An investigation of particulate matter exposure on different pedestrian routes and times of the day– a case study of three TU Dublin campuses

Kristina Leontjevaite

DT491/4

A dissertation presented in partial fulfilment of the requirement for a BSc (Hons) in

Environmental Health

Presented to the School of Food Science and Environmental Health, Dublin

Technological University Dublin, Cathal Brugha Street, County Dublin

Supervisor: Aoife Donnelly

Abstract

Air pollution is a complex and growing environmental health concern in the world, posing a major threat to human health, ecosystems and climate. Increased ambient air pollution can cause adverse health effects including respiratory and cardiovascular problems.

Particulate matter (PM) consists of microscopic solid and liquid particles in different shapes and sizes which can be inhaled and cause detrimental health effects. PM is often classified as coarse (particles less than 10µm in diameter, PM_{10}), fine (particles less than 2.5µm in diameter, $PM_{2.5}$) and ultrafine (particles less than 1µm in diameter, PM_1). Fine and ultrafine particles are known to cause greater risk to our health due to its smaller size and capability to penetrate deep into our lungs and bloodstream. The main sources of PM may be direct, e.g. construction sites, fields, fires, ocean spray etc., or indirect, which are more complex in nature due to their chemical composition, e.g. emissions from different modes of transport, factories, industries etc. Understanding the adverse health effects and the exposure of PM on public and our environment may potentially improve air quality management systems and public health.

The aim of this research was to investigate the outdoor levels of PM in Dublin City Centre and, in particular, measure particulate matter exposure to students who navigate between various TU Dublin campuses in Dublin City Centre to attend classes on foot using Dylos DC1700 air quality monitor. The instrument used measured "Small particle counts" and "large particle counts". "Small particle count" refers to the number of particles 0.5µm or greater in .01 cubic foot of air. The "large particle count" refers to the number of particles 2.5µm or greater in 0.01 cubic foot. In conjunction with relative humidity measurements these readings were converted into $PM_{2.5}$ concentrations (the concentration of particles less than 2.5µm in diameter).

In addition to this research, a survey was developed through Survey Monkey to understand the public perception on air quality, adverse health effects and the means of transportation the general public favours. A total of 3 campuses were monitored: Cathal Brugha Street, Kevin Street and Grangegorman. Two routes were chosen between each campus to assess the particulate matter exposure – pedestrianized streets (fewer exposure to traffic) and more heavily trafficked streets. The investigation will serve as a means of understanding the daily particulate matter pollution in Dublin City Centre, the adverse health effects it may pose and possible air quality management solution to minimize the air pollution for general public.

The findings of this research showed that the levels of $PM_{2.5}$ were at times above the EU recommended daily guidance levels (20µg/m^3). The pedestrianized streets were found to have lower $PM_{2.5}$ levels compared to more heavily trafficked streets overall. This could be an effective evidence to pursue people to choose a green/pedestrianized route due to lower $PM_{2.5}$ emissions as their commute, without affecting their health in a negative way (e.g. respiratory diseases, cardiovascular diseases). Heavily trafficked streets may eventually pose if pedestrians are exposed to PM emissions over prolonged periods of time.

Slightly higher average of PM2.5 concentrations were observed in the morning rush hours than evening rush hours. Peaks indicated that modes of transport are a main contributor to elevated levels of PM. A strong association between humidity, temperature, wind and PM levels was observed. Levels of $PM_{0.5}$ proved to be lower for the pedestrianized streets, however, the results showed elevated figures occasionally due to the contributing factors such as smoking and construction activity. The main sources of the air pollution in Dublin City Centre is the diesel and petrol operated modes of transport, smoking and active construction sites. Such air quality conditions, and environment may adversely affect the health of sensitive risk groups such as elderly, pregnant women, young children and those with respiratory or cardiovascular problems.

The Environmental Protection Agency and Public Health department in Ireland should increase awareness of the current air quality in Dublin City, provide information regarding the negative health affects exposed to air pollution and strengthen the air pollution mitigation management.

List of Contents

List of Figures

List of Tables

Acknowledgements

First and foremost, I would like to express my deep and sincere gratitude to my research supervisor, Dr. Aoife Donnelly, for giving me the opportunity to do this research. Thank you for your patience, recommendations and providing invaluable guidance throughout this research. Her guidance helped me in all the time of research and writing of this thesis.

I would like to sincerely thank Dr. Paul Hynds for agreeing to co-supervise me with this thesis, for your patience, motivation, honesty, enthusiasm and immense knowledge. Thank you for always advising me with what sometimes looked impossible to accomplish. I would also like to thank Paul for recommending me a PhD student Simon Mooney, who often went out of his way to support and help me with my thesis write-up and surveys.

Thank you so much for taking your time to answer my questions, correct my work, give insights and provide honest feedback on my progress. I could have not done this work without kind advice and help throughout completion of this thesis from these wonderful people and I consider myself very lucky for receiving supervision from you all. I cannot describe how much I appreciate this.

Special thank you to the Principal Environmental Health Officer Martin Fitzpatrick in Dublin City Council for providing me data on air quality in Dublin City Centre. Thank you for your immense and genuine help, advice and future recommendations to complete this thesis successfully.

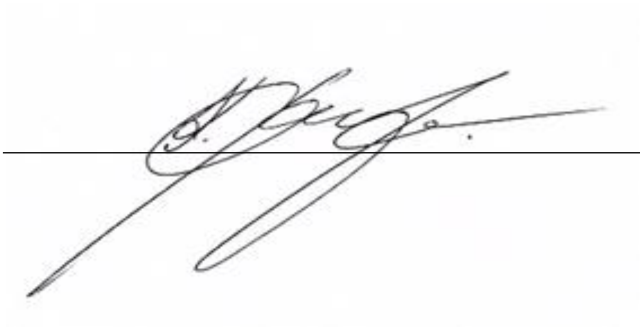
I would also like to thank TU Dublin technician Anthony Hutchinson for assisting me and providing me advice regarding my PM meter and successful data collection. Thank you for helping me with any sudden technical issues I previously had.

Special thank you for EI Travel Group Director Keith McDonnell for allowing me to send my research survey to all their staff to participate in the survey and of course, I thank the staff members for taking interest in my work and completing the survey.

Finally, I would like to thank all the TU Dublin staff and students, my friends and family for taking their time to complete and share my survey. My completion of this project could not have been accomplished without your help!

Authors Declaration

I hereby certify that this material, which I now submit in part of fulfilment of the requirement for the award B.Sc. Environmental Health is entirely my own work and has not been taken from the work of others save and to the extent such work has been cited and acknowledged within the text of my own work.

Signed: 

Date: 19/03/2020

Chapter 1: Literature Review

1.1. Introduction

Air pollution continues to cause complex and detrimental environmental impacts, becoming one of the most serious problems in the world (Newair, 2019; EEA, 2017). Mitigation of ambient air pollution remains challenging and costly, which increases problems to our health, ecosystems, built environment and the climate (Wang, 2018; EEA, 2017).

Air pollutants can be classified as primary or secondary. Primary air pollutants such as particulate matter are anthropogenic sources whereas secondary particles are formed by photo-chemical reactions in the atmosphere (Pražnikar, 2012) (EEA, 2017). Depending on the size and nature of the pollutant, it may travel over long distances and potentially affect large, urban areas (WHO, 2006). To reduce the effects of these pollutants, it is crucial to understand their source, nature and mechanisms of transport into the atmosphere (Watson, 1988) (Durães, 2018). Additionally, daily weather changes can have an immense influence on air quality (Bradley, 2019).

Understanding the adverse effects of pollutants on public health, ecosystems and climate could change our perspective on the importance of air pollution and improve potential air pollution management systems (EEA, 2017).

The work presented in this study focuses on particulate matter exposure of students travelling from various Technological University Dublin (TU Dublin) campuses in Dublin City centre to attend classes. As TU Dublin currently has 10 campuses in Dublin, students are sometimes required to travel long distances to attend classes in a specified campus and often prefer to travel on foot. As a result, students are at increased risk of exposure to direct (primary) particulate matter, which particularly derives from public transport. Therefore, the aim of this study is to measure the particulate matter levels, that the students may be exposed to, when trying to reach three TU Dublin city campuses: *Cathal Brugha street*, *Kevin street* and *Grangegorman* campuses. Theses campuses were specifically chosen due to their proximity to one and other and the similarities between the surrounding heavy traffic and pedestrianized footpaths.

Various walking routes to reach the campuses were selected, incorporating both heavy traffic and pedestrianized streets as well as segregating heavy traffic and pedestrianized streets to compare the exposure at the end of this study and suggest the safest, and possibly the fastest, way to arrive to the desired campus.

This study is applicable not only to students studying in TU Dublin, but also other students and the general public, seeking to understand the daily particulate matter pollution exposure in Dublin City centre, and possible ways to reduce the exposure. As a result, the possible adverse health effects the particulate matter may pose could be reduced.

1.2. Particulate Matter – Characteristics

Atmospheric particulate matter (PM) consists of solid particles and liquid droplets found in the air (Berube, 2006). Particulate matter may be derived from natural or anthropogenic sources and can be emitted either directly into the atmosphere (primary particles) or formed via chemical reactions amidst mixed gases and sunlight in the atmosphere (secondary particles) (AQEG, 2005). Some particles such as dirt, soot, or smoke are large enough to see with the naked eye; others require an electronic microscope to discern. These small particles can penetrate the lungs whilst inhaling the air and cause negative health effects (Berube, 2006; EPA, 2018). The composition of the particles depends on the influence of location, weather condition, sources and emissions. Particulate matter is generally measured in two main size fractions – PM_{10} (particles less than 10 micrometres in diameter) and $PM_{2.5}$ (particles less than 2.5 micrometres in diameter) (Begum, 2010).

In moist conditions, some particles blend with water vapour and produce small droplets. Hence, the term "aerosol" is generally used to describe solid particles as well as droplets suspended in the air (APIS, 2016).

1.2.1. Sources of Particulate Matter

Particulate matter may originate from three major leading sources that forms their own size and nature (APIS, 2016). These sources include:

- Gaseous chemical reactions in the atmosphere

  Gaseous pollutants may result in formation of fine particles (only a few nm in diameter) (APIS, 2016). These particles are produced by coagulation and contain various formation pathways, such as the sulphates formed in the air from atmospheric reaction of sulphur dioxide (SO2) resulting from anthropogenic or volcanic emissions (DEH, 2005).

- Mechanisms of combustion

  Combustion in industrial settings and in transport can also release small particles (usually ranging from range 0.1 - 2.5 µm diameter) (APIS, 2016). Example may include combustion of carbon-based fuels (fossil fuels: coal, oil, natural gas) by vehicles and industries or fly ash particles emitted from combustion of coal (APIS, 2016; Samson, 1988).

- Mechanical formation

This process produces larger (coarse) particles (2.5 - 20 µm) that are carried out by the wind. These particles may come from sources such as the agricultural processes and volcanic eruptions (APIS, 2016).

Primary pollutants may arise in various ways:

- As a result of combustion, where carbon dioxide can be the result formation
- As impurities or additives to the fuel, e.g. sulphur in oil, lead in petrol

The major sources of primary particulate matter are road traffic, coal combustion, industrial emissions, which are anthropogenic sources and air blown dust and sand, and salt from the sea, which are natural sources.

Secondary particles are essentially sulphates (SO_2), nitrogen oxides (NO_x) and organic particles resulting largely as a result of combustion (Barnard, n.d.). These particles are often made up all at once and by photochemistry, e.g. tropospheric ozone, which is a dominant component of photochemical smog (Schwartz, 2008). Elements of $PM_{2.5}$ and $PM_{0.5}$ that are mostly secondary pollutants in nature, and they have not been thoroughly examined yet in an epidemiologic area due to the lack of stable $PM_{2.5}$ mass and data (Schwartz, 2008).

1.3. Classification of Urban Particulate Matter

1.3.1. Particulate Matter <10 µm diameter

PM_{10}, also known as coarse particles, has a diameter less than 10µm (EPA, 2019). To understand the size of PM_{10}, human hair is often used in comparison, thus human hair is roughly 100 µm meaning that around 10-40 of these particles could make up its width (Energy, n.d.). These particles mainly derivate from primary anthropogenic sources such as combustion activities from motor vehicles and industries resulting in smoke, dusts and dirt, and natural sources such as sea salt spray and pollen (Victoria, 2016). These particles may also cause visibility reduction and are less damaging to our health compared to other finer particulate matter (O'Hanlon, 2016).

1.3.2. Particulate Matter <2.5µm diameter

$PM_{2.5}$ primarily comes from anthropogenic pollution and has a diameter of less than 2.5µm, therefore it is often described as fine particle (EPA, 2019; Energy, n.d.). Short-term exposure may be associated with increased mortality (Schwartz, 2008) due to its ability to penetrate deeper into our bodies causing adverse health issues. $PM_{2.5}$ is primarily made up from gas to particle transformation and chemical reactions with the atmosphere around them, which allows the particle to alter its composition (Murphy, 2012). Due to its small size, $PM_{2.5}$ is suspended in the atmosphere for an extensive amount of time, compared to PM_{10}, which elimination relies on wet or dry deposition as coarse particles fall rapidly due to their larger composition (Murphy, 2012). In urban and industrial environment, fine PM is mainly made up of sulphate, nitrate, ammonium, organic compounds and soot and its formation can be associated with redox reactions of different precursor gases (Murphy, 2012). Fine particulates are sensitive to environmental aspects and precursor gases such as NO_x and SO_2 (Murphy, 2012).

1.3.3. Particulate Matter <0.5µm diameter

Also known as fine particles, structure of these particles is very complex (Donaldson, 2001). Similarly to $PM_{2.5}$, the particles of $PM_{0.5}$ are also capable of penetrating deep into our bodies, however, these fine particles can easily reach the blood stream and as a result disrupt the gas exchange in the lungs and affect other vital organs. Ultrafine particles are predominantly insoluble due to its carbon core, yet they become aggregates with other chemicals such as sulphites, metals and hydrocarbons (Donaldson, 2001). These particulates are mostly measured for indoor air quality rather than outdoor air quality and not enough data can be found concerning this particulate matter outdoors.

1.4. Particulate Matter – Issue Around the Globe

The consequences of air pollution are evident in many regions globally (WHO, 2018). It has been identified that rural, low-income and middle-income regions are affected mostly compared to urban cities (WHO, 2018). Regions with particularly high exposures to pollutants are seen in Eastern Mediterranean, South-East Asian and Western Pacific Regions According to WHO estimates, countries with populations over 100,000 do not meet WHO air quality guidelines. In urban, high-income areas, however, the estimates are lower, and the percentage reaches 49% (WHO, 2018). It is estimated that around 4.2 million people worldwide die due to poor air quality and around 91% of the world's population is affected air quality exceeding WHO guideline limits (WHO, 2019).

The annual average for air pollution in most regions of the world is much higher than of the WHO air quality guideline (AQG – level of 10µg/m^3). The regions of the world with highest air quality concerns include the Mediterranean, Middle East, Central Africa and East Asia (*Figure 1.1*) (WHO, 2018). Air pollution does not respectively derive from anthropogenic sources, it can also arise from natural sources such as forest fires, volcanic activity, dust storms or sea water spray (WHO, 2018).

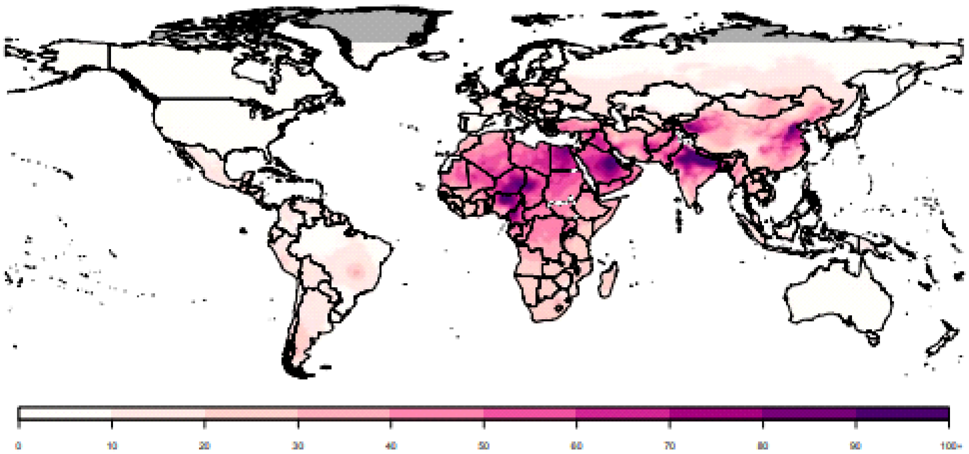


Figure 1.1: The WHO Global map of annual average concentrations of ambient (outdoor) fine particulate matter ($PM_{2.5}$) in µg/m^3 ((WHO), 2018).

