C, 497 O, 10 Na, 1 Mg, 41 Al, 241 Si, 17 K, 7 Ca, 2 Fe
158514(2)_pt1	2	PM_{10}	Quartz	O, Si	Na, Mg, Al	474 O, 2 Na, 1 Mg, 2 Al, 234 Si
158514(2)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	173 O, 1 Na, 2 Mg, 6 Al, 77 Si, 1 Ki, 1 Ca, 4 Fe
158514(2)_pt3	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	158 O, 3 Na, 4 Mg, 16 Al, 62 Si, 2 K, 1 Ca, 2 Fe
158514(2)_pt4	2	PM_{10}	Silicates	O, Si, Na, Al	Mg, S, K, Ca, Fe	271 O, 15 Na, 1 Mg, 29 Al, 100 Si, 2 S, 8 K, 5 Ca, 2 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158514(2)_pt5	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Fe	181 O, 1 Na, 1 Mg, 6 Al, 84 Si, 2 K, 1 Fe
158518(1)_pt4	2	$PM_{2.5}$	Quartz	O, Si	Na, Mg, Al, Ca	304 O, 5 Na, 2 Mg, 1 Al, 148 Si, 2 Ca
158518(1)_pt5	2	$PM_{2.5}$	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	212 O, 5 Na, 2 Mg, 11 Al, 89 Si, 1 K, 2 Ca, 7 Fe
158726 A-64(5)_pt1	2	PM_{10}	Biological Group	O, Si, C	Na, Mg, Al, P, S, Cl, K, Ca	236 C, 850 O, 4 Na, 5 Mg, 1 Al, 164 Si, 8 P, 2 S, 2 Cl, 11 K, 10 Ca
158726 A-64(5)_pt2	2	PM_{10}	Silicates	C, O, Al, Si	Na, Mg, K, Ca, Ti, Fe	98 C, 719 O, 11 Na, 16 Mg, 74 Al, 179 Si, 9 K, 10 Ca, 1 Ti, 11 Fe
158726 A-64(1)_pt1	2	PM_{10}	Silicates	C, O, Si, Al	Na, Mg, K, Ca, Fe	61 C, 114 O, 1 Na, 3 Mg, 9 Al, 44 Si, 3 K, 2 Ca, 3 Fe
158726 A-64(1)_pt2	2	PM_{10}	Silicates	C, O, Si, Al, Na	Mg, K, Ca	101 C, 656 O, 18 Na, 1 Mg, 20 Al, 204 Si, 4 K, 2 Ca,
158726 A-64(1)_pt3	2	PM_{10}	Quartz	C, O, Si	Na, Mg, Al, K, Ca	41 C, 406 O, 4 Na, 2 Mg, 8 Al, 154 Si, 1 K, 1 Ca, 4 F
158726 A-64(2)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Fe	122 O, 2 Na, 1 Mg, 11 Al, 51 Si, 1 K, 1 Fe
158726 A-64(2)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	370 O, 6 Na, 2 Mg, 8 Al, 173 Si, 1 K, 1 Ca, 3 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158726 A-64(2)_pt3	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K	559 O, 5 Na, 3 Mg, 8 Al, 271 Si, 1 K
158726 A-64(2)_pt4	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, P, K, Ca, Fe	228 O, 2 Na, 3 Mg, 11 Al, 95 Si, 1 P, 1 K, 9 Ca, 3 Fe
158726 A-64(2)_pt5	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, S, K, Ca, Fe	86 O, 1 Na, 1 Mg, 10 Al, 25 Si, 4 S, 2 K, 4 Ca, 1 Fe
158726 A-64(3)_pt1	2	PM_{10}	Silicates	O, Si, S, Cl, Ca		11 O, 2 Si, 2 S, 1 Cl, 1 Ca
158726 A-64(3)_pt2	2	PM_{10}	Silicates	O, Si, S, Ca		18 O, 5 Si, 2 S, 1 Ca
158726 A-64(4)_pt1	2	PM_{10}	Silicates	O, C, Al, Si, S	Na, Mg, P, K, Ca, Ti, Fe	188 C, 1143 O, 29 Na, 14 Mg, 102 Al, 263 Si, 1 P, 147 S, 29 K, 6 Ca, 2 Ti, 21 Fe
158726 A-64(4)_pt2	2	PM_{10}	Biological Group	C, O, Si	Na	103 C, 338 O, 1 Na, 66 Si
158727 A-94(1)_pt1	2	PM_{10}	Silicates	O, Al, Si	Na, Mg, K, Ca, Fe	427 O, 10 Na, 5 Mg, 70 Al, 152 Si, 10 K, 1 Ca, 1 Fe
158727 A-94(1)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	344 O, 8 Na, 6 Mg, 20 Al, 150 Si, 1 K, 1 Ca, 1 Fe
158727 A-94(1)_pt3	2	PM_{10}	Silicates	O, Si, Na, Al	Mg, K, Ca, Fe	538 O, 62 Na, 3 Mg, 63 Al, 201 Si, 1 K, 4 Ca, 2 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158727 A-94 (1)_pt1	2	PM_{10}	Quartz	O, Si	Na, Al, Ca	379 O, 1 Na, 1 Al, 188 Si, 1 Ca
158727 A-94 (1)_pt2	2	PM_{10}	Quartz	O, Si	Na	139 O, 1 Na, 69 Si
158727 A-94 (1)_pt3	2	PM_{10}	Silicates	O, Si, Ca	Na, Mg, Al, Fe	224 O, 1 Na, 7 Mg, 3 Al, 99 Si, 10 Ca, 2 Fe
158727 A-94 (2)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, Cl, K, Ca, Ti, Fe	350 O, 10 Na, 11 Mg, 37 Al, 126 Si, 6 Cl, 8 K, 5 Ca, 1 Ti, 11 Fe
158727 A-94 (2)_pt2	2	PM_{10}	Quartz	O, Si	Na, Al	363 O, 1 Na, 1 Al, 181 Si
158727 A-94 (3)_pt1	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, P, K, Ca, Ti, Fe	376 O, 12 Na, 7 Mg, 41 Al, 138 Si, 1 P, 3 K, 5 Ca, 2 Ti, 9 Fe
158727 A-94 (3)_pt2	2	PM_{10}	Silicates	O, Mg, Si, Ca	Na, Al, S, K, F	768 O, 7 A, 171 Mg, 20 Al, 154 Si, 22 S, 3 K, 189 Ca, 1 F
158727 A-94 (3)_pt3	2	PM_{10}	Quartz	O, Si	Na, Al	1119 O, 7 Na, 1 Al, 557 Si
158727 A-94 (3)_pt4	2	PM_{10}	Silicates	O, Si, Ca	Na, Mg, Al, K, Fe	350 O, 4 Na, 4 Mg, 7 Al, 104 Si, 1 K, 123 Ca, 2 Fe
158727 A-94 (3)_pt5	2	PM_{10}	Oxides	O, Fe		1 O, 1 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158727 A-94 (4)_pt1	2	PM_{10}	Quartz	O, Si	Na, Al	389 O, 3 Na, 1 Al, 193 Si
158727 A-94 (4)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, Cl, K, Ca, Fe, Mo	497 O, 4 Na, 5 Mg, 13 Al, 229 Si, 1 Cl, 1 K, 8 Ca, 4 Fe, 1 Mo
158727 A-94 (4)_pt3	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	251 O, 5 Na, 2 Mg, 22 Al, 103 Si, 4 K, 1 Ca, 3 Fe
158727 A-94 (4)_pt4	2	PM_{10}	Silicates	O, Si, Al	Na, Mg, K, Ca, Ti, Fe	282 O, 3 Na, 3 Mg, 13 Al, 121 Si, 2 K, 2 Ca, 1 Ti, 8 Fe
158727 A-94 (5)_pt1	2	PM_{10}	Silicates	O, Si, Ca	Na, Mg, Al, S, Cl, K, Fe	115 O, 2 Na, 7 Mg, 4 Al, 1 S, 4 Cl, 1 K, 11 Ca, 2 Fe
158727 A-94 (5)_pt2	2	PM_{10}	Silicates	O, Si, Al, Ca, Mg	Na, K, Fe	92 O, 1 Na, 4 Mg, 6 Al, 35 Si, 1 K, 5 Ca, 1 Fe
158727 A-94 (5)_pt3	2	PM_{10}	Silicates	O, Si, Al, K	Na, Mg, Ca, Fe	180 O, 2 Na, 3 Mg, 28 Al, 64 Si, 8 K, 1 Ca, 1 Fe
158727 A-94 (5)_pt4	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	233 O, 2 Na, 2 Mg, 5 Al, 109 Si, 1 K, 2 Ca, 2 Fe
158727 A-94 (6)_pt1	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, Ca, Fe	279 O, 1 Na, 6 Mg, 3 Al, 127 Si, 10 Ca, 3 Fe
158727 A-94 (6)_pt2	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, Ca	184 O, 1 Na, 1 Mg, 2 Al, 89 Si, 2 Ca