According to the World Health Organisation (WHO), over 400,000 premature deaths recorded annually in Europe are the result of unsatisfactory air quality (EPA, 2019). The WHO has defined present air pollution as the "single biggest environmental health risk" (EPA, 2019).

A study by Kiesewetter (2015) demonstrated significant increase in $PM_{2.5}$ from anthropogenic sources such as domestic heating mainly from coal and woods, road transport and industrial combustion in Europe. The cities such as Northern Italy, Poland, Romania and Bulgaria have the greatest exposure to $PM_{2.5}$. The study stressed the adverse effects of $PM_{2.5}$ and explained the relationship between $PM_{2.5}$ and life expectancy. Ireland and Sweden showed to have one of the lowest impacts on life expectancy with overall possible life expectancy value reduced to 0.7 months, whereas Bulgaria had 4.5 months. Therefore, in Belgium, Poland, the Czech Republic, Hungary and Romania people are expected to lose more than 6 months on average even in 2030.

1.4.1. Particulate Matter in Ireland

Compared to other European Union (EU) Member States, Ireland's air quality is currently satisfactory. However, maintaining the criteria constituting 'good' air quality is a growing challenge (EPA, 2019). Although Ireland's air quality falls within EU limit values, levels specifically for particular matter (PM) constitute a growing concern (EPA, 2019). PM concern rises drastically during winter months due to solid fuel burning, which is directly released into the atmosphere. This impacts the air quality and can instantaneously enter our body via inhaling the air, which then eventually affects our health (EPA, 2019). In larger urban areas, such as Dublin City, potential exceedances of nitrogen dioxide limit values are expected unless we reduce dependency on private vehicles (EPA, 2019).

In Ireland the number of premature deaths due to air pollution estimates a total of 1,510 people per annum and the main health concern is cardiovascular disease (EPA, 2019).

1.5. Effects of Urban Particulate Matter - Common Problems

Particulate matter is becoming an increasing concern for health. Particulate matter, depending on the source of emission, can carry hydrophobic substances such as PAH, dioxins and heavy metals which are extremely toxic for our health and can act as irritants or pose harmful effects to our vital organs (Tjell, 2009).

1.5.1. Health problems

1.5.1.1. The Skin

The human skin is the biggest and the fastest-growing organ on our bodies. It covers around $2m^2$ of total area and is directly exposed to air pollution (Tjell, 2009). Skin buffers the human body from harmful substances, helps regulate body temperature via sweat and hair and adjusts to peripheral circulation and fluid balance via sweat (CliniMed, 2019). However, the human skin is sensitive and contains network of nerve cells that react to changes in the environment due to different receptors for heat, cold, touch and pain (CliniMed, 2019).

Although skin works as an effective protective barrier, some substances can efficiently enter the skin and deliver systemic toxic responses (Magnani, 2015). Various airborne pollutants can come in contact with skin such as fibreglass or dust, which may potentially affect and damage the skin by irritation and inflammation. This may cause depletion of keratin within the skin and undermine and its protective potency against alien substances and microorganisms (Tjell, 2009;

JM, 1986). Air pollution may also cause an allergic reaction, such as atopic dermatitis, allergic rhinitis, and allergic sensitization in relation to PM exposure (Yang, 2019; JM, 1986). As a result of the air pollution, skin can also be exposed to harmful UV radiation due to ozone layer depletion in the atmosphere (Tjell, 2009).

1.5.1.2. The Eyes

Vision is one of the most complex bodily processes. The conversion of light into electrical signals and transport of these signals to the brain creates an image of our surroundings (IQWiG, 2009). The eyes are arguably the most important sense (Newman, 2018).

The most important parts of the eye include:

- The iris – the coloured part of the eye. It helps regulate the amount of light that enters the eye (IQWiG, 2009; HMN, 2015)
- The cornea – the transparent layer covering the iris and the pupil. Its main function is to protect the eye from foreign objects and prevent injury as well as refracts the light on the way into the eye (IQWiG, 2009)
- The lens – made of transparent, flexible tissue and is located behind the iris and the pupil (Duffy, 2019). It is responsible for focusing light and image on retina (Duffy, 2019)
- The retina – located near the optic nerve, is a thin layer of tissue that lines the back of the eye on the inside. The retina is responsible in receiving light that the lens is focusing, converting the light into neural signals and sending them to the brain (HMN, 2015; Heiting, 2017).

The eyes are among the organs in our body that are exposed to the outside environment directly in contact with the air pollution. Particulate matter may therefore have a direct impact. When chemicals or foreign matter enter the epithelium tissue, the eyes may become irritated, resulting in blurry vision (Tjell, 2009). Certain symptoms as a result of air pollution may vary and include chronic discomfort, eye itching, increased sensitivity to foreign bodies (sensation), tears, increased mucus secretion and swelling of the eyelids (Klopfer, 1989; Gang Tan, 2018). Although it is evident that airborne pollutants can cause damage to the eyes, it is unclear how exactly its processes cause damage (Gang Tan, 2018). Environmental factors can cause Dry Eye, which is one of the most common symptoms on the eye surface (Gang Tan, 2018).

1.5.1.3. The Nose

The nose performs an important role in the transmitting of air into the lungs (Barclay, 2018). The exterior of the nose is of different temperature and humidity to the air in the atmosphere entering the human body via inhalation. The inner structure of the nose increases the surface area of tract and causes the inhaled air to approach the mucous membranes lining located in the nasal cavity, where air is warmed and humidified before it enters the lungs (Barclay, 2018). Hair and mucous inside the nose acts as a filter catching any solid, alien particles before it enters the lungs (Barclay, 2018). The air which is exhaled from the lungs, passes through the back of the nose where moisture and heat of the air is trapped by the nasal membranes and is used to warm and humidify the next inhaled breath of air (Barclay, 2018)

Some air passes through nasal epithelia, whose thin layer of mucus traps some of the foreign molecules from the air (Barclay, 2018). The molecules contact the olfactory hairs spreading from olfactory receptor neurons in the epithelium (Barclay, 2018). Nasal epithelia can react and metabolise with some pollutants to become more toxic, affecting the olfactory epithelium, which is especially sensitive (Tjell, 2009).

The nose is also sensitive to irritating substances and some pollutants that are held back in the nose for long periods of time may be carcinogenic to the cells and the mucous membranes in the nose (CPSC, n.d.). Smaller particles can bypass through the membranes and enter the blood stream inside the human body (Tjell, 2009).

1.5.1.4. The Trachea and The Lungs

The trachea is a wide, hollow tube that connects larynx to the bronchi of the lungs and has a crucial function of providing air flow to and from the lungs needed for respiration (Barclay, 2017).

The lungs are spongy pair, air-filled organs located on each side of the chest, as shown in *Figure 1.2* (Hoffman, 2019). The trachea helps to transport inhaled air into the lungs via bronchi, which eventually divide into bronchioles and become microscopic in the end of the process (Hoffman, 2019).

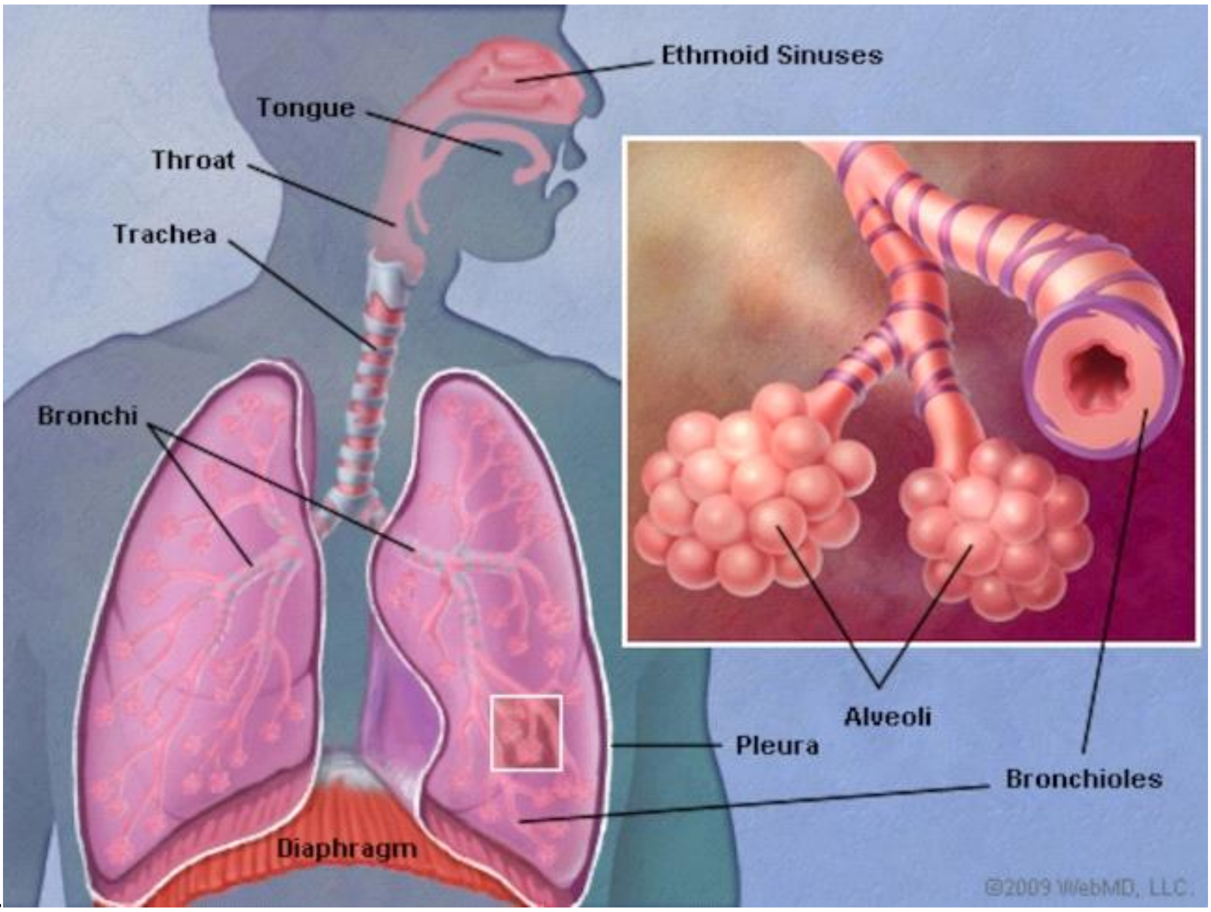


Figure 1.2: Anatomy of the Lungs (Hoffman, 2019).

Epidemiological studies have shown that urban particulate matter (PM) increases the risk of respiratory infection (Xiaoyan Chen, 2018). PM disturbs the activation of the airways' antibacterial defence (Xiaoyan Chen, 2008). Epidemiological studies, such as by Sigaud (2007) and Chen (2008), showed that exposure to ambient air particles causes an inflamed alveolar milieu in which oxidative stress impairs antibacterial function in alveolar macrophages and decreases bacterial clearance, reveal increased incidence of lung infection when air pollution particle levels are increased.

- Particles larger than PM_{10} in size are removed from the upper airways by the mucous and serous cells fluid produced in the airways wall located in the lungs (Tjell, 2009). These particles are trapped and transported up towards pharynx by cilia, which is controlled by the central nervous system (Tjell, 2009). Once the pollutants are in the pharynx, they can be either swallowed or expectorated (Tjell, 2009).
- Smaller particles may penetrate deeper in the lungs and may deposit by sedimentation or impaction (Tjell, 2009). Whereas larger particles can be

removed from our bodies easier by cough or sneeze, smaller particles (smaller than 10 micrometres in diameter) get trapped in our lungs (Tjell, 2009).

- Ultrafine particles are now able to reach alveoli, which contributes significantly to chronic lung disease and general respiratory health issues (Tjell, 2009). They may exist as single particles or aggregates (K. Donaldson, 2001). Ultrafine particles are exceptionally toxic to the lungs, even if the materials inhaled in the air are not toxic due to their ability to penetrate deeper, e.g. titanium dioxide and carbon black (MacNee, 1998). This may suggest that ultrafine particle toxicity is a result of their size and not the chemical composition of the compound in question (MacNee, 1998).

Ultrafine particles can inhibit alveolar macrophage phagocytosis, which is crucial in removing the particles from the lungs (Donaldson, 2001). Failure to remove these particles from the lungs may result in overload of particles in mass and consequently lead to adverse health effects such as asthma, fibrosis and tumours at long-term and high exposures (Donaldson, 2001). These particles can also easily pass through the lungs and enter the bloodstream, which is important in carrying the oxygen throughout our body (ALA, 2019).

Generally, increased exposure to particles may lead to variety of adverse health effects in lungs, including:

- Lung diseases, such as chronic obstructive pulmonary disease (COPD) and bronchitis
- Premature deaths due to lung diseases
- Aggravated asthma
- Decreased lung function
- Decreased respiratory function and increased symptoms, such as breathing difficulties and coughing (EPA, 2018)

An interesting study by Tian (2019) aimed to see associations between ambient PM pollution and pneumonia hospitalizations in 184 Chinese cities. It was found that short-term elevations in PM were associated with increased pneumonia-related hospital admissions in Chinese adults.

1.5.1.5. The Heart

Urban air pollution is linked to cardiovascular diseases and mortality as a result. The molecular mechanisms appear to be directly affecting the cardiovascular system or indirectly causing pulmonary inflammation and oxidative stress from free radicals (Tjell, 2009). Ischemic heart disease, heart failure and ischemic or thrombotic stroke are just a few cardiovascular diseases that may arise from exposure to PM. PM has also shown to disturb endocrine system, that can assist to an increase in metabolic diseases such as obesity and diabetes, which can also contribute to cardiovascular diseases (Mutlu, 2018). Behaviour and social (lifestyle) factors, such as inactivity, tobacco smoking and alcohol consumption, together with PM exposure could double the adverse effects on cardiovascular system.

Fine (especially ultra-fine particles (UFPs) (<0.1 µm)) can penetrate easier and deeper in our bodies (Yixing Du, 2016; Donaldson, 2001). These particles can cross pulmonary epithelium and enter the alveolar-capillary barrier easily compared to coarse particles, such as PM_{10} (Yixing Du, 2016; Furuyama A., 2009). As a result of this ability, fine and UFPs can cause serious health effects (Yixing Du, 2016).

However, more investigation is required to further understand the adverse effects on the cardiovascular system as currently, very little data is available, and most is hypothesized.

1.5.2. Who is at risk?

Anyone who lives exposed to high levels of air pollution is at risk to developing adverse health effects. However, some people may be at higher risk to acquire adverse health effects, including:

- Elderly (over 65 years of age). As the human body ages, it becomes less immune to the effects of the environmental threats (Air Now, 2017). Air pollution effects in elderly may lead to increased medication use, frequent visits to care providers and admissions to the emergency rooms and hospitals, as well as death (Air Now, 2017).
- Infants and young children, due to their ability to breath in more air far more quickly than adults (Wynd, 2018). At birth, most children have 20% less lung mass compared to adult lungs (Wynd, 2018). As a result, children breath in more air pollutants and due to their weak lung ability to fight off air pollution effects, they are far more susceptible to various infections and respiratory issues related to air

pollution, which has a greater effect on child's overall health (Wynd, 2018). This is a major reason for premature deaths caused by air pollution (WHO, 2018; HEART, 2017)

- People suffering from lung from lung diseases such as bronchitis or asthma
- People suffering from cardiovascular/pulmonary diseases or diabetes, increasing hospital admissions in response to higher levels of PM and overall reducing the life expectancy by several years (Brook, 2004).
- People with lower income or living in developing countries. Air pollution is strongly linked to poverty as shown in *Figure 1.3*, majority of the deaths cases registered related to air pollution occurred in low and middle income countries where air quality laws are weak or not existing, vehicle emission standards are less stringent and coal stations are more common (HEART, 2017; UNEP, 2019). Air pollution is expensive as it can result in medical costs as well as affect productivity and economic growth (HEART, 2017).

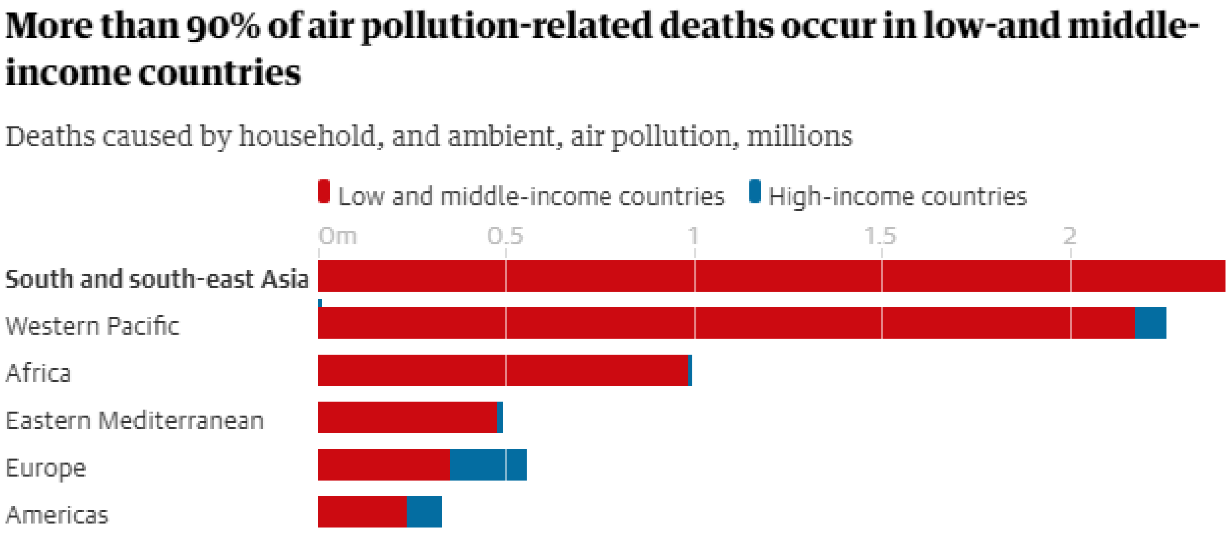


Figure 1.3: Deaths caused by household, and ambient, air pollution, millions, compared in low- and middle-income countries (Watts, 2018).

- People who frequently work or exercise outdoors (ALA, 2019). During aerobic activity, more air is inhaled deeply into the lungs, therefore during exercise or working outside, people are exposed to more polluted (Laskowski, 2017).

PM concentration has been shown in population-based studies affecting older, susceptible individuals and those with existing medical issues by Simoni (2015) and Hamanaka (2018) to increase when the subject is exposed to combustion of fossil fuels such as traffic and power plant emissions.

1.6. Environmental Effects

Particulate matter can have serious effect on the environment, which can effectively affect the entire planet (Lafond, 2019). The most common recorded environmental issues due to PM exposure include:

- Visibility impairment, which is caused mainly due to suspended fine particles (aerosols), can sometimes be noted as a haze in urban regions as well as rural areas, such as forests, national parks and mountains (Lafond, 2019; EPA, 2018; Fenger, 2009). In urban regions, visibility decrease could be dangerous because of the higher population density, which can lead to increased traffic accidents followed by injuries and hospitalization (Lafond, 2019). Particles dominate in the urban atmosphere (accounting for over 80% of the total contribution to the optical attenuation), however, their impact may vary greatly with many factors and range in visibility (2-60km). In megacities, such as in Beijing (China) and Bangkok (Thailand), visibility reduction is a major problem (Fenger, 2009; Quality.org, n.d.).
- Acid Rain, which is composed of nitrogen oxides, sulfuric acid and other volatile compounds all take part in the formation of the acidified particles creating the acid rain, when the particles fall into the ground and water (Bhargava, 2013). This contact with surface ground can make lakes and other water bodies become acidic, which can eventually lead to acid rain via hydrological cycle (Lafond, 2019). Acid rain can damage nature, e.g. damage some plant species and reduce animal species such as frogs, as well as contribute to building material erosion and staining, which can result in monuments and statue as well as building degradation (Lafond, 2019; Ro-Poulsen, 2009). Acid rain is a major contribution to ecosystem damage.

Due to particle ability to travel long distances and their chemical composition, they can negatively affect the health of the ecosystem (EPA, 2018). Some damaging effects may also include nutrient balance change in coastal waters and rivers, reduce in nutrient content in soil, damage in forests and crops and visible fault on ecosystem’s diversity (EPA, 2018).

1.7. Meteorological impacts on Particulate Matter

It is well acknowledged that meteorological conditions affect the concentration of PM in the atmosphere (Xin Fang, 2017). Various meteorological factors may impact PM concentration in ambient air. PM concentrations affected by meteorological factors as dispersion processes, removal mechanisms and chemical formation of PM are influenced by wind, rainfall rate, relative humidity and solar radiation. Chen (2018) found that temperature exerts the strongest and most stable influence on PM2.5 in all seasons across China and precipitation is dominant meteorological influence mainly in coastal regions. Previous study by Keary (1998) discovered that PM10 concentration measured in Dublin decreased with an increase in precipitation rate, wind speed and frequency and temperature, which could easily relate to PM2.5 as well.

The dispersal of the particles could be explained by convention. During convention, warm air rises and cold air sinks in the atmosphere. When inversion takes place, calm or light wind will increase poor air quality by repressing the mixing of air in the atmosphere. This activity keeps the air dormant on the surface due to the warm layer of air between the layers of cooler air (Garcia, 2019). Strong inversion usually happens during night typically when calm winds and cold temperatures are present, leading air stagnant on surface (Garcia, 2019).

1.7.1. Temperature

Both, cold and hot temperatures may increase particulate matter concentration in the atmosphere causing adverse health complications (Xin Fang, 2017). Mortality rates during cold temperatures increases more than during hot temperatures, evidently due to the increased burning of fossil fuels such as household heating and vehicle emissions resulting in large concentrations of particulate matter emission into the atmosphere (Xin Fang, 2017). The increase in fossil fuel emissions into the atmosphere increases toxins in the air and combined with the temperature inversion creates the smog that we breathe every winter, which is full of $PM_{2.5}$ (Airlief, 2017).

Low particulate concentrations may be explained by thermally induced convections; ground heats up and winds increase, leading to particulate matter dispersal in the atmosphere (Hernandez, 2017). During night-time, temperature drop supresses the spread of particulate matter. Increased combustion and condensation of volatile compounds are other causes for PM increase (Hernandez, 2017).

In China alone, 1.6 million people die annually from heart, lung and stroke problems because of air pollution (Guardian, 2015). China is known as one of the worst countries for air pollution, particularly for PM emissions. This is mainly due to its economic growth and usage of cheap fossil fuels for heating, cooking, electricity generation and vehicle emissions and incomplete combustion (Airlief, 2018).

1.7.2. Relative Humidity

Rainfall washes PM through the “scavenging” effect and dissolves other gaseous pollutants from the atmosphere, significantly reducing air pollution levels during the time of precipitation. Precipitation is the result of atmospheric water vapour that blends forming large drops that fall under gravity (NASA, 2003). However, particulate matter can prevent the clouds from coalescing to create clean, unpolluted rainfall and in turn can reduce overall precipitation rates (NASA, 2003).

If relative humidity approaches 100 % in the atmosphere, mist or fog could form and this could trigger this could be detected as particles and increase particle 2.5 µm by over 50 % while larger particles may see increase of around 28% (Jayaratne, 2018). Jayaratne (2018) found that there is a significant increase in particle number and concentration at humidity above 75%.

1.7.3. Wind

Wind direction can affect the variations of the PM concentrations (Guerra, 2006). Higher wind speeds allow particulate matter to disperse rapidly in the air, leading to lower PM aggregation.

Fine particulate matter (≤2.5 µm) is smaller in size than coarse particulate matter and therefore the particulate concentrations of $PM_{2.5}$ and less is expected to decrease in the atmosphere due to active dispersal of the particles in the presence of wind. However, these particles can also remain in the air for longer periods of time as well as transfer longer distances than larger particles.

PM_{10} are larger in size and therefore will not remain in the atmosphere for long periods of time under gravity. This said, according to a study carried out by Zhang (2018) on "*Influences of wind and precipitation on different-sized particulate matter concentrations"*, explains that course particulate concentrations would increase due to dust resuspension under strong wind.

1.8. Additional Contributors to Air Pollution

Other contributors to air pollution may also introduce harmful substances in the air causing serious toxicological impact on human health and the environment (Ghorani-Azam, 2016).

This occurs when the harmful substances (e.g. foreign gases, odour, dust, or fumes) in the air are at levels that can damage health of animals and humans and environment (Madaan, n.d.).

1.8.1. Agriculture

Nitrogen-containing compounds (NO_2, NO, NH_3, N_2O) are emitted to the atmosphere from agricultural activities (AQEG, 2018). Ammonia (NH_3) emissions from agricultural processes are increasing in Ireland, becoming the lead issue for air pollution (Foody, 2019).

Ammonia contributes to particulate matter formation in the atmosphere consequently increasing adverse effects on human mortality and morbidity (AQEG, 2018).

In 2017, ammonia emissions increased by a total of 2% and it is expected that the figures will continue to increase up to 2030 and onwards (Foody, 2019).

90% of Ireland's ammonia emissions are from animal manure, livestock farming on account of a growing livestock population, and the remainder 10% are a mixture of chemical fertilizers and road transport (Foody, 2019; CBS, n.d.). Ireland is the leading country in the Europe producing the largest amounts of PM emissions into the atmosphere from agricultural processes as seen in *Figure 1.4*.

Other contributors are agricultural industries burning the stubble off their fields and smoke emanating from fireplaces and wood burners for energy and heat (Airlief, 2017).

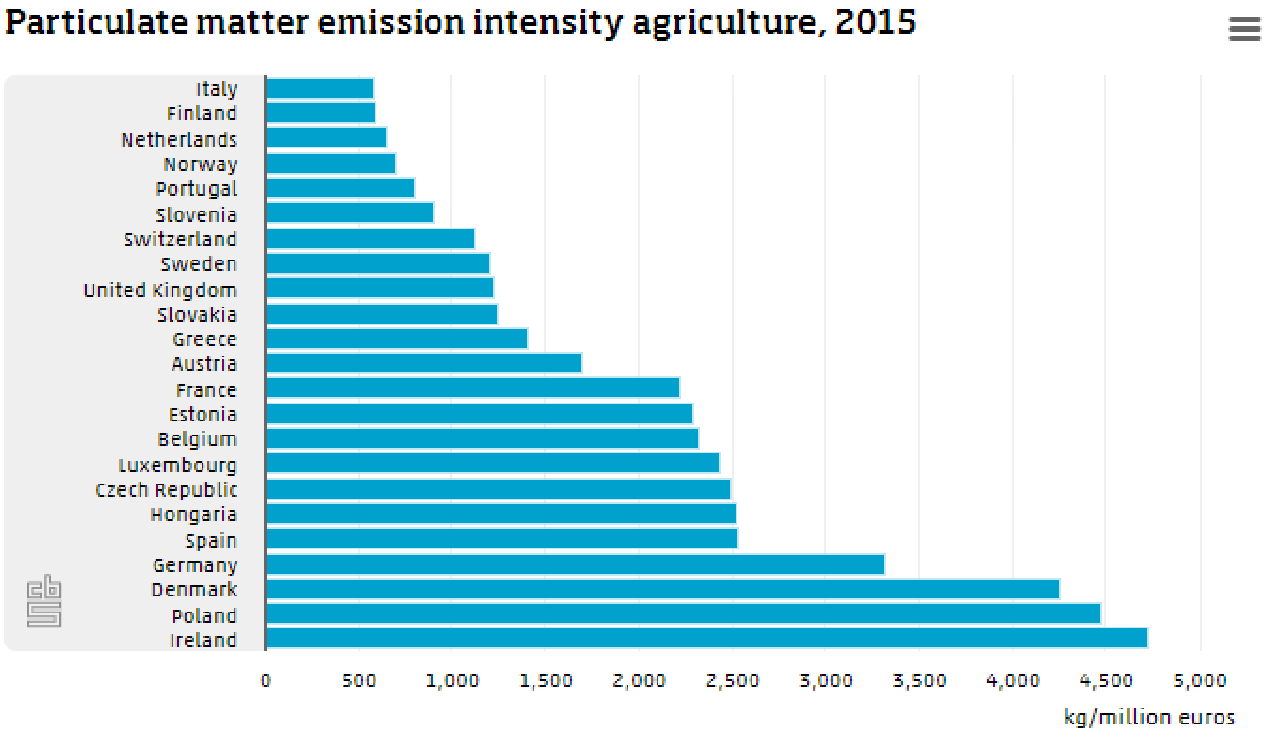


Figure 1.4: Particulate matter emission intensity in agriculture, 2015 - Ireland is the leading country in producing agricultural PM emissions (CBS, n.d.)

1.8.2. Household and farming chemicals

Approximately 3.8 million people a year die from the exposure to household and farming air pollution, according to WHO (WHO 2020).

Use of household and farming chemicals can release harmful particulates and gases into the atmosphere and have capability to contribute to air pollution. This type of pollution comes from a variety of different gases, chemicals and substances (WHO, 2020). Examples of these include fertilizers, household cleaning products, painting supplies, hair sprays, deodorant sprays, pesticides (Madaan, n.d.).

The main concern of the household and farming products is that it is a rising issue that may be of increased concern in the future for human and environment health.

Volatile organic compounds (VOCs) produced as a result from household and farming products, may react in the atmosphere producing either ozone or particulate matter, which can implicate health problems (Borkhataria, 2018).

1.8.3. Heating

Heating can increase PM emissions. Heating using fossil fuels (e.g. peat, petroleum and coal) is among the most popular. However, Domestic use of solid fuel can harm the environment and human health, particularly respiratory and cardiovascular problems. It is also predicted that Ireland's stock of fossil fuels will run out in the next 40 – 50 years (Aodha, 2017).

According to The European Environment Agency (EEA) have Air Quality in Ireland 2018 report, it is estimated that 1,180 premature deaths occurred in Ireland in 2016 directly attributable to air quality, associated with fine particulate matter (PM2.5) from the use of solid fuels such as wood, coal and peat for home heating are mainly responsible (EPA, 2019).

Wood is often used for heating and is a clean, renewable and cheap energy source and a great substitute to fossil fuel burning. The study by Ghafghazi (2011) concluded that using high-quality wood fuel from natural, uncontaminated stem wood would produce the least PM emissions compared to other available wood types, including unrefined types.

Therefore, wood which is unrefined, contains complex elements that are important to keep under control while burning in order to ensure low emissions (irCELine, n.d.).

A study by Kiesewetter (2015) demonstrated significant increase in PM2.5 from anthropogenic sources such as domestic heating mainly from coal and woods, road transport and industrial combustion in Europe. The cities such as Northern Italy, Poland, Romania and Bulgaria have the greatest exposure to PM2.5. The study stressed the adverse effects of PM2.5 and explained the relationship between PM2.5 and life expectancy. Ireland and Sweden showed to have one of the lowest impacts on life expectancy with overall possible life expectancy value reduced to 0.7 months, whereas Bulgaria had 4.5 months. Therefore, in Belgium, Poland, the Czech Republic, Hungary and Romania people are expected to lose more than 6 months on average even in 2030 (Kiesewetter, 2015).

1.9. Particulate Matter and Climate Change

Climate change can impact air quality, and vice versa, through complex interactions in the atmosphere (EPA, 2019; EC, 2010).

Pollutant emissions into the air may result in changes to the climate (EPA, 2019). PM can have either warming or cooling effects on the climate. Direct emissions of air pollutants (e.g. black carbon) may contribute to warming of the Earth, while those formed from emissions such as particulate sulphates reflect energy from sunlight back into the space resulting in cooling influence on climate change (EC, 2010; CARB, 2020).

Particulate matter concentrations are very likely to increase under changing climate, causing major future concern for increased mortalities, morbidity and broad range of negative health outcomes associated with PM exposure (Dias, 2012).

1.10. Air Quality Management

1.10.1. Environmental Protection Agency (EPA)

The Environmental Protection Agency (EPA) is a national competent, monitoring and reporting body worldwide (EPA, 2017). Created under the Environmental Protection Agency Act 1992, the EPA is an independent, national body of environmental protection and policing, intended to ensure the environment is protected by monitoring environmental development to observe early indication of neglect or degradation (EPA, 2019). The EPA's major responsibility is to protect the environment and human health working together with numerous organizations that carry particular functions for the environment (US EPA, 2019) (EPA, 2019). The EPA also derives its order from Waste Management Act, 1996, and the Protection of the Environment Act, 2003 and Radiological Protection (Miscellaneous Provisions) Act 2014 (EPA, 2019).