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
158727 A-94 (6)_pt3	2	PM_{10}	Quartz	O, Si	Mg, Al, K, Ca, Fe	126 O, 1 Mg, 4 Al, 59 Si, 1 K, 1 Ca, 2 Fe
158727 A-94 (6)_pt4	2	PM_{10}	Quartz	O, Si	Na, Mg, Al, K, Ca	463 O, 2 Na, 1 Mg, 20 Al, 213 Si, 6 K, 2 Ca
A-120 (2)_pt1	3	TSP	Quartz	O, Si	Na, Al, Ca, Ti	168 O, 1 Na, 1 Al, 78 Si, 7 Ca, 1 Ti
A-120 (2)_pt2	3	TSP	Silicates	O, Mg, Al, Si, Ca	Na, S, Cl, K, Fe	419 O, 6 Na, 24 Mg, 19 Al, 167 Si, 3 S, 1 Cl, 3 K, 11 Ca, 5 Fe
A-120 (2)_pt3	3	TSP	Silicates	O, Al, Si	Na, Mg, Cl, K, Ca. Fe	127 O, 1 Na, 3 Mg, 9 Al, 50 Si, 1 Cl, 2 K, 1 Ca, 4 Fe
A-120 (2)_pt4	3	TSP	Silicates	O, Si, Al	Na, Mg, K, Ca, Fe	98 O, 1 Na, 1 Mg, 6 Al, 42 Si, 2 K, 1 Ca, 1 Fe
A-120 (1)_pt1	3	TSP	Quartz	O, Si	Na, Mg, Al, K, Ca	263 O, 1 Na, 1 Mg, 8 Al, 124 Si, 2 K, 2 Ca
A-120 (1)_pt2	3	TSP	Silicates	O, Si, Al	Na, Mg, K, Ca, Ti, Fe	184 O, 2 Na, 1 Mg, 11 Al, 77 Si, 2 K, 1 Ca, 1 Ti, 5 Fe
A-120 (1)_pt3	3	TSP	Quartz	O, Si		2 O, 1 Si
A-120 (1)_pt4	3	TSP	Quartz	O, Si	Na, Mg, Al, K, Ca, Fe	180 O, 2 Na, 2 Mg, 8 Al, 81 Al, 1 K, 2 Ca, 2 Fe

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
A-129(1)_pt2	1	PM_{10}	Biological Group	C, O, Si	Na, Al, S, Cl, K, Ca	621 C, 174 O, 4 Na, 1 Al, 79 Si, 2 S, 9 Cl, 11 K, 2 Ca
A-129(2)_pt1	1	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, K, Ca	1508 C, 158 O, 2 Na, 69 Si, 5 S, 1 Cl, 1 K, 3 Ca
A-129(2)_pt2	1	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, K, Ca	2963 C, 257 O, 3 Na, 118 Si, 5 S, 2 Cl, 1 K, 2 Ca
A-129(5)_pt1	1	PM_{10}	Biological Group	C, O, Si	Na, Al, S, Cl, K, Ca	817 C, 162 O, 4 Na, 1 Al, 71 Si, 4 S, 4 Cl, 4 K, 1 Ca
A-129(5)_pt2	1	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, K, Ca	1003 C, 259 O, 5 Na, 125 Si, 2 S, 2 Cl, 2 K, 1 Ca
A-129(6)_pt1	1	PM_{10}	Soot	C, O, Si	Na, Mg, S, Cl, K, Ca	1425 C, 76 O, 2 Na, 1 Mg, 30 Si, 4 S, 1 Cl, 1 K, 2 Ca
A-129(7)_pt1	1	PM_{10}	Biological Group	C, O, Si	Na, Mg, Cl, K, Ca	2435 C, 136 O, 5 Na, 1 Mg, 54 Si, 16 Cl, 6 K, 21 Ca
A-129(7)_pt2	1	PM_{10}	Quartz	O, Si	C, Na, Mg	104 C, 630 O, 5 Na, 1 Mg, 313 Si
A-129(11)_pt4	1	PM_{10}	Biological Group	C, O, Si	Na, Mg, Al, P, Ca	742 C, 262 O, 4 Na, 1 Mg, 2 Al, 125 Si, 2 P, 1 Ca
A-129(12)_pt1	1	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, K, Ca	1320 C, 199 O, 7 Na, 93 Si, 2 S, 6 Cl, 4 K, 1 Ca

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
A-129(12)_pt2	1	PM_{10}	Quartz	C, O, Si		1 C, 6 O, 3 Si
A-150(1)_pt1	2	PM_{10}	Biological Group	C, O , Si	Na, P	206 C, 28 O, 1 Na, 12 Si, 2 P
A-150(1)_pt2	2	PM_{10}	Biological Group	C, O, Si	Na, Mg, Al, P, Cl, K, Mo	5000 C, 962 O, 34 Na, 8 Mg, 1 Al, 421 Si, 36 P, 2 Cl, 5 K, 3 Mo
A-150(4)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca	1073 C, 272 O, 2 Na, 132 Si, 2 S, 1 Ca
A-150(4)_pt2	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca, Al	1720 C, 309 O, 3 Na, 1 Al, 148 Si, 3 S, 1 Ca
A-150(4)_pt3	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca	1045 C, 115 O, 1 Na, 55 Si, 1 S, 1 Ca
A-150(9)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, Mg, Al, S, Cl, Ca	567 C, 98 O, 3 Na, 2 Mg, 1 Al, 34 Si, 4 S, 20 Cl, 23 Ca
A-150(13)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, Ca	704 C, 81 O, 1 Na, 36 Si, 3 S, 1 Cl, 1 Ca
A-150(13)_pt2	2	PM_{10}	Quartz	C, O, Si	Na	50 C, 181 O, 1 Na, 90 Si
A-150(14)_pt1	2	PM_{10}	Biological Group	C, O, Si		50 C, 2 O, 1 Si

Table B4. *Particulate matter identification (continued)*

SEM ID number	Site number	Particle type	Mineral group	Major elements	Minor elements	Formulas from SEM data
A-129(12)_pt2	1	PM_{10}	Quartz	C, O, Si		1 C, 6 O, 3 Si
A-150(1)_pt1	2	PM_{10}	Biological Group	C, O , Si	Na, P	206 C, 28 O, 1 Na, 12 Si, 2 P
A-150(1)_pt2	2	PM_{10}	Biological Group	C, O, Si	Na, Mg, Al, P, Cl, K, Mo	5000 C, 962 O, 34 Na, 8 Mg, 1 Al, 421 Si, 36 P, 2 Cl, 5 K, 3 Mo
A-150(4)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca	1073 C, 272 O, 2 Na, 132 Si, 2 S, 1 Ca
A-150(4)_pt2	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca, Al	1720 C, 309 O, 3 Na, 1 Al, 148 Si, 3 S, 1 Ca
A-150(4)_pt3	2	PM_{10}	Biological Group	C, O, Si	Na, S, Ca	1045 C, 115 O, 1 Na, 55 Si, 1 S, 1 Ca
A-150(9)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, Mg, Al, S, Cl, Ca	567 C, 98 O, 3 Na, 2 Mg, 1 Al, 34 Si, 4 S, 20 Cl, 23 Ca
A-150(13)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, S, Cl, Ca	704 C, 81 O, 1 Na, 36 Si, 3 S, 1 Cl, 1 Ca
A-150(13)_pt2	2	PM_{10}	Quartz	C, O, Si	Na	50 C, 181 O, 1 Na, 90 Si
A-150(14)_pt1	2	PM_{10}	Biological Group	C, O, Si		50 C, 2 O, 1 Si
A-150(15)_pt1	2	PM_{10}	Biological Group	C, O, Si	Na, Cl, K	777 C, 252 O, 1 Na, 125 Si, 1 Cl, 1 K