The EPA treats the environment as a valuable resource by protecting people and the environment from harmful effects of pollution and radiation. The EPA plays an important role in environmental regulatory affairs, delivering provision of knowledge and advocacy for the environment (EPA, 2019).

The EPA in Ireland is responsible for miscellaneous functions to protect the environment, its main functions include:

- Environmental licensing
- Enforcement of environmental law
- Environmental planning, education and guidance
- Monitoring, analysing and reporting on the environment
- Regulating Ireland's greenhouse gas emissions
- Environmental research development
- Strategic environmental assessment
- Waste management
- Radiological protection (EPA, 2019).

1.10.1.1. Air Quality Monitoring and Monitoring Stations under EPA

The EPA is responsible for managing national ambient air quality monitoring network. The EPA measures levels of specific outdoor air pollutants of most concern such as Particulate Matter and Nitrogen Dioxide, which products of traffic emissions. Other pollutants include ozone, carbon dioxide, sulphur dioxide, benzene, lead, PAH (Poly Aromatic Hydrocarbons), arsenic, nickel, cadmium and mercury.

1.10.1.2. Air Quality Index for Health (AQIH)

The EPA uses AQIH to identify the current air quality, ranging from 1 to 10 (These points are divided into four coloured bands – good (readings of 1-3), fair (readings of 4-6), poor (7-9) and very poor (10)) (EPA, 2019). The AQIH can tell the public whether there is concern for air quality in the specific region and whether it may affect the human health (EPA, 2019). The AQIH is calculated every hour based on pollutant concentrations as shown in *Figure 1.6* and the most up-to-date readings can be accessed on the EPA website. The AQIH is widely used by health practitioners to assist patients who are sensitive to air pollution and manage their condition by reducing the symptoms (EPA, 2019). Examples of how the AQIH is calculated are contained in *Appendix A*.

The AQIH readings can be interpreted as shown in *Figure 1.5*.:

Band	Index	Accompanying health messages for at-risk groups and the general population	
		At-risk individuals *	General population
Good	1	Enjoy your usual outdoor activities.	Enjoy your usual outdoor activities.
	2		
	3		
Fair	4	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.	Enjoy your usual outdoor activities.
	5		
	6		
Poor	7	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical activity, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors.
	8		
	9		
Very Poor	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

Figure 1.5: The AQIH health advice messages to help persons to better manage their health. The table above gives health messages for individuals who are sensitive to air pollution (at risk) and for the general population (EPA, 2019).

Four bands of air quality:	Index (1-10):	Five air pollutants which can harm your health:				
		Ozone Running 8-hour mean (µg/m^3)	Nitrogen dioxide 1-hour mean (µg/m^3)	Sulphur dioxide 1-hour mean (µg/m^3)	$PM_{2.5}$ particles Running 24-hour mean (µg/m^3)	PM_{10} particles Running 24-hour mean (µg/m^3)
Good air quality	1	0-33	0-67	0-29	0-11	0-16
	2	34-65	68-134	30-59	12-23	17-33
	3	67-100	135-200	60-89	24-35	34-50
Fair air quality	4	101-120	201-267	90-119	36-41	51-58
	5	121-140	268-334	120-149	42-47	59-66
	6	141-160	335-400	150-179	48-53	67-75
Poor air quality	7	161-187	401-467	180-236	54-58	76-83
	8	188-213	468-534	237-295	59-64	84-91
	9	214-240	535-600	296-354	65-70	92-100
Very Poor air quality	10	241 or more	601 or more	355 or more	71 or more	101 or more

Figure 1.6: The table above shows the ranges of concentration (amounts) for each pollutant (EPA,2019)

1.10.1.3. National Ambient Air Quality Monitoring Programme (AAMP)

The national ambient air quality monitoring programme began at the end of 2017 and was established to provide more comprehensive, real-time air quality information related to public health (EPA, 2017). The programme will upgrade the current information on EPA website, and it will provide information on a wider scale across Ireland, for rural and urban areas (EPA, 2017). This will help local authorities, policy makers and the EPA to access, identify and investigate surrounding air quality concerns easier and to ensure the monitoring is flexible and stationed properly (EPA, 2017). The data obtained from various available stations will provide accurate information on current air quality status in local area and serve as the basis to support development of national policies and local policies promoting cleaner air (EPA, 2017).

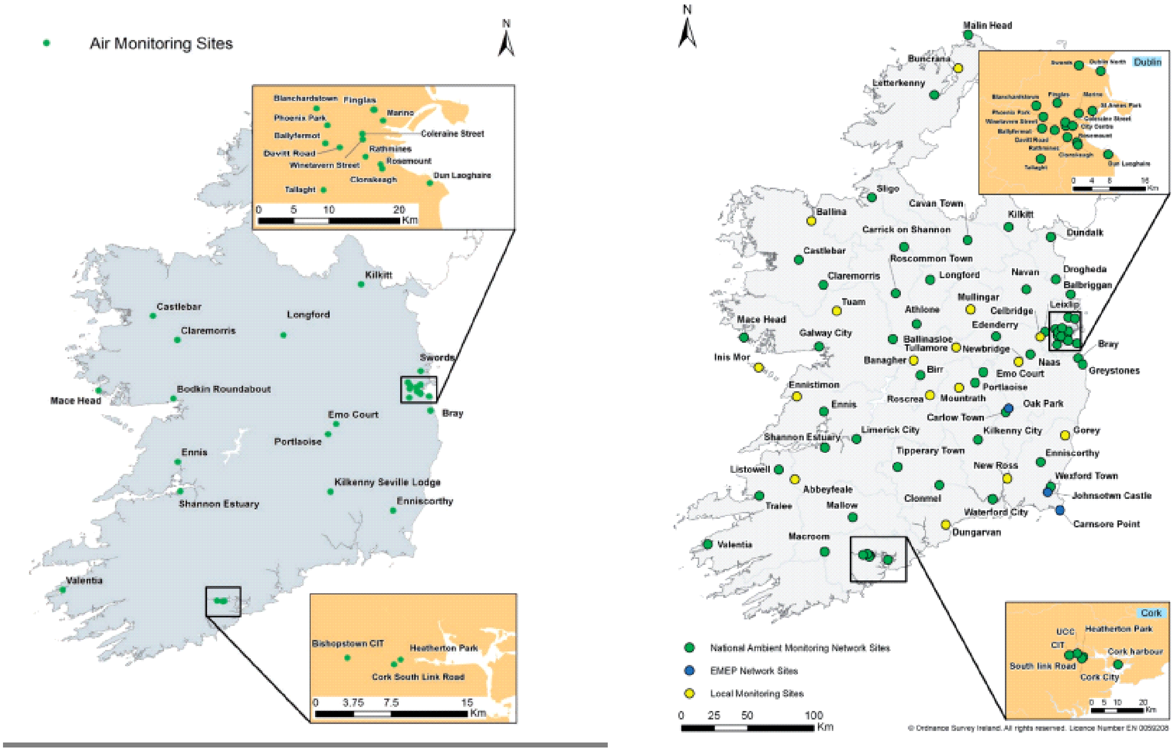
The programme will also enable citizens to access the information and view the current air quality in their local area, which will help the citizens to plan their activities ahead of time (EPA, 2017). The programme will allow the public to access and view the high-risk areas of polluted air on the map and will bring attention and encourage the public to engage in bringing awareness to their local areas and taking scientific initiatives regarding air quality issues (EPA, 2017). The programme will also, for the first time, provide the framework for the alignment of resources nationwide and will consider meeting the needs of people in Ireland (EPA, 2017).

1.10.1.3.1. AAMP Monitoring

The new national monitoring network will extend the present CAFÉ network to support greater area for monitoring air quality in urban and rural territories (EPA, 2017) as shown in *Figure 1.7.(a).* The placement of the station will depend on the population size, exposure to air quality issues and spatial distribution. Network sites will monitor for particulates, heavy metals, inorganic and organic gases (EPA, 2017). The proposed AAMP Monitoring plan can be seen in *Figure 1.7. (b)*.

The programme will rely on partnership basis and its success will depend on participation of partners, primarily EPA and Local Authorities for funding and strategic intelligence from principal government (EPA, 2017).

The programme is set to be completed by 2022 (EPA, 2018).



(a) *(b)*

Figure 1.7: Current ambient air quality monitoring network (a) and future (proposed) AAMP network (b) (EPA, 2017).

1.10.2. CAFÉ Directive (Cleaner Air for Europe) (2008/50/EC)

CAFÉ Directive was established to protect human health and the environment in Europe against harmful emissions and pollutants in ambient air (EPA, 2019). The directive sets down air quality standards in EU member states for various pollutants and highlights guidelines concerning monitoring, reduction and management of ambient air quality levels (EPA, 2016).

The CAFÉ Directive was an addition to European Commission 6th Environment Action Programme of the Thematic Strategy about air pollution, the Directive on Ambient Air Quality and Cleaner Air for Europe and Impact Assessment (EEA, 2019) (Ask About Ireland, n.d.). Thematic Strategy on air pollution was set to reduce the number of pre-mature deaths from air pollution related disease by 40% by 2020 (Ask About Ireland, n.d.).

The CAFÉ Directive was published in May 2008 and it replaces the Framework Directive and the first, second and third Daughter Directives (EPA, 2019). The fourth Daughter Directive

(2004/107/EC) will be introduced in CAFE at a later stage (EPA, 2019). The four Daughter Directives describe the limits for specific pollutants:

- 1st Daughter Directive: Sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead
- 2nd Daughter Directive: Carbon monoxide and benzene
- 3rd Daughter Directive: Ozone
- 4th Daughter Directive: Polyaromatic hydrocarbons, arsenic, nickel, cadmium and mercury in ambient air (EPA, 2019).

The CAFÉ Directive was incorporated into the Irish legislation Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011), which replaced Air Quality Standards Regulations 2002 (S.I. No. 271 of 2002), the Ozone in Ambient Air Regulations 2004 (S.I. No. 53 of 2004) and S.I. No. 33 of 1999 (EPA, 2019).

The Directive requires EPA to monitor and set national standards for ambient air quality for air pollutants (EPA, 2016).

Table 1.1. shows the limit and target values for CAFÉ Directive (2008/50/EC) which are outlined below (EPA, 2019).:

Pollutant	Limit Value Objective	Averaging Period	Limit Value ug/m3	Limit Value ppb	Basis of Application of the Limit Value	Limit Value Attainment Date
SO2	**Protection of human health**	**1 hour**	**350**	**132**	**Not to be exceeded more than 24 times in a calendar year**	**1 Jan 2005**
SO2	**Protection of human health**	**24 hours**	**125**	**47**	**Not to be exceeded more than 3 times in a calendar year**	**1 Jan 2005**
SO2	**Protection of vegetation**	**calendar year**	**20**	**7.5**	**Annual mean**	**19 July 2001**

SO2	Protection of vegetation	1 Oct to 31 Mar	20	7.5	Winter mean	19 July 2001
NO2	Protection of human health	1 hour	200	105	Not to be exceeded more than 18 times in a calendar year	1 Jan 2010
NO2	Protection of human health	calendar year	40	21	Annual mean	1 Jan 2010
NO + NO 2	Protection of ecosystems	calendar year	30	16	Annual mean	19 July 2001
PM10	Protection of human health	24 hours	50		Not to be exceeded more than 35 times in a calendar year	1 Jan 2005
PM10	Protection of human health	calendar year	40		Annual mean	1 Jan 2005
PM2.5 - Stage 1	Protection of human health	calendar year	25		Annual mean	1 Jan 2015
PM2.5 - Stage 2	Protection of human health	calendar year	20		Annual mean	1 Jan 2020
Lead	Protection of human health	calendar year	0.5		Annual mean	1 Jan 2005
Carbon Monoxide	Protection of human health	8 hours	10,000	8620	Not to be exceeded	1 Jan 2005
Benzene	Protection of human	calendar year	5	1.5	Annual mean	1 Jan 2010

	health					

The EU 7th Environmental Action Programme's aims is to ensure by 2020 that the outdoor air quality limits in EU are significantly improved and the limits and are like those proposed by the WHO (EPA, 2016).

1.10.3. World Health Organisation (WHO)

The WHO developed air quality guidelines for specific air pollutants in order to inform the policy makers and set suitable air quality targets based on the latest health information, which can be applicable worldwide (EPA, 2016). Since 2012, EPA has reported exceedances in particulate matter and ozone and called for the WHO to endorse stricter guidelines on PM and ozone.

Currently, the WHO stresses the importance of the link between PM and adverse health effects in humans. In 2013, the WHO's International Agency for Research on Cancer (IARC) completed a research that proves that outdoor air pollution is carcinogenic to human health, with PM being of most concern due to associated increased cancer incidence such as lung cancer (WHO, 2018).

The WHO 2005 guideline aims to achieve the lowest possible PM concentration as PM impacts health at very low concentrations (WHO, 2018). As a result of the recent publication on PM health effects on humans, the WHO is set to review their guidelines and new WHO guidelines are expected to be released in 2020 (WHO, 2018).

Table 1.2. outlines the current WHO 2005 guidelines for $PM_{2.5}$ and PM_{10} are outlined below (WHO, 2006):

$PM_{2.5}$	1 year	10
	24 h (99th percentile)	25
PM_{10}	1 year	20
	24 h (99th percentile)	50

1.10.4. European Environment Agency (EEA)

The European Environment Agency (EEA) is the European Union's air pollution data centre and it enforces utilization of EU legislation for ambient air pollution (EEA, 2017). The EEA additionally assists the evaluation of EU air pollution policies as well as strategies for long-term air quality improvement in Europe (EEA, 2017).

The EEA’s work consists of:

- Publicizing different available air pollution data
- Assessing and documenting the available air pollution trends and associated policies and standards in Europe
- Investigating air pollution changes and policies in different areas, such as climate change, energy and transport (EEA, 2017).

In the recent EEA’s report, “*Air quality in Europe — 2019 report*”, it was noted that are large part of Europe was affected by continuously growing PM concentrations, exceeding EU limit values and the WHO Air Quality Guidelines (AQG’s): “*For PM with a diameter of 10 µm or less (PM10), concentrations above the EU daily limit value were registered at 22 % of the reporting stations (646 out of 2 886) in 17 of the 28 EU Member States (EU 28) and in six other reporting countries. For PM2.5, concentrations above the annual limit value were registered at 7 % of the reporting stations (98 out of 1 396) in seven Member States and three other reporting countries. The long-term WHO AQG for PM10 was exceeded at 51 % of the stations (1 497 out of 2 927) and in all of the reporting countries, except Estonia, Finland and Ireland. The long-term WHO AQG for PM2.5 was exceeded at 69 % of the stations (958) located in all of the reporting countries, except Estonia, Finland and Norway* (EEA, 2019)”.

The EEA has also taken part in planning a project for national and local measures of air pollution, and together with European Commission, arranged local authorities to meet and understand the policy implementation (EEA, 2019). 10 out of 12 cities took part in this project, including Dublin (Ireland) (EEA, 2019). The cities were involved in the project, mainly due to the implementation of the EU policies, as a result improved their air management such as measuring methods and monitoring and understanding of the air pollution sources and adverse health effects it may pose to humans (EEA, 2019).

1.10.5. Air Pollution Act 1987

Under Air Pollution Act 1987, local authorities are obliged to: "*may organise and conduct research, surveys or investigations into the nature and extent, the cause and effect, and the prevention or limitation, of air pollution and may establish and maintain educational programmes relating to such matters and may publish, or cause to be published, any information derived from any such research, surveys, investigations or educational programmes*" (Government of Ireland, 1987).

Other roles and functions of the local authorities under Air Pollution Act 1987 are described below:

- Monitoring of emissions or the ambient air in the area
- Assessing compliance with the relevant legislation
- Dealing with complaints regarding air pollution
- Licensing certain categories of industry which produce emissions
- Enforcing the ban on the marketing, distribution sale and burning of certain fuel (such as bituminous coal)
- Supporting or assisting anyone engaged in any research, survey or investigation into the nature and extent, the cause and effect and the prevention or limitation of ambient air pollution
- Enforcement of the Act. The local authorities have the power to enforce penalties for anyone found in breach with the Act in their area and may face a fine and/or imprisonment. Local authority may recommend a solution or issue a warning regarding air pollution, which if ignored, the case may proceed to High Court (Citizens Information, 2016) (Government of Ireland, 1987).