APPENDIX C

Table C1

Elemental compositions in soil samples (analyzed by ICP-MS)

Elements	Li	Be	B	Na	Mg	Al	P	S	K	Ca
Unit Symbol	ppm	ppm	ppm	%	%	%	%	%	%	%
Detection Limit	0.1	0.1	1	0.001	0.01	0.01	0.001	0.001	0.01	0.01
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-ICP	AR-ICP	AR-MS	AR-MS
14-N1-38	15	0.7	8	0.044	0.73	2.66	0.062	0.048	0.42	0.44
14-N2-100	11.1	0.6	7	0.023	0.53	2.05	0.062	0.054	0.37	0.38
14-N3-200	10.4	0.6	5	0.021	0.51	2.07	0.059	0.042	0.34	0.39
14-N4-300	10.6	0.7	7	0.018	0.51	2.14	0.064	0.042	0.37	0.44
14-S1-38	15.3	0.7	9	0.02	0.75	2.6	0.06	0.033	0.38	0.44
14-S2-100	15.2	0.8	8	0.016	0.77	2.6	0.068	0.04	0.41	0.47
14-S3-200	17.2	0.8	10	0.019	0.88	3.03	0.069	0.043	0.48	0.48
14-S4-300	12.7	0.7	7	0.018	0.65	2.39	0.067	0.039	0.4	0.43
15-1N1-38-1	11.2	0.5	3	0.019	0.58	1.69	0.063	0.046	0.3	0.53
15-1N1-38-2	11.5	0.5	3	0.02	0.62	1.61	0.062	0.057	0.26	0.61
15-1N1-38-3	11.9	0.5	3	0.019	0.63	1.68	0.074	0.057	0.31	0.67
15-1S1-38-1	13.5	0.4	4	0.064	0.93	1.51	0.059	0.107	0.18	1.48
15-1S1-38-2	16.7	0.5	4	0.105	1.17	1.53	0.063	0.116	0.16	1.64
15-1S1-38-3	12.6	0.5	3	0.061	0.84	1.46	0.057	0.077	0.17	1.31
15-1S2-100-1	14.2	0.6	4	0.018	0.74	2.03	0.069	0.044	0.34	0.57
15-1S2-100-2	12.6	0.5	3	0.02	0.65	1.86	0.065	0.039	0.31	0.52
15-1S2-100-3	14.8	0.6	3	0.018	0.75	2.05	0.067	0.041	0.32	0.54

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Li	Be	B	Na	Mg	Al	P	S	K	Ca
Unit Symbol	ppm	ppm	ppm	%	%	%	%	%	%	%
Detection Limit	0.1	0.1	1	0.001	0.01	0.01	0.001	0.001	0.01	0.01
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-ICP	AR-ICP	AR-MS	AR-MS
15-2-N-38	22.2	1	5	0.031	0.76	2.48	0.07	0.051	0.31	0.52
15-2-N-100	19.5	0.9	3	0.03	0.62	2.33	0.064	0.042	0.3	0.38
15-2-N-200	18.7	0.9	4	0.033	0.61	2.34	0.063	0.043	0.31	0.41
15-2-N-300	18.4	1	4	0.03	0.6	2.4	0.069	0.043	0.31	0.43
15-2-S-38	23.6	0.9	4	0.114	1.12	2.19	0.059	0.127	0.16	1.34
15-2-S-100	26.5	1.2	4	0.026	0.89	2.9	0.069	0.039	0.32	0.45
15-2-S-200	26.9	1.2	5	0.024	0.89	2.9	0.072	0.042	0.33	0.46
15-2-S-300	22	1	4	0.029	0.74	2.57	0.07	0.039	0.33	0.41
15-3-N-38	20	0.9	3	0.029	0.68	2.24	0.07	0.05	0.27	0.55
15-3-N-100	17.8	0.9	2	0.027	0.58	2.22	0.064	0.039	0.29	0.35
15-3-N-200	18.3	1	5	0.028	0.63	2.38	0.078	0.055	0.31	0.48
15-3-N-300	14.7	0.7	1	0.027	0.49	1.89	0.064	0.033	0.25	0.36
15-3-S-38	22.6	0.9	4	0.074	0.91	2.15	0.057	0.115	0.18	0.93
15-3-S-100	23.4	1.1	4	0.03	0.78	2.73	0.069	0.038	0.33	0.44
15-3-S-200	24.2	1	4	0.026	0.81	2.82	0.072	0.044	0.35	0.4
15-3-S-300	24.4	1.1	5	0.029	0.84	2.81	0.073	0.041	0.35	0.46
15-4-N-38	22.1	0.9	3	0.027	0.73	2.4	0.067	0.079	0.24	0.46
15-4-N-100	17.5	0.8	2	0.027	0.57	2.14	0.063	0.044	0.27	0.34
15-4-N-200	16.1	0.8	1	0.029	0.54	2.05	0.066	0.043	0.25	0.36
15-4-N-300	17.6	0.9	2	0.03	0.6	2.26	0.065	0.043	0.27	0.42

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Li	Be	B	Na	Mg	Al	P	S	K	Ca
Unit Symbol	ppm	ppm	ppm	%	%	%	%	%	%	%
Detection Limit	0.1	0.1	1	0.001	0.01	0.01	0.001	0.001	0.01	0.01
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-ICP	AR-ICP	AR-MS	AR-MS
15-4-S-38	23.1	0.9	3	0.077	0.91	2.32	0.062	0.066	0.21	0.77
15-4-S-100	26.3	1.2	6	0.029	0.88	3.01	0.073	0.042	0.36	0.45
15-4-S-200	20.4	0.9	3	0.028	0.7	2.47	0.074	0.042	0.3	0.42
15-4-S-300	18.6	0.8	2	0.026	0.64	2.23	0.069	0.033	0.29	0.39
15-4-B-N	16.2	1	3	0.039	0.48	1.73	0.057	0.055	0.23	0.56
15-4-B-S	27.3	1.1	18	0.398	1.18	2.03	0.072	0.087	0.26	2.39
15-4-C-N	24	1.2	5	0.031	0.67	2.21	0.047	0.039	0.23	0.98
15-4-C-S	20.6	1.1	5	0.035	0.77	1.88	0.05	0.049	0.22	1.56
15-4-M-N	17.5	0.6	5	0.114	1.33	1.05	0.05	0.059	0.14	2.77
15-4-M-S	18.7	1	4	0.052	0.77	1.71	0.058	0.052	0.18	1.94
15-5-R-C	74	1.5	64	0.089	1	1.29	0.057	0.094	0.12	5.51
15-5-R-T	16.5	1.2	16	0.294	0.61	1.64	0.045	0.146	0.2	1.39
16-1-S-38	12	0.7	13	0.1	1.7	2	0.071	0.087	0.3	1.7
16-1-S-100	11.4	1	15	0.1	1.2	2.3	0.092	0.062	0.6	0.7
16-1-S-200	12.6	0.9	14	< 0.001	1.2	2.5	0.084	0.061	0.6	0.6
16-1-S-300	11	0.8	13	< 0.001	1.1	2.1	0.083	0.056	0.6	0.6
16-1-N-38	10.7	0.8	13	< 0.001	1.1	2	0.078	0.05	0.5	0.7
16-1-N-100	9.7	0.8	14	< 0.001	0.9	2	0.08	0.056	0.6	0.5
16-1-N-200	9.5	0.9	12	< 0.001	1	2	0.091	0.062	0.5	0.6