The owners of industrial plants must obtain an air pollution licence from local authority or the EPA to operate certain production that will produce emissions (Ask About Ireland, n.d.).

1.10.5.1. Smokey Coal Ban

Fossil fuel burning such as coal contributes greatly to air pollution (Ask About Ireland, n.d.).

In 1990, the then Minister for Health Mary Harney introduced a ban on smoky coal under the Air Pollution Act 1987 within Dublin city and the Dublin region (Finn, 2019). Due to extensive use of bituminous (smoky) coal, "Winter Smog" was a growing issue in urban areas during that time posing serious adverse health effects to public (Ask About Ireland, n.d.).
As a result of Smoky Coal Ban, marketing, sale and distribution of bituminous coal was prohibited in Dublin area and substantial improvement on smoke and sulphur dioxide (SO2) levels. In Dublin alone, approximately 8'000 deaths have been prevented since the ban back in the 1990 (DCCAE, 2019). The Ban was eventually expanded to other areas in Ireland under various amendments to the 1998 Regulations (Ask About Ireland, n.d.).

Burning smoky coal and other prohibited fuels is banned and applies in all Low Smoke Zones (LSZs) in order to complement the ban on marketing, selling and distribution of these fuels in Low Smoke Zones (LSZ's) (DCCAE, 2019). Therefore, this means that smoky coal bought elsewhere cannot be burned in LSZ's (DCCAE, 2019). More specifically, the ban took effect in the following areas:

- Dublin from 1990
- Cork from 1995
- Arklow, Drogheda, Dundalk, Limerick and Wexford from 1998
- Celbridge, Galway, Leixlip, Naas and Waterford from 2000
- Bray, Kilkenny, Sligo and Tralee from 2003
- Athlone, Arklow, Clonmel and Ennis from 2011
- Greystones, Letterkenny, Mullingar, Navan, Newbridge, Portlaoise and Wicklow Town from 2013
- Maynooth from 2015 (Ask About Ireland, n.d.).

1.11. Factors and Effect Influencing Pedestrian Route Choice

Walking remains one of the most popular mode of travel. There are many factors influencing public to use a pedestrianised route such as availability, quality and connectivity of infrastructure (Martin, 2006). It is important to understand the reason why the public chooses to commute on foot rather than deciding on preferable transport mode.

The more available pedestrian routes are available, the more likely the public is influenced to choose walking as preferable means of transport. However, the safety of the pathways plays a crucial role in this decision as well. For instance, some of the pedestrianised footpaths in Dublin City Centre are too narrow for the number of people in Dublin and are too close to the road. The dominance of the vehicles in Dublin is recognized throughout the space ratio given to the pedestrianised footpaths versus road provided for the vehicles. The ratio is around 1:3 for the pedestrianised footpaths, providing more space for transport and private vehicles to get by. The numbers of people in Dublin City Centre are increasing daily due to the incoming tourists from abroad, therefore, the footpaths are generally avoided due to the congestion and time delay it may cause getting through. Although, the choice may be also influenced by the fact that it does not cost anything and additionally, does not pollute the environment, which in return increases overall human health.

Quality of the footpaths may encourage people to walk instead of using motorized modes of transport. The cleanliness, which the presence of litter, dirt, spills, available rubbish bins and the condition of the pavement are important factors. Poor maintenance of public structures such as bus stops, rubbish bins and their absence, damaged pavements may detract persons from walking (Hodgson, 2004).

Connectivity of infrastructure is also an important factor influencing people to consider walking. Good planning and network of the city providing good connections and access to services (e.g. shops, work, education institutions etc.) and facilities (e.g. footpaths, crossing, traffic lights etc.). Some people may consider the shortest and straightest path to reach their point, however, this may not be possible due to the city's infrastructure and the person may consider other means of transport or calculate another possible route, however, this may also depend on the type of person (Hodgson, 2004).

Safety aspects may also play an important part when it comes to choosing a mode of transport.

An article by Sharma (2019) explained that there is a relationship between gender and travel behaviour, which could serve as a factor determining the mode choice. According to the article, women are more inclined to take trips or consider taking transport modes that are perceived as unsafe, which is often influenced by seeing or overhearing something unpleasant and dangerous that might restrain women from taking certain modes of transport. Calje (1992) demonstrated that personal experience of a certain activity (e. g. commuting by bus, ferry) affected the level of uncertainty of perceived risk, e.g. made the risk seem lower/higher. A study by Lindberg (2000) supports the Sharma's explanation as the study explains that women were reported to have more frequent feelings of unsafety compared to men due to the various factors such as lighting, time of day, absence of personnel and travelling alone. The feeling of unsafety was related more to walking than other means of transportation in this study. Additionally, Atkins (1988) showed that women are more likely to worry and feel unsafe due to the fear of being attacked or harassed at night compared with daytime. A study by Dewi (2010), however, shows different results. The study explained that male students are more likely to consider safety, comfort and convenience as first influencing factors, whereas female students were inclined to consider transport mode based on transport frequency and variation.

Age and disability can also be important factors for people choosing a transport mode.

1.12. Impact of Transport Mode on Exposure to Pollution in Urban Areas

There is an issue concerning transport mode air pollution in urban areas. Larger cities notably encounter struggle to attain set air quality limits in their region to protect human and environmental health.

The concentrations of air pollutants generated by road transportation may represent a major public health issue (Apparicio, 2018). According to Apparicio (2018), motorists and public transit commuters have higher levels of exposure to air pollution than cyclists and pedestrians, but because of higher levels of ventilation, cyclists and pedestrians may inhale more pollutants.

A study by Schneidemesser (2019), found that total exposure to air pollution is often disproportionately affected by the relatively short amount of time spent commuting or in the proximity of traffic.

Exposure to poor air quality by people using various transport modes was investigated by Cepeda (2016) who found that car commuters were more exposed to air pollution than active commuters (71%; in 30 of 42 comparisons), followed by commuters who travelled by bus (52%; in 57 of 109), and then by motorcycle (50%; in 16 of 32).

Buses, coaches, private cars, light-rail trains and trains are the major transportation types in Dublin. Walking is a universal and common form of transport, followed by cycling. The preferred transport mode is by walking-bus or bus-Luas travel. Direct exposure to airborne particles can vary, depending on the traffic intensity, transport type, vehicle type and age and driving behaviour in the traffic microenvironment (Stakeeva, 2013).

A study by Moreno (2015) found that subway particles are coarser (mode 90 nm) than in buses or trams (<70 nm), and concentrations of fine particulate matter ($PM_{2.5}$) are lower in the tram when compared to both bus and subway.

Chapter 2: Methodology

2.1. Aims

The main aims of this project are to estimate The $PM_{2.5}$ (fine particulate) and $PM_{0.5}$ (ultrafine particulate) exposure of students and general public between three TU Dublin campuses in Dublin City Centre, focusing on the traffic populated and pedestrian streets.

2.2. Objectives

A number of sub objectives were identified to achieve the above aim:

- To identify using Google Maps the two pedestrian routes between each of fastest and safest route(s) to walk from Cathal Brugha City Centre Campus and Kevin street and Cathal Brugha City Centre Campus to Grangegorman Campus. Routes are chosen based on proximity to heavily trafficked street. The routes were selected carefully: one clean (pedestrianised) street and one polluted (traffic induced/mixed transport) street.
- To investigate the PM exposure along each of the routes using a Portable Particulate Monitor – Dylos DC1700.
- To review and compare data against the existing national policies and regulations that control the particulate matter emissions to be addressed and recommend improvements and practices to minimize the exposure of PM from the results obtained in this study (such as CAFÉ Directive, the WHO, EPA etc.)
- To investigate the public's perception on air quality. The main aim of the survey is to establish public knowledge on air pollution and adverse health effects it poses as well as investigate the selection of the transport the public favours and the reasons behind their transport preferences.

2.3. Preparation before Fieldwork

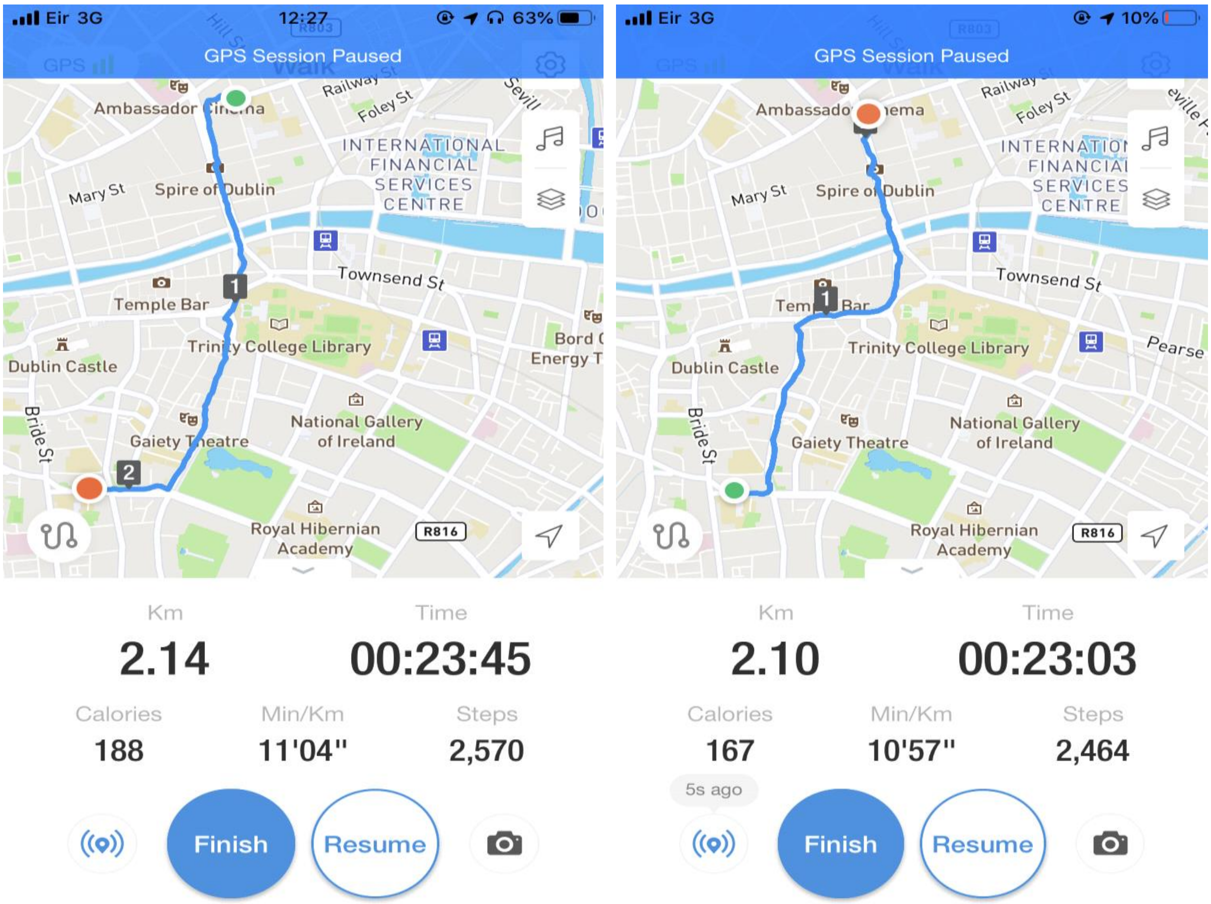
- Two different routes to access the areas from the starting point A (Cathal Brugha Street TU Dublin City Centre Campus) were identified and assessed prior to starting to collect data. The following streets were selected:

- <u>Cathal Brugha street to Kevin street – Pedestrianized route (as shown in *Figure 2.1.(a)*):</u>

Cathal Brugha Street → O’Connell Street Upper → O’Connell Street Lower → O’Connell Bridge → Westmoreland Street → College Green → Grafton Street → King Street South → St Stephen’s Green → Cuffe Street → Kevin Street Lower

- <u>Cathal Brugha street to Kevin street – Mixed route (as shown in *Figure 2.1. (b)*):</u>

Cathal Brugha Street → Upper O’Connell Street → Lower O’Connell Street → O’Connell Bridge → Westmoreland Street → College Green → Dame Street → South Great George’s Street → Aungier Street → Redmond’s Hill → Kevin Street Lower



(a) (b)

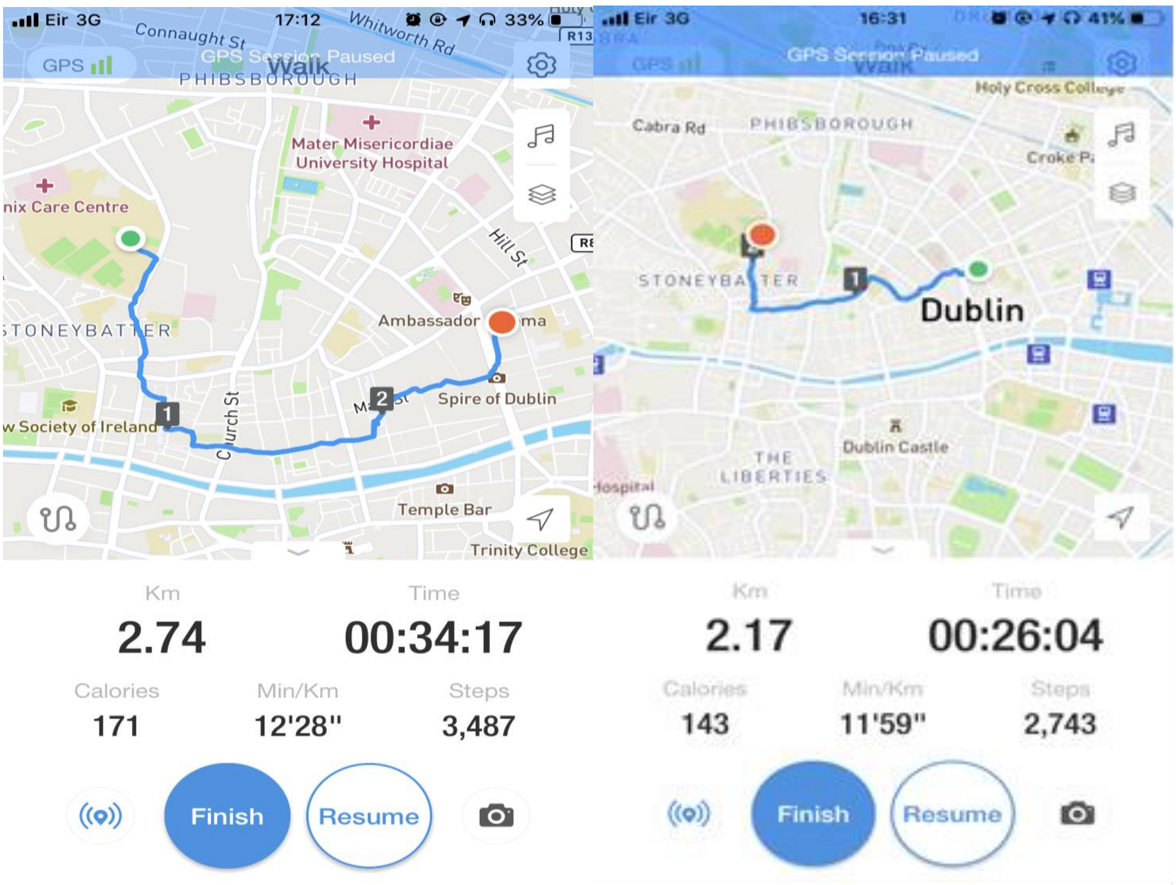
Figure 2.1: Cathal Brugha Street to Kevin Street City campus - Pedestrianized route (a) and more heavily trafficked route (b)

- <u>Cathal Brugha street – Grangegorman – Pedestrianized route (as shown in *Figure 2.2. (a)*):</u>

Cathal Brugha Street → O'Connell Street Upper → Henry Street → Mary Street → Jervis Street Upper → Abbey Street Upper → Chancery Street → Church Street → Hammond Lane → Smithfield → Red Cow Lane → Brunswick Street North → Grangegorman Lower

- <u>Cathal Brugha street – Grangegorman – Mixed street (as shown in *Figure 2.2. (b)*):</u>

Cathal Brugha Street → O'Connell Street Upper → Parnell Street → King Inn's Street → North King Street → George's Lane → Grangegorman Lower



(a) (b)

Figure 2.2: Cathal Brugha Street to Grangegorman campus - Pedestrianized route (a) and more heavily trafficked route (b)

- Different traffic prone streets/routes were analysed via various online websites, such as

Google Maps and Traffic Infrastructure Ireland. Pedestrianized streets were also included to contrast the results collected for the traffic populated streets. The streets were tested before starting the research work to ensure the streets are safe (e.g. inspecting anti-social behaviour issues etc.) and suit the desired research requirement

- An appropriate app for tracking walked routes and time were researched. The selected app is Pacer, which works as a pedometer and step counter as shown in *Figure 2.3*. It allows the user to track distances walked on a GPS map.