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Li	Be	B	Na	Mg	Al	P	S	K	Ca
Unit Symbol	ppm	ppm	ppm	%	%	%	%	%	%	%
Detection Limit	0.1	0.1	1	0.001	0.01	0.01	0.001	0.001	0.01	0.01
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-ICP	AR-ICP	AR-MS	AR-MS
16-1-N-300	9.4	0.9	12	< 0.001	0.9	2.1	0.076	0.05	0.6	0.6
16-2-S-38	10.9	0.8	13	0.1	1.4	1.9	0.077	0.074	0.4	1.3
16-2-S-100	13.5	1	15	< 0.001	1.3	2.4	0.086	0.049	0.6	0.6
16-2-S-200	14.9	1.1	16	< 0.001	1.5	2.8	0.086	0.048	0.6	0.6
16-2-S-300	11.9	0.9	14	< 0.001	1.2	2.2	0.081	0.047	0.6	0.6
16-N-38	9.4	0.6	13	0.1	1	1.7	0.069	0.048	0.4	0.9
16-2-N-100	9.2	0.8	13	< 0.001	0.9	1.9	0.077	0.052	0.6	0.5
16-2-N-200	10.5	0.9	13	< 0.001	1.1	2.2	0.087	0.061	0.6	0.6
16-2-N-300	10.3	0.8	14	< 0.001	1	2.2	0.067	0.057	0.5	0.6
Elements	V	Cr	Ti	Mn	Fe	Co	Ni	Cu	Zn	Ga
Unit Symbol	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	1	1	0.01	1	0.01	0.1	0.1	0.01	0.1	0.02
Analysis Method	AR-MS	AR-MS	AR-ICP	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N1-38	56	39	0.05	595	2.6	11.4	32	27.1	94.5	6.67
14-N2-100	48	32	0.05	571	2.19	10.2	26.2	20	81.3	4.98
14-N3-200	48	32	0.05	631	2.12	10.9	26.7	18.5	84.9	4.88
14-N4-300	50	34	0.05	700	2.29	11.6	29.8	17.8	87.5	4.85
14-S1-38	55	37	0.05	603	2.61	11.3	32.8	26.4	87.6	6.59

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	V	Cr	Ti	Mn	Fe	Co	Ni	Cu	Zn	Ga
Unit Symbol	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	1	1	0.01	1	0.01	0.1	0.1	0.01	0.1	0.02
Analysis Method	AR-MS	AR-MS	AR-ICP	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-S2-100	55	36	0.05	657	2.67	11.4	31.3	28	95.1	6.02
14-S3-200	61	41	0.06	714	2.95	12.2	33.6	31.6	103	7.66
14-S4-300	51	34	0.05	626	2.55	11	28.9	25.5	92.1	5.85
15-1N1-38-1	46	28	0.02	641	2.36	10.8	27.3	21.8	90.3	5.84
15-1N1-38-2	48	28	0.02	668	2.51	11.3	31.6	22.9	87.6	4.45
15-1N1-38-3	46	31	0.02	684	2.49	10.8	28.8	24.3	92.5	6.43
15-1S1-38-1	47	31	0.03	559	2.53	12	31.8	23	79.3	4.5
15-1S1-38-2	45	32	0.03	707	2.53	12.5	38.9	25.7	82	4.92
15-1S1-38-3	45	28	0.02	509	2.39	10.8	29.8	20.7	71.6	5.16
15-1S2-100-1	53	37	0.02	731	2.89	12.1	35.3	29.4	98.3	6.74
15-1S2-100-2	48	30	0.02	669	2.6	11.1	28.9	24.9	88.8	6.64
15-1S2-100-3	54	35	0.02	707	2.89	12.1	33.5	30.9	92.3	6.77
15-2-N-38	53	31	0.05	566	2.18	9.6	31.7	30.3	93.5	1.24
15-2-N-100	51	31	0.05	526	1.95	9.5	29.8	23	84.2	< 0.02
15-2-N-200	52	32	0.05	563	1.96	9.6	30.3	26.2	89.8	< 0.02
15-2-N-300	56	33	0.05	607	2.1	10.4	33.1	24.8	91.6	< 0.02
15-2-S-38	41	120	0.06	393	2.13	9.7	97.5	28.3	74.7	2.15
15-2-S-100	55	90	0.05	565	2.43	10.4	49.5	37.5	96.7	2.46

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	V	Cr	Ti	Mn	Fe	Co	Ni	Cu	Zn	Ga
Unit Symbol	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	1	1	0.01	1	0.01	0.1	0.1	0.01	0.1	0.02
Analysis Method	AR-MS	AR-MS	AR-ICP	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-2-S-200	56	35	0.05	574	2.41	9.7	34.2	45.4	99.5	2.81
15-2-S-300	53	39	0.05	520	2.22	9.5	32.6	29.3	93	0.76
15-3-N-38	49	28	0.05	502	2.01	8.8	29.7	26.8	87	0.68
15-3-N-100	50	31	0.05	531	1.93	9.2	29.3	22.9	84.7	0.19
15-3-N-200	51	31	0.05	603	1.98	9.6	30.5	26.8	105	< 0.02
15-3-N-300	46	26	0.05	515	1.77	8.6	25.8	16.2	79.4	< 0.02
15-3-S-38	50	31	0.05	370	2.04	8.6	31.9	25.2	73.1	2.15
15-3-S-100	56	33	0.05	545	2.34	9.7	34.1	31.8	98	1.31
15-3-S-200	55	34	0.05	551	2.31	9.4	32	33.5	94.3	2.81
15-3-S-300	59	35	0.05	565	2.45	10.2	34.8	33.6	103	1.43
15-4-N-38	51	29	0.05	425	2	8.7	31.7	27.1	81.4	1.65
15-4-N-100	49	27	0.05	482	1.86	8.5	29.6	22.7	77.2	0.2
15-4-N-200	48	26	0.05	492	1.78	9	28.3	20.4	76.7	< 0.02
15-4-N-300	54	30	0.06	561	1.97	9.8	32.8	21.9	87.1	< 0.02
15-4-S-38	52	29	0.06	451	2.15	10.2	33.1	28	80	2.21
15-4-S-100	59	34	0.05	559	2.44	9.9	34.6	36.9	97.4	2.96
15-4-S-200	53	29	0.05	537	2.18	9.2	30.3	27.4	95.4	0.66
15-4-S-300	51	28	0.05	508	2.21	9.2	31.3	24.8	85.5	0.15
15-4-B-N	40	21	0.05	670	2.37	8.1	27.3	19.6	72.1	< 0.02
15-4-B-S	49	27	0.06	847	2.8	9.9	36.5	27.5	74.4	< 0.02

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	V	Cr	Ti	Mn	Fe	Co	Ni	Cu	Zn	Ga
Unit Symbol	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	1	1	0.01	1	0.01	0.1	0.1	0.01	0.1	0.02
Analysis Method	AR-MS	AR-MS	AR-ICP	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-4-C-N	42	24	0.05	526	2.08	8.3	27.3	21.1	63.8	< 0.02
15-4-C-S	40	22	0.04	722	2.96	8.7	27.3	20.2	64.6	< 0.02
15-4-M-N	22	13	0.04	447	1.28	4.7	18.3	9.43	36.8	< 0.02
15-4-M-S	40	21	0.04	670	2.71	7.5	30.3	17	70.2	< 0.02
15-5-R-C	54	24	0.04	2330	7.24	11.7	35.3	25.5	72	< 0.02
15-5-R-T	39	23	0.08	689	3.26	5	18.2	17.9	30.9	< 0.02
16-1-S-38	45	33	0.06	384	2.7	8.3	38.8	26.9	93.3	3.6
16-1-S-100	45	33	0.06	518	2.6	8.7	41.7	29.9	111	3.6
16-1-S-200	47	36	0.06	520	2.8	8.7	45.8	33.6	120	4.2
16-1-S-300	45	33	0.05	467	2.6	8	37.8	29	111	3.8
16-1-N-38	44	30	0.05	468	2.5	8.4	33.8	25.4	101	3.6
16-1-N-100	44	30	0.06	483	2.3	9.1	47.8	22.5	100	3.3
16-1-N-200	45	32	0.05	581	2.4	9.5	42.8	26	123	3.3
16-1-N-300	49	34	0.05	601	2.5	10.2	39.6	24.3	115	3.4
16-2-S-38	43	29	0.06	368	2.4	8.2	46	23.1	86.3	3.4
16-2-S-100	49	35	0.06	511	2.8	9.5	42.9	35.2	110	4.9
16-2-S-200	52	38	0.06	513	3	9.8	43.5	38.2	116	5.3
16-2-S-300	48	33	0.05	476	2.7	9.1	34.1	29.3	111	4.2
16-N-38	41	27	0.05	412	2.2	7.9	30.9	21.9	90	3.3
16-2-N-100	44	29	0.06	508	2.3	9.3	32.8	25.3	106	3.5

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	V	Cr	Ti	Mn	Fe	Co	Ni	Cu	Zn	Ga
Unit Symbol	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	1	1	0.01	1	0.01	0.1	0.1	0.01	0.1	0.02
Analysis Method	AR-MS	AR-MS	AR-ICP	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
16-2-N-200	47	33	0.07	543	2.5	9.8	37.1	27.3	110	3.7
16-2-N-300	50	34	0.06	552	2.5	10.2	41.7	23.6	106	3.5