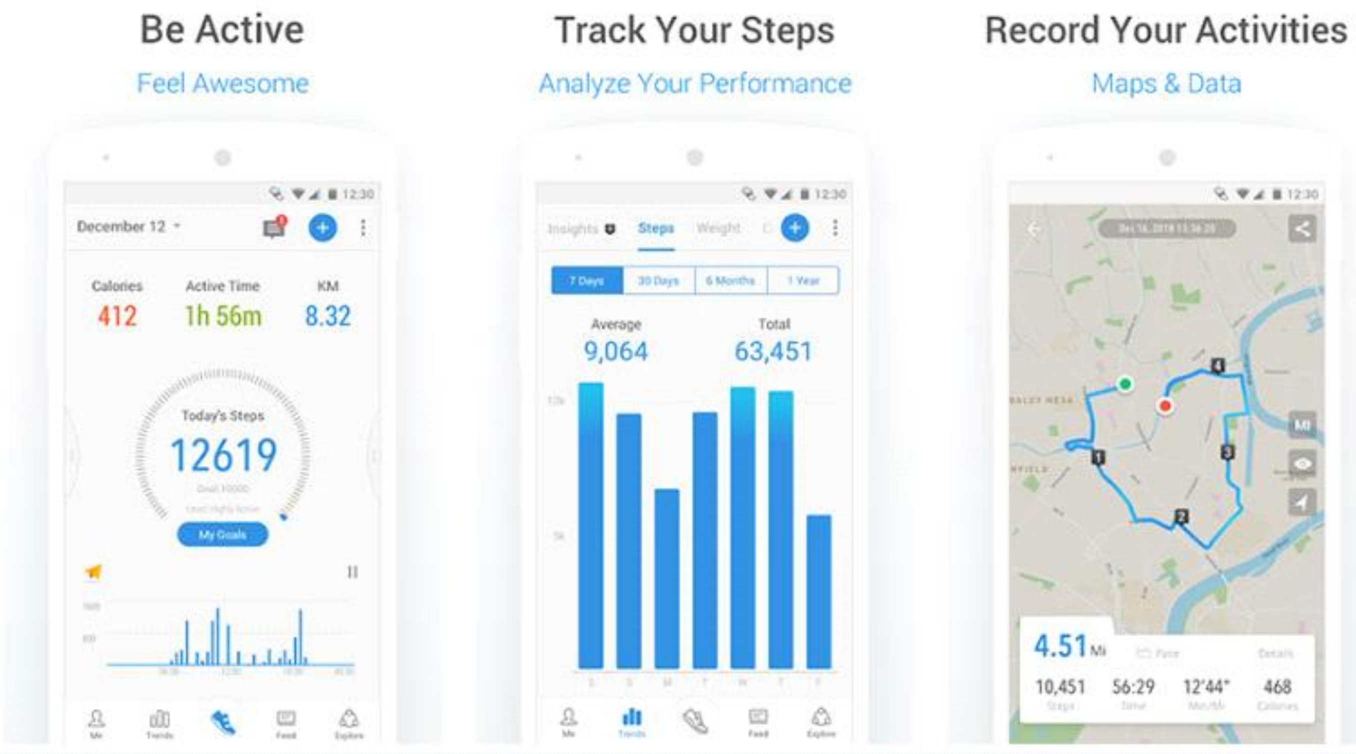


Figure 2.3: Pacer App functions displayed (Hindy, 2019).

- Times during the day when the data were to be collected were identified – the busiest times of the day were noted to be morning and evening rush hours. It was decided to select one pedestrianized route and one mixed (traffic induced and pedestrianized) route to assess Kevin street and Grangegorman from Cathal Brugha street.
- The Dylos DC1700 air quality monitor was attained, in order to measure $PM_{2.5}$ and $PM_{0.5}$ counts during each walking route as shown in *Figure 2.4* and *Figure 2.5*.

Figure 2.4: Dylos air quality monitor DC1700 - front

Figure 2.5: Dylos air quality monitor DC1700 - back

- A USB COM port and a 9-serial pin cable were also attained from TU Dublin Technicians to allow for data transfer between Dylos monitor and PC
- Dylos logger software version 1.6 was installed on a PC
- Together with the TU Dublin Technicians, Dylos logger software version 1.6 was tested by transferring the test data already collected to see if the cable and the logger is working appropriately.

2.4. Procedure of Fieldwork – Sampling

- It was important to test if the monitor is fully charger prior to commencing data collection by checking the monitor. This was achieved by turning the meter on and checking the battery life. The meter was charged once to twice a daily to ensure the battery life is full and no data is lost
- If this is a new test, clear history. Press the “Mode” button located in the middle until “clear history?” is displayed, then press “Select” located on the right side to clear previous data.
- Cathal Brugha street campus is reached to start data collection, either during the morning (from 6 am to 7-8 am) or evening time (from around 4 pm to 5-6pm).
- Weather report is checked before starting each walking route – especially taken noting temperature and humidity.
- Pacer app is set on the mobile phone to investigate the actual time needed to walk to the desired location. Map of the walked distance is displayed on the app. If any previous data is present on the app, it is required to reset the data.
- The Dylos monitor was placed at approximately face height, filter facing the face/front, away from the face. This is to ensure that the data collected would mimic the breathing in of the PM outdoors.
- Turn the Dylos DC1700 monitor by pressing the power button located on the furthest left side of the meter.
- The date and time were set on the meter.
- “Mode” button was clicked until “date time mode” is shown. “Select” button was clicked to change time.
- Select a mode on Dylos meter by pressing “Mode” button and select “Continuous Mode”, which records data every minute.

- The Dylos monitor is turned on first (2 seconds) before the Pacer app is. This is because it takes approximately 2-3 seconds for the monitor to turn on.
- The Pacer app is turned on after 2-3 seconds and the data is collected by assessing the desired, planned routes.
- Initially the Dylos monitor was left on working for the remainder of time needed to walk to the required points (B-Kevin street and C-Grangegorman), which highly depended on the traffic exposed on the day and the time of the day as well the selected street distance to walk to the end point (usually between 20-30 mins).
- The Dylos monitor and the Pacer app was turned off at the same time once the end destination has been reached to ensure the accuracy of the data.
- The campuses which were assessed that day were recorded on the monitoring schedule created (as seen in *Table 2.1*) specifically to keep track on the data collected for accurate results– date, time of the day (morning or evening), route (route 1 or route 2) walked, and campus/street which was monitored for PM were all recorded.

Table 2.1. below shows a monitoring schedule - recorded days which were walked: the street, the time of the day (morning or evening (and the route (route 1 or route 2)) assessed were all the information considered.

	Monitoring Schedule					
	Morning		Evening		Campus assessed (walked to)	
Week Commencing	Route 1	Route 2	Route 1	Route 2	Cathal Brugha st – Kevin st	Cathal Brugha st - Grangegorman
15/05/2019	✓	✓	✓	✓	✓	
17/05/2019	✓	✓	✓	✓	✓	
19/05/2019	✓	✓	✓	✓	✓	
26/05/2019	✓	✓	✓	✓	✓	✓
28/05/2019	✓	✓	✓	✓		✓
01/06/2019	✓	✓	✓	✓		✓
19/06/2019	✓	✓	✓	✓	✓	
20/06/2019	✓	✓	✓	✓		✓
21/06/2019	✓	✓	✓	✓		✓
26/06/2019	✓	✓	✓	✓		✓
01/07/2019	✓		✓	✓		✓
02/07/2019			✓	✓	✓	
03/07/2010	✓	✓	✓	✓		✓
10/07/2019	✓	✓	✓	✓		✓
11/07/2019			✓	✓	✓	
11/08/2019	✓	✓	✓	✓	✓	
18/08/2019	✓	✓	✓		✓	
21/08/2019	✓	✓				✓
24/08/2019	✓					✓
25/08/2019	✓	✓			✓	
26/08/2019	✓	✓			✓	
27/08/2019	✓	✓	✓	✓		✓
28/08/2019	✓	✓	✓	✓		✓
02/09/2019	✓	✓				✓
03/09/2019	✓	✓			✓	
10/09/2019	✓	✓	✓	✓	✓	
11/09/2019	✓	✓	✓	✓		✓
12/09/2019	✓	✓			✓	
15/09/2019	✓	✓	✓	✓		✓
17/09/2019	✓	✓				✓
19/09/2019	✓	✓	✓	✓	✓	
20/09/2019	✓	✓			✓	
23/09/2019			✓	✓	✓	
03/11/2019	✓	✓	✓	✓	✓	
04/11/2019	✓	✓	✓	✓		✓
05/11/2019	✓	✓	✓	✓		✓
07/11/2019	✓	✓	✓	✓		✓
10/11/2019	✓	✓	✓	✓	✓	
11/11/2019			✓	✓	✓	
14/11/2019	✓	✓	✓		✓	
15/11/2019	✓	✓	✓	✓		✓
18/11/2019	✓	✓	✓	✓		✓
26/11/2019	✓	✓	✓	✓		✓
27/11/2019	✓	✓	✓	✓	✓	
29/11/2019	✓	✓	✓	✓	✓	
01/12/2019	✓	✓	✓	✓		✓
04/12/2019	✓	✓	✓	✓		✓
05/12/2019	✓	✓	✓	✓		✓
06/12/2019	✓	✓	✓	✓	✓	
07/12/2019	✓	✓	✓	✓	✓	
08/12/2019	✓	✓	✓	✓	✓	

2.5. Procedure for Transferring Particle Count Data to Dylos Logger Software

- A 9-serial pin was plugged into the Dylos monitor and into the PC via a USB COM port.
- The Dylos monitor was turned on.
- The Dylos logger software was opened on the PC.
- Select the available COM Port with the “Port” selection.
- Use the folder symbol next to the drop-down box below the “Stop After” box to select a file in which the data will be transferred (desktop, documents etc.)
- Below this select “particles per”, then select “cubic foot/100 in order to graph the data correctly
- “Download history” was then selected to download the data from the meter to the left of the “Port” selection.
- When the data has been downloaded, “Create Log” was selected. Now the data is saved, it can be imported into Microsoft Excel and the logger can now be closed.
- The data was later transferred onto another Microsoft Excel file and placed accordingly to the date and time data was collected for accuracy.
- The instrument used measured "Small particle counts" and "large particle counts". "Small particle count" refers to the number of particles 0.5µm or greater in .01 cubic foot of air. The "large particle count" refers to the number of particles 2.5µm or greater in 0.01 cubic foot. In conjunction with relative humidity measurements these readings were converted into $PM_{2.5}$ concentrations (the concentration of particles less than 2.5µm in diameter).
- Additional Microsoft Excel file was created to add results of the weather, temperature and humidity of the day and time the data was collected. This information will be graphed against the overall $PM_{2.5}$ concentration results throughout the whole collection period (day and time of the day). The fine and large particle count will be used to estimate the $PM_{2.5}$ prior to graphing the results.

2.6. Comparing the Data Attained from DCC against the Data Obtained During $PM_{2.5}$ Collection

Air Quality and Noise Control Unit in Dublin City Council is responsible for air quality monitoring, enforcement of air and noise legislation, carrying research and providing expertise in relation to air and noise quality. The data collected by Air Quality and Noise Control Unit is sent to the EPA before the collective report on findings is published.

- Principal Environmental Health Officer (PEHO) in DCC was contacted via email. The idea of the project was proposed to the PEHO in DCC to review the project and agree upon the distribution of the results collected by the air quality specialists in DCC.
- The data was agreed to be shared via email and I was advised to also access the results of the air quality in Dublin City published by EPA.
- The data from DCC was requested only for the dates the research on the PM was done in Dublin City Centre
- The results were compared against the DCC collected results to validate the results collected from the Dylos monitor. The street used to compare the results was St John's Road located on the west side of the Dublin City Centre.

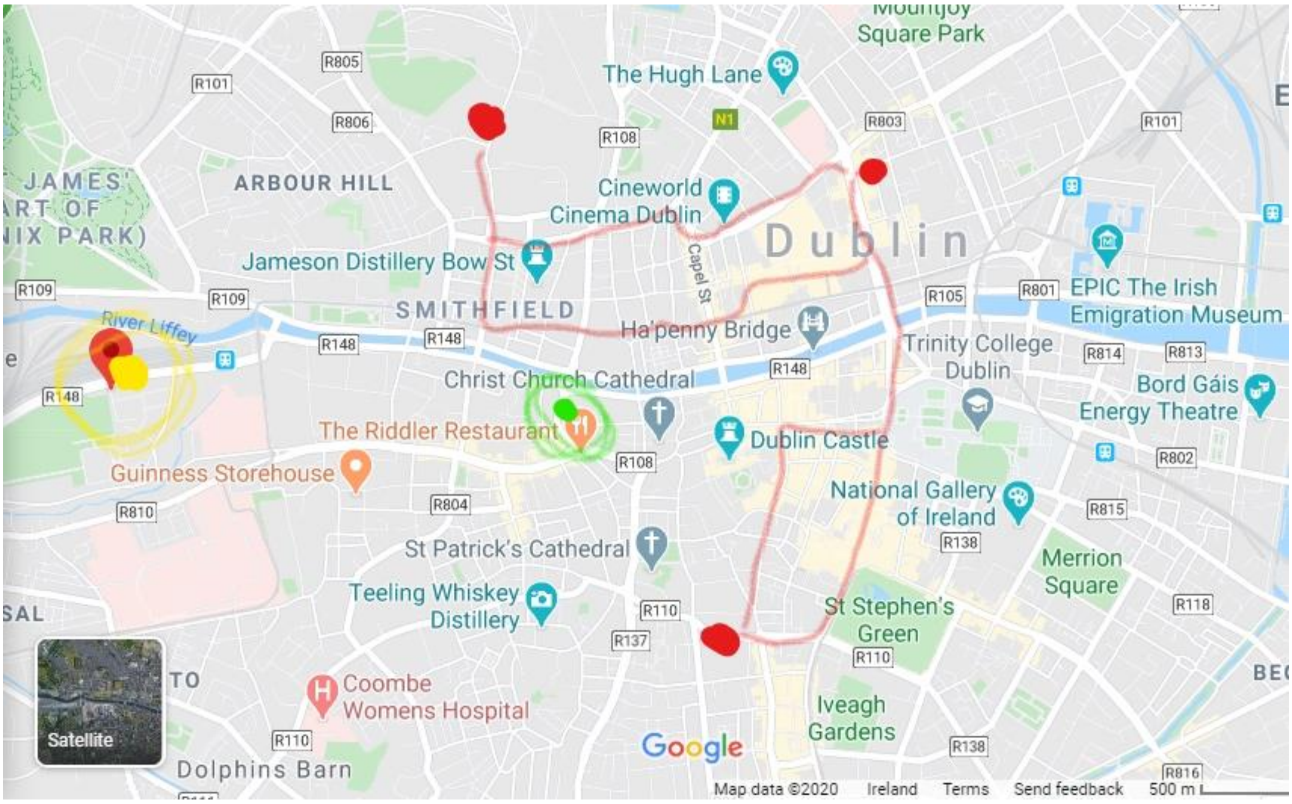


Figure 2.6: Map showing the monitored routes and the distance between the routes and monitors. The TU Dublin Campuses are marked in red and the two closest monitors are highlighted in different colours: Green – Winetavern street, Wood Quay and Yellow – St John's Road.

2.7. Gathering public information regarding the air quality and transport in Dublin City Centre via online survey

- Survey was completed using Survey Monkey website. The survey has 18 questions in total relating to air quality and transport in Dublin City Centre. The survey is comprised of a total of 30 questions and is completely anonymous – no names, IP addresses etc are seen or registered. The survey design consists of multiple choice questions (allowing the respondent to answer only one question from a list of choices), checkboxes (allowing the respondent to select all the choices that apply to them), and an interactive slider (which allows the respondents to drag an item or question by dragging an interactive slider). The survey is also accompanied by a brief introduction regarding the overall purpose of the study.