Elements	Ge	As	Se	Rb	Sr	Y	Zr	Sc	Pr	Gd
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N1-38	< 0.1	6.1	0.8	22.1	61.8	10.7	3.6	5.5	4.9	3.5
14-N2-100	< 0.1	6.1	0.7	18.2	64.6	9.91	2.7	4	5	3.3
14-N3-200	< 0.1	6	0.5	18.3	84.6	10	2.4	4.4	4.8	3.2
14-N4-300	< 0.1	6.6	0.7	18	98.6	10.9	2.6	4.7	5	3.5
14-S1-38	< 0.1	5.9	0.7	21.1	67.4	10.7	3.7	5.4	4.9	3.5
14-S2-100	< 0.1	5.6	0.8	22.2	55.7	10.4	3.6	5.1	5.1	3.6
14-S3-200	< 0.1	5.7	0.9	26.2	49.6	11.5	3.9	5.9	5.1	3.7
14-S4-300	< 0.1	5.6	0.8	19.4	71.8	10.1	2.7	5	4.6	3.3
15-1N1-38-1	0.2	6.5	1.3	10.4	73.4	8.09	4.6	4.3	4	2.6
15-1N1-38-2	0.3	5.9	1.2	8.7	56.6	7.81	4	4.6	3.9	2.7
15-1N1-38-3	0.3	5.8	1.4	10.8	64.1	7.55	4.5	4	3.9	2.8
15-1S1-38-1	0.3	6.2	0.7	8.5	79.7	7.99	4.2	5.4	4	2.8
15-1S1-38-2	0.3	4.7	1.6	9.1	96.7	8.49	7.1	4.9	3.9	2.8
15-1S1-38-3	0.3	5.2	1.3	7.2	90.9	7.37	3.9	4.2	3.8	2.6
15-1S2-100-1	0.2	6.6	1.2	12.5	62.8	8.27	4.7	5.3	4.4	2.9

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Ge	As	Se	Rb	Sr	Y	Zr	Sc	Pr	Gd
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-1S2-100-2	0.3	6.7	1.1	11.8	72.3	8.07	4.1	4.4	4	2.7
15-1S2-100-3	0.3	6.4	1.1	12	64.7	8.39	4.7	5.3	4.3	3
15-2-N-38	< 0.1	5.7	< 0.1	19.5	46.4	10.4	4.1	5.1	4.7	2.7
15-2-N-100	< 0.1	6.5	< 0.1	19.5	61.3	10.2	2.6	4.7	5	2.7
15-2-N-200	< 0.1	6.5	< 0.1	20	64	10.4	3.3	4.8	5	2.8
15-2-N-300	< 0.1	7.5	< 0.1	19.5	80.8	11.1	2.5	5.2	5.1	2.9
15-2-S-38	< 0.1	5.1	< 0.1	13.3	64.5	9.98	7.6	5.1	4.4	2.6
15-2-S-100	< 0.1	6	< 0.1	22.5	41.8	10.7	3	5.7	4.9	2.9
15-2-S-200	< 0.1	5.6	< 0.1	23.2	35.1	10.8	3.9	5.4	4.9	2.9
15-2-S-300	< 0.1	6.2	< 0.1	20.6	54.6	10.1	3.2	5.2	4.6	2.7
15-3-N-38	< 0.1	5.5	< 0.1	17.1	45.2	9.66	3.1	4.7	4.6	2.6
15-3-N-100	< 0.1	6.2	< 0.1	19	57.4	10.1	2.7	4.6	4.9	2.7
15-3-N-200	< 0.1	5.9	< 0.1	21.1	61.3	11	3.3	4.8	4.9	2.9
15-3-N-300	< 0.1	6.1	< 0.1	16	66.5	9.56	1.6	4.1	4.6	2.6
15-3-S-38	< 0.1	4.8	< 0.1	14.2	52.1	9.57	7.8	5	4.4	2.6
15-3-S-100	< 0.1	6.2	< 0.1	22.1	51	10.4	2.8	5.3	4.8	2.7
15-3-S-200	< 0.1	5.4	< 0.1	23.8	34.5	10	3.9	5.2	4.6	2.7
15-3-S-300	< 0.1	6.2	< 0.1	23.1	55	11.1	3.4	5.7	5.2	3
15-4-N-38	< 0.1	5.2	< 0.1	17.9	41.4	9.77	4.5	5	4.8	2.7
15-4-N-100	< 0.1	6.2	< 0.1	18.5	53.9	9.52	2.6	4.4	4.7	2.6
15-4-N-200	< 0.1	6.2	< 0.1	17.7	58.5	9.33	2.8	4.1	4.5	2.6
15-4-N-300	< 0.1	7	< 0.1	19.1	72.7	10.9	2.7	5	5.1	2.9
15-4-S-38	< 0.1	5	< 0.1	16.2	57.2	10	5.7	5	4.7	2.8
15-4-S-100	< 0.1	6.1	< 0.1	24.6	37.7	10.7	3.5	5.8	4.9	2.9

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Ge	As	Se	Rb	Sr	Y	Zr	Sc	Pr	Gd
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-4-S-200	< 0.1	5.7	< 0.1	20.8	51.2	9.72	2.4	5	4.4	2.7
15-4-S-300	< 0.1	6.2	< 0.1	18.4	57.2	9.53	3	4.7	4.6	2.6
15-4-B-N	< 0.1	9.5	< 0.1	17.2	25.2	10.5	2.6	3.7	4.7	2.7
15-4-B-S	< 0.1	9.7	< 0.1	20.5	70.8	11.2	4.3	4.6	5	3
15-4-C-N	< 0.1	9	< 0.1	19.5	29.4	10.3	4.7	4.1	5.3	2.9
15-4-C-S	< 0.1	11.5	< 0.1	17.1	36.6	10	4.5	4	4.7	2.6
15-4-M-N	< 0.1	3.7	< 0.1	10.8	45.7	7.17	1.4	2.3	4.1	2.1
15-4-M-S	< 0.1	10.4	< 0.1	13.4	38.1	9.92	1.9	3.9	4.6	2.7
15-5-R-C	< 0.1	20	0.4	9	92.5	14.6	7.5	5.5	4	2.9
15-5-R-T	< 0.1	7.4	< 0.1	12.1	61.8	9.36	10.1	5.3	4	2.4
16-1-S-38	< 0.1	5	0.2	9.4	86.9	13.5	9.8	6.3	5.6	2.2
16-1-S-100	< 0.1	5.7	0.3	14.4	79	13.1	2.9	5.5	5.4	2.2
16-1-S-200	< 0.1	5.8	0.3	15.2	52	13	4.1	6.2	5.7	2.2
16-1-S-300	< 0.1	5.7	0.3	13.3	77.3	12.2	3.7	5.8	4.9	2.1
16-1-N-38	< 0.1	5.9	0.3	12	56.7	11.5	5.1	5.7	4.8	2
16-1-N-100	< 0.1	6.7	0.3	12.8	69.9	11.2	3.6	5.1	4.9	2
16-1-N-200	< 0.1	6.7	0.5	14.1	76	13.1	5.3	5.3	5.3	2.1
16-1-N-300	< 0.1	7.5	0.4	13.1	95.4	14.2	3.6	6.6	5.6	2.4
16-2-S-38	< 0.1	5.3	0.1	9.4	73.3	11.6	6.6	5.9	4.9	2
16-2-S-100	< 0.1	6.6	0.3	15	50.8	12.5	4.4	6.4	5.3	2.2
16-2-S-200	< 0.1	6.2	0.3	16.1	44.5	13.7	5	7.3	5.3	2.3
16-2-S-300	< 0.1	6.3	0.3	14.6	66.6	12.6	3.3	6.1	5.2	2.1
16-N-38	< 0.1	6	0.2	10.3	64.6	10.8	3.7	4.9	4.6	1.8
16-2-N-100	< 0.1	7.1	0.4	12.7	77.6	12.1	3.9	5.3	5.1	2.1

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Ge	As	Se	Rb	Sr	Y	Zr	Sc	Pr	Gd
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
16-2-N-200	< 0.1	6.8	0.3	14.7	77.1	13.4	3.8	6.2	5.4	2.3
16-2-N-300	< 0.1	8.1	0.3	13.1	96.9	14.4	4.1	6.1	5.6	2.3
Elements	Dy	Ho	Er	Tm	Nb	Mo	Ag	Cd	In	Sn
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.1	0.01	0.002	0.01	0.02	0.05
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N1-38	2.3	0.4	1.1	0.2	0.8	0.9	0.136	0.35	0.06	> 200
14-N2-100	2.1	0.4	1.1	0.1	0.7	0.81	0.036	0.41	0.03	177
14-N3-200	2.1	0.4	1	0.1	0.6	0.78	0.046	0.38	0.03	32.4
14-N4-300	2.3	0.4	1.1	0.2	0.7	0.75	0.066	0.37	0.04	50.9
14-S1-38	2.3	0.4	1.1	0.1	0.6	0.8	0.098	0.31	0.04	31.9
14-S2-100	2.4	0.4	1.1	0.1	0.7	0.89	0.097	0.37	0.03	20.6
14-S3-200	2.4	0.4	1.2	0.2	0.8	0.95	0.106	0.39	0.04	27.3
14-S4-300	2.1	0.4	1	0.1	0.6	0.84	0.087	0.39	0.03	32.5
15-1N1-38-1	1.3	0.4	0.8	0.1	0.6	0.96	0.097	0.5	0.06	1.42
15-1N1-38-2	1.3	0.4	0.9	0.1	0.6	1.53	0.069	0.42	< 0.02	2.41
15-1N1-38-3	1.3	0.4	0.8	0.1	0.6	1.22	0.088	0.5	< 0.02	> 200
15-1S1-38-1	1.4	0.4	0.8	0.1	0.6	1.32	0.065	0.36	< 0.02	2.33
15-1S1-38-2	1.5	0.4	0.8	0.1	0.5	1.17	0.11	0.38	< 0.02	> 200
15-1S1-38-3	1.2	0.4	0.8	0.1	0.5	1.08	0.047	0.34	< 0.02	3.16
15-1S2-100-1	1.5	0.4	0.9	0.1	0.6	1.23	0.069	0.46	< 0.02	67.1
15-1S2-100-2	1.3	0.4	0.8	0.1	0.5	1.11	0.06	0.4	< 0.02	1.62
15-1S2-100-3	1.4	0.4	0.8	0.1	0.6	1.03	0.071	0.42	< 0.02	3.78
15-2-N-38	2.2	0.4	1.1	0.1	1	1.06	0.332	0.36	0.03	18.2

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Dy	Ho	Er	Tm	Nb	Mo	Ag	Cd	In	Sn
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.1	0.01	0.002	0.01	0.02	0.05
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-2-N-100	2.2	0.4	1.1	0.1	0.8	0.91	0.179	0.36	0.03	2.05
15-2-N-200	2.3	0.4	1.1	0.1	0.9	1.06	0.164	< 0.01	< 0.02	> 200
15-2-N-300	2.4	0.4	1.1	0.2	0.7	0.84	0.128	0.33	0.03	5.87
15-2-S-38	2.1	0.4	1.1	0.1	0.6	2.08	0.131	0.18	< 0.02	8.57
15-2-S-100	2.4	0.4	1.1	0.2	0.7	2.07	0.161	< 0.01	< 0.02	> 200
15-2-S-200	2.4	0.4	1.1	0.1	0.8	0.95	0.153	0.34	0.03	14.4
15-2-S-300	2.3	0.4	1.1	0.1	0.8	1.12	0.135	0.39	0.03	4.45
15-3-N-38	2.2	0.4	1	0.1	0.9	1	0.138	1.8	0.11	> 200
15-3-N-100	2.2	0.4	1	0.1	0.8	0.95	0.106	0.12	< 0.02	198
15-3-N-200	2.4	0.4	1.1	0.2	0.8	0.93	0.108	0.43	0.02	13.1
15-3-N-300	2.1	0.4	1	0.1	0.7	0.76	0.096	0.29	< 0.02	13.6
15-3-S-38	2.1	0.4	1	0.1	0.8	1.35	0.125	2.41	0.13	> 200
15-3-S-100	2.3	0.4	1.1	0.1	0.8	0.94	0.129	< 0.01	< 0.02	155
15-3-S-200	2.2	0.4	1	0.1	0.8	0.94	0.107	0.23	< 0.02	35.1
15-3-S-300	2.5	0.4	1.2	0.2	0.9	0.95	0.141	< 0.01	< 0.02	166
15-4-N-38	2.2	0.4	1	0.1	0.9	0.86	0.122	0.09	< 0.02	57
15-4-N-100	2.1	0.4	1	0.1	0.8	0.81	0.101	0.06	< 0.02	81.4
15-4-N-200	2.1	0.4	1	0.1	0.7	0.81	0.135	0.84	< 0.02	> 200
15-4-N-300	2.4	0.4	1.1	0.2	0.8	0.86	0.13	0.17	< 0.02	132
15-4-S-38	2.3	0.4	1.1	0.1	0.8	1.26	0.142	0.21	< 0.02	16
15-4-S-100	2.4	0.4	1.1	0.2	0.9	0.96	0.14	0.37	0.04	1.46
15-4-S-200	2.2	0.4	1	0.1	0.7	0.94	0.114	0.38	0.03	2.12
15-4-S-300	2.1	0.4	1	0.1	0.7	0.86	0.111	0.35	0.03	1.42
15-4-B-N	2.2	0.4	1.1	0.1	0.8	1.29	0.132	0.35	0.03	2.9

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Dy	Ho	Er	Tm	Nb	Mo	Ag	Cd	In	Sn
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.1	0.1	0.01	0.002	0.01	0.02	0.05
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-4-B-S	2.5	0.4	1.2	0.2	1	1.16	0.141	0.37	0.02	1.85
15-4-C-N	2.3	0.4	1.1	0.1	0.9	1.02	0.12	0.28	0.02	2.5
15-4-C-S	2.1	0.4	1	0.1	0.7	1.34	0.098	0.25	0.03	2.79
15-4-M-N	1.6	0.3	0.8	< 0.1	0.7	0.56	0.094	0.17	< 0.02	0.97
15-4-M-S	2.1	0.4	1	0.1	0.7	1.18	0.1	0.23	0.03	4.09
15-5-R-C	2.7	0.5	1.5	0.2	0.3	4.1	0.088	1.97	0.09	> 200
15-5-R-T	2	0.3	0.9	0.1	0.7	2.46	0.108	4.55	0.26	> 200
16-1-S-38	1.5	0.3	0.8	0.3	1	1.4	0.2	0.2	< 0.02	23.7
16-1-S-100	1.5	0.3	0.8	0.2	1	1.2	0.1	0.3	< 0.02	2.8
16-1-S-200	1.5	0.3	0.8	0.2	0.9	1.1	0.1	0.3	< 0.02	3.9
16-1-S-300	1.4	0.3	0.7	0.2	0.9	1	0.1	0.2	< 0.02	5.5
16-1-N-38	1.3	0.3	0.7	0.2	1	1.1	0.1	0.2	< 0.02	19.3
16-1-N-100	1.4	0.3	0.7	0.2	1	1.1	0.1	0.2	< 0.02	153
16-1-N-200	1.5	0.3	0.8	0.2	0.9	1	0.1	0.6	< 0.02	> 200
16-1-N-300	1.6	0.3	0.8	0.3	0.8	1	0.1	0.3	< 0.02	29.3
16-2-S-38	1.3	0.3	0.7	0.2	0.9	1.2	0.1	< 0.01	< 0.02	165
16-2-S-100	1.5	0.3	0.8	0.2	0.8	1.3	0.3	0.3	< 0.02	69.4
16-2-S-200	1.6	0.3	0.8	0.2	0.9	1.1	0.2	0.3	< 0.02	162
16-2-S-300	1.5	0.3	0.7	0.2	0.9	1.1	0.1	0.3	< 0.02	49.2
16-N-38	1.3	0.3	0.6	0.2	0.9	1.1	0.1	0.2	< 0.02	42.7
16-2-N-100	1.4	0.3	0.7	0.2	1	1	0.1	0.2	< 0.02	42.8
16-2-N-200	1.5	0.3	0.8	0.2	0.9	1.1	0.1	0.3	< 0.02	79.1
16-2-N-300	1.6	0.3	0.8	0.2	0.9	1	0.1	0.2	< 0.02	80.2