- The survey was piloted prior gathering information with academic supervisors, friends, family members to establish the quality of the survey and gather opinions and advice.
- An agreement was set with TU Dublin and EI Travel Group to share the survey among all the student and staff members.
- Survey was shared via social media (Facebook and LinkedIn), shared via email with TU Dublin students and staff members and shared among tourism company EI Travel Group staff members via HR app - BambooHR.
- All the data collected from the survey was analysed in great detailed and recorded in the graphs using Microsoft Excel.
- The results gathered on Microsoft Excel were generated into graphs.
- Results were later used to analyse further public choices in the project and to understand what is more popular: walking or choosing public transport, and to understand if public is aware of the air quality exposure as well as if they are happy with the current Dublin City transport/pedestrianized areas.

2.8. Limitations

Due to resources constraints, it was not always possible to access Dublin City centre at the same time of the day to carry this research. Therefore, the times of the research sometimes varied. Also, the times selected for the research were not perfectly recorded due to the public transport not running early in the morning (6am) on the weekends to carry the study. This caused issues to record and produce accurate results.

The PM meter is not weatherproofed and therefore was difficult to carry the research during the days when there was rainfall.

Occasionally, the Pacer app refused to work or stop working mid experiment. Therefore, the time was simply recorded on the mobile phone using stopwatch as a backup.

The streets that were assessed during this study do not have fixed monitoring stations (operated by EPA or DCC). Therefore, only one street (St John's Road) was used to compare the overall readings.

DCC does not measure $PM_{0.5}$ and therefore, there was no possibility to compare the collected data against another source. However, the health impacts of these fine particles mean that it is likely routine monitoring will take place in the future.

Chapter 3: Results

This chapter contains the results obtained from the course of this study for fine PM concentration will be showed and explained briefly. The collected fine and ultrafine particle count can be found in *Appendix B* and the conversion of particle count to PM concentration can be found in *Appendix C*. Study examined the distributions of each routes, pedestrianized and mixed, from Cathal Brugha Street to Kevin Street TU Dublin campus and Cathal Brugha Street to Grangegorman TU Dublin campus. Temperature, humidity, fine and ultrafine particulate matter data was recorded while assessing the routes. The results were collected over 7 months (May, June, July, August, September, November and December) from total of 51 days assessing the various routes. The routes were assessed during morning (from 7 am – 9 am) and evening rush hours (from 4pm to 6 pm), which are the busiest times for public and private transport in Dublin City Centre. The average estimated walk by a pedestrianized street was estimated to be around 30-35 minutes, whereas a mixed route was approximately 20-30 minutes.

Pedestrianized routes were exposed to light traffic from modes of transport, e.g. LUAS, private vehicles, however, with little exposure to heavy traffic. The streets were segregated from main roads by large buildings, e.g. apartments, cafes, restaurants, shops etc, and pedestrian friendly streets.

Mixed routes were exposed to moderate to heavy traffic from varying modes of transport, e.g. buses, coaches, LUAS, private vehicles. The streets allowed for pedestrian crossing and had pedestrian footpaths. Most of the streets comprised of narrow pedestrian footpaths, which made it difficult to use especially due to increased numbers of people outdoors during morning and evening rush hours. The assessed streets were mainly enclosed with large buildings and structures, such as apartments, monuments, shops, cafes and restaurants.

The presented graphs show $PM_{2.5}$ concentration levels (ug/m3), set to a maximum scale of 60 (ug/m3) (vertical axis) and measurements that show for each day/month (horizontal axis) that were assessed during pedestrianized and mixed route PM level data collection from Cathal Brugha Street to Kevin Street TU Dublin campus and from Cathal Brugha Street to Grangegorman TU Dublin campus separately.

The results show that there were sudden fluctuations in fine PM concentration levels (as seen in graphs), however, overall results show that PM concentration levels are safe for pedestrians walking through the assessed streets.

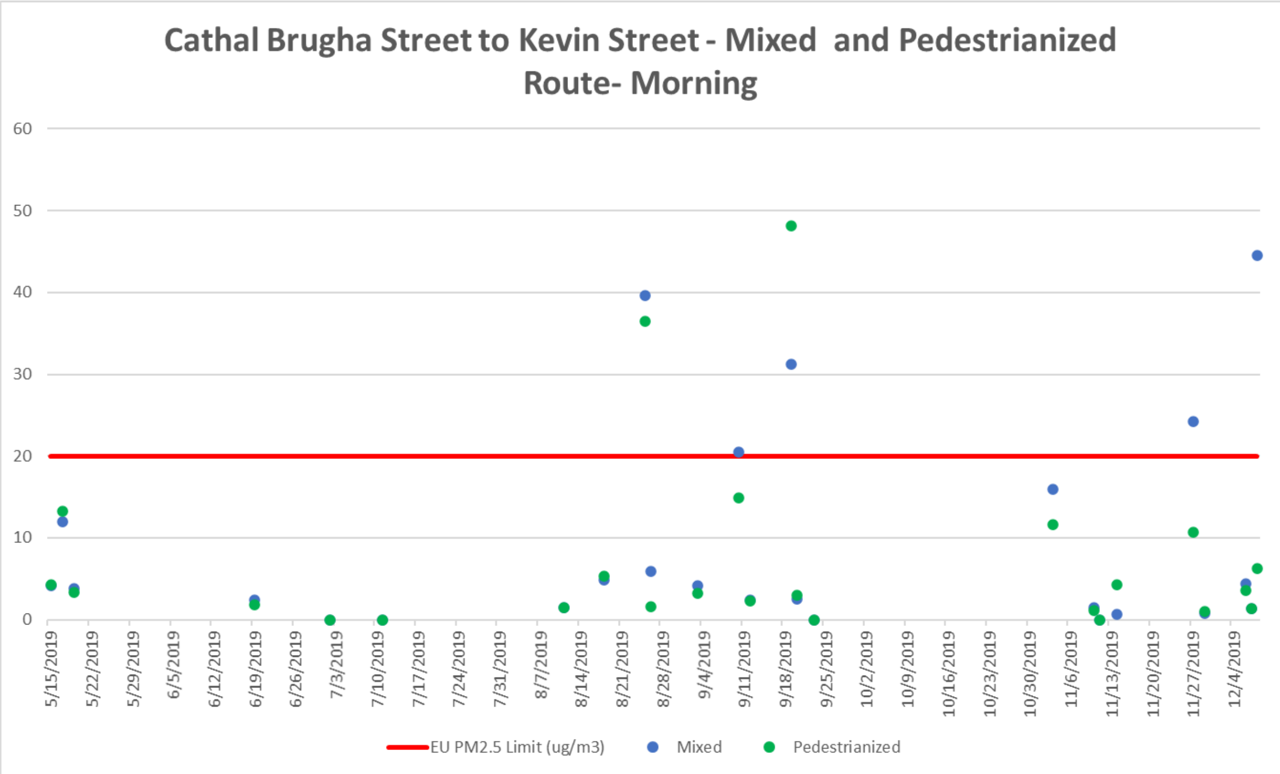


Figure 3.1. Graph showing Cathal Brugha Street to Kevin Street (mixed and pedestrianized) walked routes in the morning – comparison. The dates on the x-axis show every 7th day and y-axis represents the $PM_{2.5}$ concentration µg/m³.

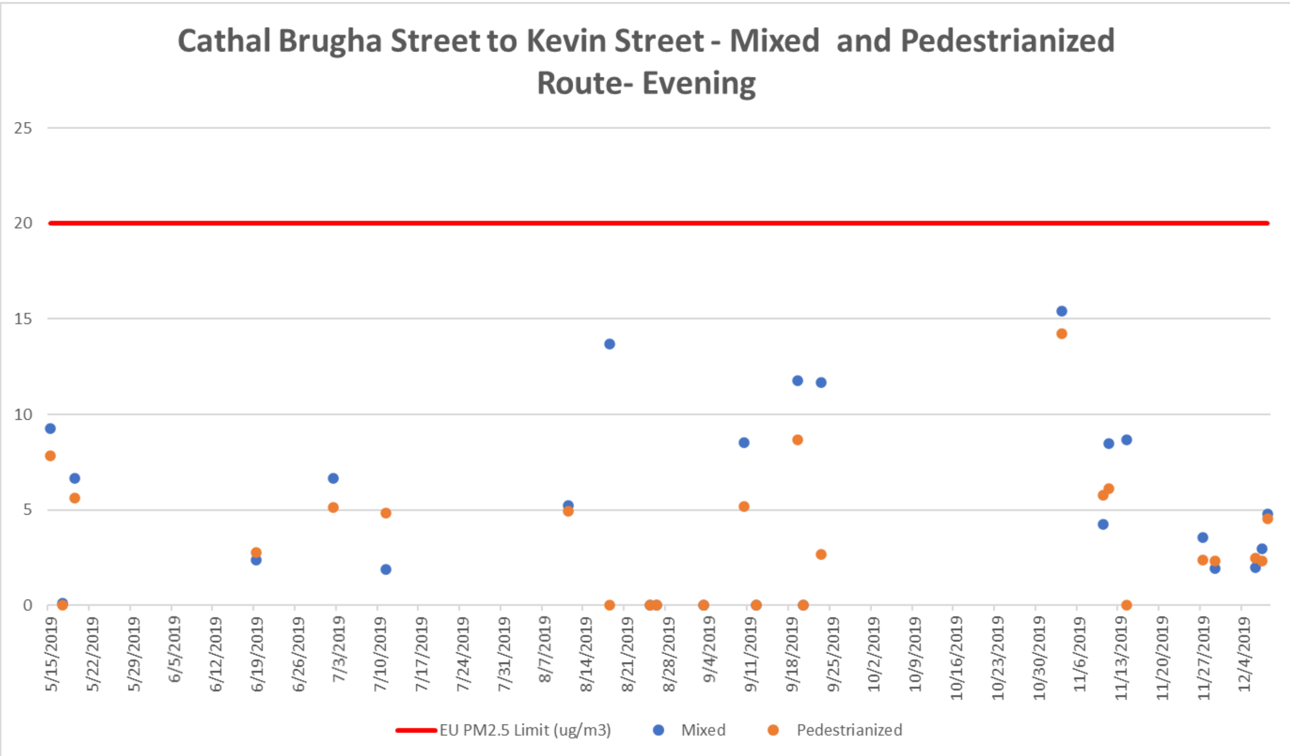


Figure 3.2. Graph showing Cathal Brugha Street to Kevin Street (mixed and pedestrianized) walked routes in the evening – comparison. The dates on the x-axis show every 7th day and y-axis represents the $PM_{2.5}$ concentration µg/m³.

3.1. Average fine particle concentration ($<PM_{2.5}$ µg/m^3) of Cathal Brugha Street – Kevin Street - Morning

As per results obtained from the study of pedestrianized and mixed routes from Cathal Brugha street to Kevin street in the morning time, it was identified that the main sources of air pollution are attained from various transport mode emissions. Walking time for both routes was quite similar, the pedestrianised street only being 2-5 minutes longer than mixed route.

3.1.1. Pedestrianised Route

The pedestrianized route proved to have lower PM emissions compared to data collected from mixed route. The reason for lower emissions is the lower exposure to traffic. The main contributing factors for elevated PM concentration included construction activities, road works and cigarette smoking, which was very evident on pedestrianized streets.

Dates of highest PM concentration were seen on:

- 17th May – 13.27 µg/m^3
- 25th August – 36.51 µg/m^3
- 19th September – 48.15 µg/m^3
- 3rd November – 11.58 µg/m^3
- 27th November – 10.72 µg/m^3

No data was collected on:

- 2nd July
- 11th July
- 23rd September

3.1.2. Mixed Route

Mixed route proved to have higher PM emission levels compared to pedestrianized routes. The contributing factors to elevated PM data included traffic, road works, industrial activity and construction activity.

Dates of highest PM concentration were seen on:

- 15th May – 11.97 µg/m^3
- 25th August – 39.68 µg/m^3
- 10th September – 20.51 µg/m^3
- 19th September – 31.28 µg/m^3
- 3rd November – 15. 89 µg/m^3
- 27th November – 24.18 µg/m^3
- 8th December – 44.58 µg/m^3

No data was collected on:

- 2nd July
- 11th July
- 23rd September
- 11th November

Average fine particle concentration (µg/m^3) of Cathal Brugha Street – Kevin Street campus (morning) was 7.17 µg/m^3 for pedestrianised route and 9.13 µg/m^3 for mixed route. The figures indicate that mixed route have a greater exposure to fine PM by 1.96 µg/m^3.

Both pedestrianized and mixed routes showed very low levels of PM during weekends. The following dates were assessed to collect PM data:

Table 3.1: Cathal Brugha Street to Kevin Street - Pedestrianized Route - Morning		
Date:	**Day of the week:**	**Fine PM concentration (µg/m^3):**
19/05/2019	Sunday	4.22
11/08/2019	Sunday	1.51
25/08/2019	Sunday	36.51
03/11/2019	Sunday	11.58
10/11/2019	Sunday	1.07
07/12/2019	Saturday	1.31

08/12/2019	Sunday	6.30

Table 3.2: Cathal Brugha Street to Kevin Street- Mixed Route - Morning		
Date:	**Day of the week:**	**Fine PM concentration (μg/m^3):**
19/05/2019	Sunday	3.82
11/08/2019	Sunday	1.52
25/08/2019	Sunday	39.68
03/11/2019	Sunday	15.89
10/11/2019	Sunday	1.49
07/12/2019	Saturday	1.30
08/12/2019	Sunday	44.58

- Pedestrianised route on 19th May had a greater PM concentration levels compared to mixed route PM levels.
- 25th August PM levels were extremely high (39.68 μg/m^3– mixed route; 36.51 μg/m^3– pedestrianised route). The PM levels were greater than the daily recommended value by EPA (20 μg/m^3).
- 3rd November also seen elevated PM levels, especially for the mixed route (15.89 μg/m^3).
- Mixed route, on 8th December, had an extremely high fine PM concentration levels – 44.58 μg/m^3. It is higher, compared to pedestrianised route, by 38.28 μg/m^3.

3.2. Average fine particle concentration (<$PM_{2.5}$ µg/m^3) of Cathal Brugha Street – Kevin Street - Evening

As per results obtained from the study of pedestrianized and mixed routes from Cathal Brugha street to Kevin street in the evening time, it was identified that the averages for PM concentration (µg/m^3) om evening time were much lower compared to morning averages: pedestrianised route: 3.51 µg/m^3, mixed route – 5.16 µg/m^3. The figures show that mixed route has higher exposure to fine PM by 1.65 µg/m^3. Main sources of air pollution are consistently from different transport modes and construction activity.

3.2.1. Pedestrianised Route

Pedestrianized route proved to have lower PM emissions than mixed route. The primary reason for lower concentration levels is the lower exposure to traffic and the main contributing factors for increased PM concentration contained construction activities and cigarette smoking from pedestrians.

Dates of highest PM concentration were seen on:

- 3rd November – 14. 24 µg/m^3

No data was collected on:

- 18th August
- 25th August
- 26th August
- 3rd September
- 12th September
- 20th September
- 14th November

3.2.2. Mixed Route

Mixed route proved to have higher PM emission levels compared to pedestrianized routes. The contributing factors to elevated PM data included traffic, road works, industrial activity and construction activity.

Dates of highest PM concentration were seen on:

- 18th August – 13.67 μg/m^3
- 19th September – 11.77 μg/m^3
- 23rd September – 11.65 μg/m^3
- 3rd November – 15.40 μg/m^3

No data was collected on:

- 25th August
- 26th August
- 3rd September
- 12th September
- 20th September

Both pedestrianized and mixed routes showed very low levels of PM during weekends. The following dates were assessed to collect PM data:

Table 3.3: Cathal Brugha Street to Kevin Street - Pedestrianized Route - Evening		
Date:	**Day of the week:**	**Fine PM concentration (μg/m^3):**
19/05/2019	Sunday	5.59
11/08/2019	Sunday	4.92
25/08/2019	Sunday	NO DATA COLLECTED
03/11/2019	Sunday	14.24
10/11/2019	Sunday	5.77
07/12/2019	Saturday	2.32
08/12/2019	Sunday	6.30

Table 3.4: Cathal Brugha Street to Kevin Street - Mixed Route - Morning		
Date:	**Day of the week:**	**Fine PM concentration (μg/m³):**
19/05/2019	Sunday	6.63
11/08/2019	Sunday	5.21
25/08/2019	Sunday	NO DATA COLLECTED
03/11/2019	Sunday	15.40
10/11/2019	Sunday	4.25
07/12/2019	Saturday	2.96
08/12/2019	Sunday	4.78

- The most prominent difference in PM concentration is seen between morning and evening totals on date on 8th December for mixed route. The total PM concentration was 44.58 μg/m³ in the morning, whereas in the evening it dropped to 4.78 μg/m³, by a total of 39.8 μg/m³.