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Sb	Te	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.02	0.02	0.02	0.5	0.5	0.01	0.02	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N1-38	0.51	0.05	1.91	211	19.7	40.2	19.1	3.9	0.8	0.4
14-N2-100	0.39	0.05	1.56	211	20.3	41.5	19	3.8	0.7	0.4
14-N3-200	0.33	< 0.02	1.49	257	19.5	39.4	18.1	3.5	0.7	0.4
14-N4-300	0.34	0.03	1.54	330	20.5	41.8	19.2	3.8	0.8	0.4
14-S1-38	0.5	0.03	1.83	214	19.7	40.4	19.1	3.8	0.8	0.4
14-S2-100	0.54	0.03	1.94	199	19.8	40.8	19.3	3.9	0.8	0.5
14-S3-200	0.57	0.03	2.32	179	20.5	42.5	19.9	4	0.8	0.5
14-S4-300	0.43	0.03	1.73	230	18.7	38.6	18.1	3.6	0.7	0.4
15-1N1-38-1	0.4	0.03	1.05	239	17.1	29.4	13.7	2.5	0.6	0.3
15-1N1-38-2	0.62	0.04	0.77	196	17	29.1	14.3	2.5	0.7	0.3
15-1N1-38-3	0.48	0.06	0.92	226	16.5	28.7	13.5	2.5	0.6	0.3
15-1S1-38-1	0.48	0.06	1.06	156	16.9	28.6	14	2.5	0.7	0.4
15-1S1-38-2	0.73	0.08	1.4	123	17.1	29.3	14.1	2.7	0.6	0.3
15-1S1-38-3	0.53	< 0.02	1.05	204	16.1	26.7	13	2.5	0.6	0.3
15-1S2-100-1	0.78	0.04	1.33	213	18.1	31.4	14.8	2.6	0.6	0.3
15-1S2-100-2	0.63	0.05	1.11	232	17.2	29.2	13.5	2.5	0.7	0.3
15-1S2-100-3	0.69	0.06	1.14	219	18.1	30.8	13.9	2.6	0.6	0.4
15-2-N-38	0.49	0.03	1.55	196	19.9	39.3	18.1	3.6	0.7	0.4
15-2-N-100	0.41	0.03	1.57	244	20.5	40.6	18.8	3.8	0.7	0.4
15-2-N-200	0.39	0.02	1.61	265	20.9	41.2	18.7	3.8	0.7	0.4
15-2-N-300	0.39	0.03	1.5	315	21.3	42	19.5	4	0.8	0.4
15-2-S-38	0.45	< 0.02	1.06	136	18.3	36.2	16.7	3.4	0.7	0.4
15-2-S-100	0.56	0.04	1.72	183	20	39.5	18.6	3.9	0.8	0.4
15-2-S-200	0.57	0.04	1.92	167	20	39.5	18.7	3.8	0.8	0.4

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Sb	Te	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.02	0.02	0.02	0.5	0.5	0.01	0.02	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-2-S-300	0.47	0.04	1.75	221	19.4	38	17.9	3.7	0.7	0.4
15-3-N-38	0.46	0.03	1.27	193	19	37.7	17.1	3.6	0.7	0.4
15-3-N-100	0.41	0.02	1.54	222	19.7	39.4	17.9	3.6	0.7	0.4
15-3-N-200	0.35	0.02	1.6	266	20.1	39.5	18.3	3.9	0.7	0.4
15-3-N-300	0.3	< 0.02	1.15	288	19.2	38	17.4	3.5	0.7	0.4
15-3-S-38	0.49	0.03	1.02	135	18.2	36.2	16.5	3.4	0.7	0.4
15-3-S-100	0.52	0.03	1.84	212	19.7	38.9	18.2	3.7	0.7	0.4
15-3-S-200	0.46	0.04	1.91	163	18.7	37.1	17.3	3.6	0.7	0.4
15-3-S-300	0.54	0.03	1.96	228	21.2	41.6	19.9	4	0.8	0.4
15-4-N-38	0.45	0.02	1.33	173	20.1	39.4	17.9	3.6	0.7	0.4
15-4-N-100	0.41	< 0.02	1.48	213	19.6	38.9	17.7	3.7	0.7	0.4
15-4-N-200	0.36	0.03	1.38	232	18.5	37.2	16.9	3.5	0.7	0.4
15-4-N-300	0.41	0.02	1.52	297	21.1	41.6	19.4	4	0.8	0.4
15-4-S-38	0.46	0.03	1.21	151	19.7	38.7	18	3.9	0.8	0.4
15-4-S-100	0.52	0.03	1.99	180	20.4	40.1	18.9	4	0.8	0.4
15-4-S-200	0.4	0.03	1.75	221	18.5	36.4	16.8	3.6	0.7	0.4
15-4-S-300	0.42	0.02	1.53	231	19.4	38.4	17.6	3.5	0.7	0.4
15-4-B-N	0.62	0.02	1.37	549	19.1	38.1	17.7	3.4	0.7	0.4
15-4-B-S	0.73	0.03	1.89	435	20.5	40.1	18.8	3.9	0.8	0.4
15-4-C-N	0.57	0.02	1.61	389	21.8	43.3	20	4	0.7	0.4
15-4-C-S	0.69	0.03	1.38	618	19.3	38.3	17.5	3.5	0.6	0.4
15-4-M-N	0.33	< 0.02	1	242	17.1	34.3	15.5	3	0.5	0.3
15-4-M-S	0.65	< 0.02	0.9	642	18.7	37.1	17.4	3.7	0.7	0.4
15-5-R-C	1.15	< 0.02	0.78	864	16.6	33.3	15.7	3.4	0.7	0.4

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Sb	Te	Cs	Ba	La	Ce	Nd	Sm	Eu	Tb
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.02	0.02	0.02	0.5	0.5	0.01	0.02	0.1	0.1	0.1
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-5-R-T	0.9	< 0.02	0.91	497	16.9	33.1	15.1	3.2	0.6	0.3
16-1-S-38	0.5	< 0.02	0.8	180	22	34.3	18.4	3.6	1	0.6
16-1-S-100	0.5	< 0.02	1.3	291	20.8	33.8	18.5	3.6	1	0.5
16-1-S-200	0.6	< 0.02	1.5	223	22	34.9	18.9	3.7	1	0.6
16-1-S-300	0.5	< 0.02	1.3	275	19.6	32.2	17.6	3.5	0.9	0.5
16-1-N-38	0.5	< 0.02	1.1	226	19.2	32.4	16.9	3.5	0.9	0.5
16-1-N-100	0.5	< 0.02	1.2	265	19.6	33.6	17.6	3.3	0.9	0.4
16-1-N-200	0.5	< 0.02	1.1	313	20.4	34.1	18	3.6	1	0.5
16-1-N-300	0.5	< 0.02	1.2	373	21.8	36.6	19.7	3.7	1	0.6
16-2-S-38	0.5	< 0.02	0.7	212	19.1	32.1	17.2	3.3	0.9	0.4
16-2-S-100	0.7	0.1	1.4	208	20.2	33.6	18.1	3.6	1	0.5
16-2-S-200	0.7	< 0.02	1.5	188	20	34.5	18.6	3.6	1	0.5
16-2-S-300	0.5	< 0.02	1.4	258	19.4	34	18.2	3.5	1	0.5
16-N-38	0.4	< 0.02	0.8	257	18.3	31.4	16.3	3.3	0.8	0.4
16-2-N-100	0.5	< 0.02	1.2	282	20.4	34.5	18.2	3.5	0.9	0.5
16-2-N-200	0.5	< 0.02	1.3	286	20.9	35.6	18.9	3.7	1	0.5
16-2-N-300	0.5	< 0.02	1.1	349	22.1	37.6	19.8	3.9	1	0.6
Elements	Yb	Lu	Hf	Ta	W	Re	Au	Tl	Pb	Bi
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.05	0.1	0.001	0.5	0.02	0.01	0.02
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N1-38	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.19	146	0.25
14-N2-100	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	114	0.19
14-N3-200	0.8	0.1	< 0.1	< 0.05	< 0.1	0.001	< 0.5	0.14	29.3	0.15

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Yb	Lu	Hf	Ta	W	Re	Au	Tl	Pb	Bi
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.05	0.1	0.001	0.5	0.02	0.01	0.02
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
14-N4-300	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.14	39.9	0.16
14-S1-38	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.17	31.8	0.21
14-S2-100	0.9	0.1	< 0.1	< 0.05	< 0.1	0.001	< 0.5	0.17	25.7	0.23
14-S3-200	0.9	0.1	< 0.1	< 0.05	< 0.1	0.001	< 0.5	0.19	29.5	0.26
14-S4-300	0.8	0.1	< 0.1	< 0.05	< 0.1	0.001	< 0.5	0.14	30.1	0.2
15-1N1-38-1	0.6	0.1	0.1	< 0.05	< 0.1	< 0.001	1.3	0.16	46.4	0.2
15-1N1-38-2	0.7	< 0.1	0.1	< 0.05	< 0.1	0.002	1.4	0.13	66.9	0.2
15-1N1-38-3	0.7	< 0.1	0.1	< 0.05	< 0.1	< 0.001	0.6	0.14	240	0.25
15-1S1-38-1	0.8	0.1	< 0.1	< 0.05	< 0.1	0.002	1.5	0.11	25.7	0.18
15-1S1-38-2	0.8	0.1	0.1	< 0.05	< 0.1	0.002	3.6	0.12	1270	0.42
15-1S1-38-3	0.7	< 0.1	< 0.1	< 0.05	< 0.1	< 0.001	1.1	0.1	12	0.15
15-1S2-100-1	0.8	0.1	0.1	< 0.05	< 0.1	0.004	2.2	0.13	66	0.26
15-1S2-100-2	0.8	0.1	0.1	< 0.05	< 0.1	< 0.001	1.2	0.12	12.9	0.2
15-1S2-100-3	0.8	0.1	0.1	< 0.05	< 0.1	0.002	1.8	0.12	25.4	0.24
15-2-N-38	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.19	23.6	0.22
15-2-N-100	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.19	11.9	0.18
15-2-N-200	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	140	0.2
15-2-N-300	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.19	13.6	0.17
15-2-S-38	0.9	0.1	0.2	< 0.05	< 0.1	< 0.001	< 0.5	0.17	14.5	0.16
15-2-S-100	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.21	126	0.28
15-2-S-200	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.22	23.2	0.27
15-2-S-300	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	14.1	0.21
15-3-N-38	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.17	171	0.22
15-3-N-100	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.17	121	0.18

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Yb	Lu	Hf	Ta	W	Re	Au	Tl	Pb	Bi
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.05	0.1	0.001	0.5	0.02	0.01	0.02
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
15-3-N-200	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.17	21.6	0.2
15-3-N-300	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.14	21.7	0.12
15-3-S-38	0.9	0.1	0.2	< 0.05	< 0.1	< 0.001	< 0.5	0.17	205	0.22
15-3-S-100	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.21	100	0.25
15-3-S-200	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.21	34.8	0.26
15-3-S-300	1	0.2	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.23	101	0.26
15-4-N-38	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	45.2	0.22
15-4-N-100	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	58.5	0.18
15-4-N-200	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.16	146	0.19
15-4-N-300	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	87.2	0.19
15-4-S-38	0.9	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	20	0.2
15-4-S-100	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.22	14.3	0.27
15-4-S-200	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.18	13.9	0.21
15-4-S-300	0.8	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.17	10.9	0.18
15-4-B-N	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	13	0.15
15-4-B-S	1	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.24	14.4	0.23
15-4-C-N	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.22	12.5	0.2
15-4-C-S	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	11.4	0.18
15-4-M-N	0.6	< 0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.11	6.4	0.1
15-4-M-S	0.9	0.1	< 0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.22	13.5	0.15
15-5-R-C	1.4	0.2	< 0.1	< 0.05	0.1	< 0.001	< 0.5	0.19	174	0.14
15-5-R-T	0.8	0.1	0.2	< 0.05	0.2	< 0.001	< 0.5	0.14	422	0.24
16-1-S-38	0.9	0.1	0.2	< 0.05	0.1	< 0.001	< 0.5	0.2	27.4	0.2
16-1-S-100	0.9	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	16.4	0.2

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Yb	Lu	Hf	Ta	W	Re	Au	Tl	Pb	Bi
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm
Detection Limit	0.1	0.1	0.1	0.05	0.1	0.001	0.5	0.02	0.01	0.02
Analysis Method	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS	AR-MS
16-1-S-200	0.9	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	17.2	0.3
16-1-S-300	0.8	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	17.2	0.2
16-1-N-38	0.8	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	25.5	0.2
16-1-N-100	0.8	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	119	0.2
16-1-N-200	0.8	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	203	0.2
16-1-N-300	0.9	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	33	0.2
16-2-S-38	0.8	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.1	123	0.2
16-2-S-100	0.9	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	62	0.3
16-2-S-200	0.9	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	125	0.3
16-2-S-300	0.8	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	47.3	0.2
16-N-38	0.7	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.1	40.6	0.2
16-2-N-100	0.8	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	40.6	0.2
16-2-N-200	0.9	0.1	0.1	< 0.05	< 0.1	< 0.001	< 0.5	0.2	72.6	0.2
16-2-N-300	0.9	0.1	0.1	< 0.05	0.1	< 0.001	< 0.5	0.2	67.1	0.2

Elements	Th	U	Hg
Unit Symbol	ppm	ppm	ppb
Detection Limit	0.1	0.1	10
Analysis Method	AR-MS	AR-MS	AR-MS
14-N1-38	4.5	0.8	50
14-N2-100	4.2	0.8	50
14-N3-200	4	0.7	30
14-N4-300	4	0.8	40
14-S1-38	4.9	0.8	30
14-S2-100	4.7	0.8	40

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Th	U	Hg
Unit Symbol	ppm	ppm	ppb
Detection Limit	0.1	0.1	10
Analysis Method	AR-MS	AR-MS	AR-MS
14-S3-200	4.6	0.8	30
14-S4-300	4.1	0.8	100
15-1N1-38-1	2.9	0.7	70
15-1N1-38-2	2.7	0.8	80
15-1N1-38-3	2.7	0.8	60
15-1S1-38-1	3.7	1.1	40
15-1S1-38-2	4.9	1.2	60
15-1S1-38-3	3.4	0.9	70
15-1S2-100-1	3	0.8	60
15-1S2-100-2	2.7	0.7	40
15-1S2-100-3	2.8	0.8	30
15-2-N-38	4.9	0.8	80
15-2-N-100	4.6	0.7	110
15-2-N-200	4.7	0.8	130
15-2-N-300	4.7	0.8	140
15-2-S-38	6.4	1	30
15-2-S-100	5.3	0.7	100
15-2-S-200	5.2	0.7	110
15-2-S-300	4.6	0.7	100
15-3-N-38	4.6	0.8	30
15-3-N-100	4.6	0.7	20
15-3-N-200	4.2	0.8	20
15-3-N-300	3.9	0.7	< 10
15-3-S-38	6	1	30

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Th	U	Hg
Unit Symbol	ppm	ppm	ppb
Detection Limit	0.1	0.1	10
Analysis Method	AR-MS	AR-MS	AR-MS
15-3-S-100	4.8	0.7	20
15-3-S-200	4.7	0.7	20
15-3-S-300	5	0.8	20
15-4-N-38	5.5	0.8	20
15-4-N-100	4.5	0.7	20
15-4-N-200	4.3	0.7	30
15-4-N-300	5	0.8	20
15-4-S-38	6	1	30
15-4-S-100	5.4	0.8	30
15-4-S-200	4.2	0.7	20
15-4-S-300	4.5	0.8	20
15-4-B-N	4.5	0.9	20
15-4-B-S	5.8	0.9	30
15-4-C-N	5.8	0.8	20
15-4-C-S	5.4	1	20
15-4-M-N	3.8	0.6	< 10
15-4-M-S	4.7	0.9	30
15-5-R-C	4.8	2.8	30
15-5-R-T	5.5	1.5	< 10
16-1-S-38	5.5	1.3	70
16-1-S-100	3.3	0.9	50
16-1-S-200	3.9	1	40
16-1-S-300	3.4	0.9	40
16-1-N-38	3.6	0.9	20

Table C1. *Elemental compositions in soil samples (analyzed by ICP-MS) (continued)*

Elements	Th	U	Hg
Unit Symbol	ppm	ppm	ppb
Detection Limit	0.1	0.1	10
Analysis Method	AR-MS	AR-MS	AR-MS
16-1-N-100	3.4	0.8	30
16-1-N-200	3	0.9	40
16-1-N-300	3.8	1	20
16-2-S-38	4.7	1	40
16-2-S-100	4.1	0.8	70
16-2-S-200	4.2	0.8	60
16-2-S-300	3.6	0.9	40
16-N-38	3.7	0.8	30
16-2-N-100	3.5	0.8	30
16-2-N-200	3.8	0.9	40
16-2-N-300	4.1	0.9	30