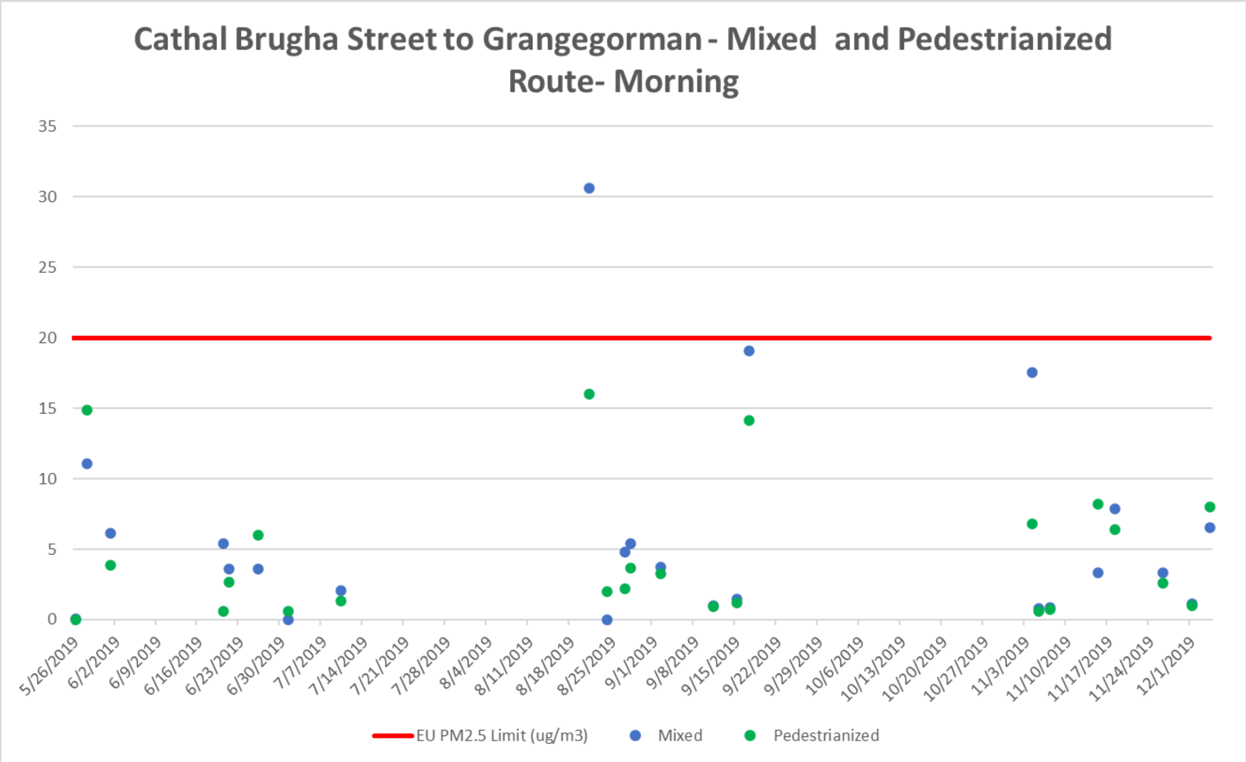


Figure 3.3. Graph showing Cathal Brugha Street to Grangegorman (mixed and pedestrianized) walked routes in the morning – comparison. The dates on the x-axis show every 7th day and y-axis represents the $PM_{2.5}$ concentration µg/m³.

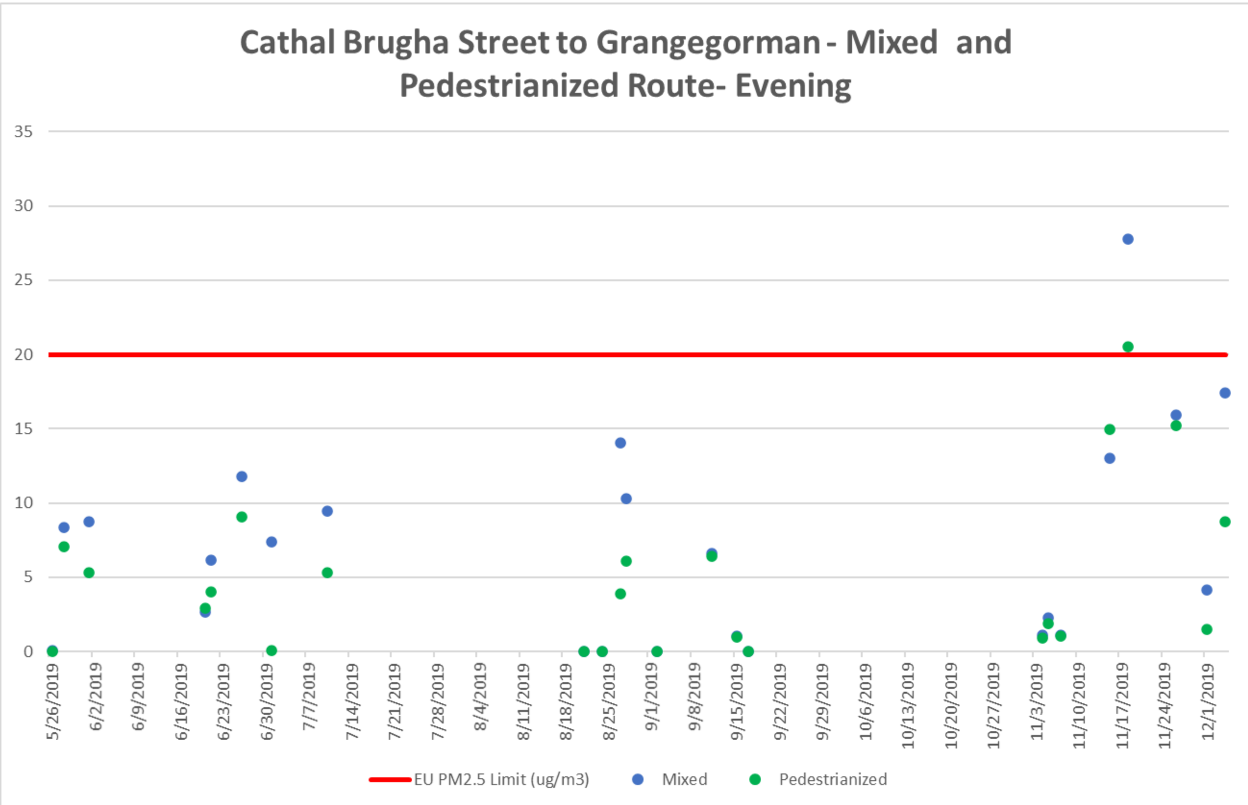


Figure 3.4. Graph showing Cathal Brugha Street to Grangegorman (mixed and pedestrianized) walked routes in the evening – comparison. The dates on the x-axis show every 7th day and y-axis represents the $PM_{2.5}$ concentration µg/m³.

3.3. Average fine particle concentration (<$PM_{2.5}$ µg/m^3) of Cathal Brugha Street – Grangegorman Campus - Morning

3.3.1. Pedestrianized Route

The time to walk down to Grangegorman from Cathal Brugha Street campus was longer than the walk to Kevin Street from Cathal Brugha Street, however, the PM concentration levels are quite similar. This shows that pedestrians are exposed less to PM if they chose to walk this route. However, the time to walk this route is longer compared to Mixed route. The main contributing factors to PM concentration were the road works, construction activity and occasional cigarette smoke.

Dates of highest PM concentration were seen on:

- 28th May – 14.86 µg/m^3
- 21st August – 15.98 µg/m^3
- 17th September – 14.17 µg/m^3
- 5th November – 10.48 µg/m^3

Data was collected on all scheduled dates.

3.3.2. Mixed Route

Mixed route PM concentration levels were proven to be higher than the PM levels compared to pedestrianized route. Main contributing factors to the PM concentration was traffic and road works. The PM count was slightly elevated close to Grangegorman campus due to on-going construction.

Dates of highest PM concentration were seen on:

- 26th May – 11.06 µg/m^3
- 21st August – 30.62 µg/m^3
- 17th September – 19.09 µg/m^3
- 4th November – 17.56 µg/m^3
- 5th December – 18.23 µg/m^3

No data was collected on:

- 1st July
- 24th August

From the collected figures, it is evident that PM concentration levels are much higher when assessing mixed route compared to pedestrianized route during rush hours. The average for mixed route is 6.33 µg/m^3, whereas pedestrianized route is 4.74 µg/m^3. This indicates that the average PM is higher on mixed routes by 1.59 µg/m^3.

Both pedestrianized and mixed routes showed very low levels of PM during weekends. The following dates were assessed to collect PM data:

Table 3.5: Cathal Brugha Street to Grangegorman - Pedestrianized Route - Morning		
Date:	**Day of the week:**	**Fine PM concentration (µg/m^3):**
26/05/2019	Sunday	0.01
01/06/2019	Saturday	3.83
24/08/2019	Saturday	2.03
15/09/2019	Sunday	1.21
01/12/2019	Sunday	1.01

Table 3.6: Cathal Brugha Street to Grangegorman - Mixed Route - Morning		
Date:	**Day of the week:**	**Fine PM concentration (µg/m^3):**
26/05/2019	Sunday	0.03
01/06/2019	Saturday	6.16
24/08/2019	Saturday	NO DATA COLLECTED
15/09/2019	Sunday	1.49
01/12/2019	Sunday	1.11

3.4. Average fine particle concentration (<$PM_{2.5}$ µg/m^3) of Cathal Brugha Street – Grangegorman Campus - Evening

3.4.1. Pedestrianised Route

The time to walk down to Grangegorman from Cathal Brugha Street campus, the PM concentration levels were seen to be lower than those in the morning rush hours. It is primarily suspected to be the case of temperature and humidity factors, which are expected to be elevated during evening time compared to morning time and increased PM dispersion in the air. Again, this shows that pedestrians are exposed to less PM if they chose to walk this route.

Dates of highest PM concentration were seen on:

- 15th November – 14.99 µg/m^3
- 18th November – 20.53 µg/m^3
- 26th November – 15.21 µg/m^3

No data was collected on:

- 21st August
- 24th August
- 2nd September
- 17th September

3.4.2. Mixed Route

Mixed route PM concentration levels were proven to be higher than the PM levels compared to pedestrianized route during evening rush hours. Main contributing factors to the PM concentration was traffic and road works.

Dates of highest PM concentration were seen on:

- 26th June– 11.77 µg/m^3
- 27th August – 14.02 µg/m^3
- 28th August– 10.27 µg/m^3
- 15th November – 12.99 µg/m^3

- 18th November – 27.80 µg/m^3
- 26th November – 15.95 µg/m^3
- 4th December – 17.45 µg/m^3

No data was collected on:

- 21st August
- 24th August
- 2nd September
- 17th September

PM concentration levels are much higher when assessing mixed route compared to pedestrianized route during rush hours. The average for mixed route is 6.82 µg/m^3, whereas pedestrianized route is 4.71 µg/m^3. Average PM is higher on mixed routes by 2.11 µg/m^3.

Both pedestrianized and mixed routes showed low levels of PM during weekends. The PM levels were higher during weekend evenings than it was during weekday mornings, the numbers increase on mixed route greatly compared to pedestrianized route. The following dates were assessed to collect PM data:

Table 3.7: Cathal Brugha Street to Grangegorman - Pedestrianized Route - Evening		
Date:	Day of the week:	Fine PM concentration (µg/m^3):
26/05/2019	Sunday	0.03
01/06/2019	Saturday	5.33
24/08/2019	Saturday	NO DATA COLLECTED
15/09/2019	Sunday	0.98
01/12/2019	Sunday	1.52

<u>Table 3.8: Cathal Brugha Street to Grangegorman - Mixed route - Evening</u>		
Date:	Day of the week:	Fine PM concentration ($\mu g/m^3$):
26/05/2019	Sunday	0.04
01/06/2019	Saturday	8.38
24/08/2019	Saturday	NO DATA COLLECTED
15/09/2019	Sunday	1.06
01/12/2019	Sunday	4.16

3.5. Dublin City Council Findings

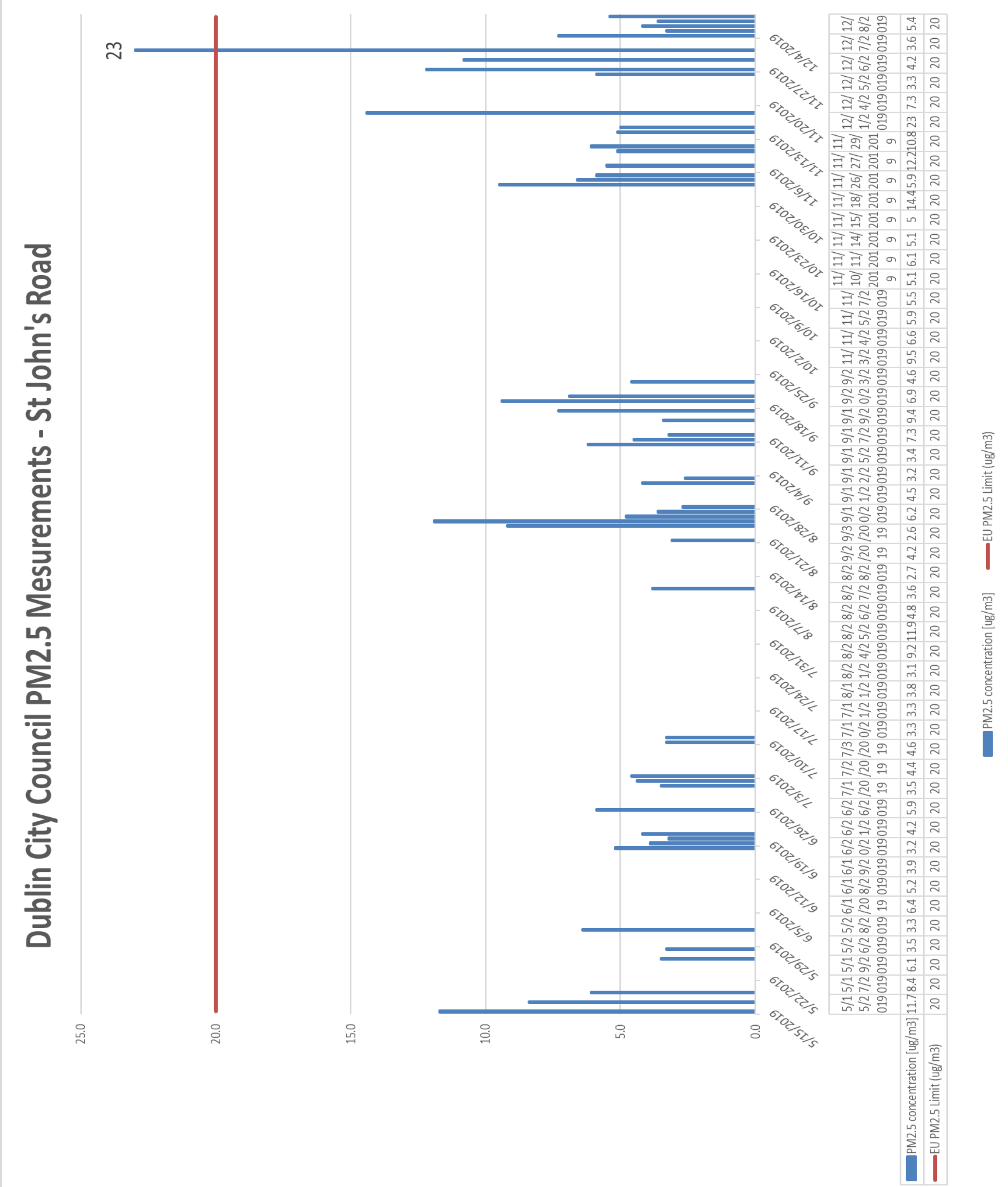


Figure 3.5: Dublin City Council Measurements for PM2.5 - St John's Road

The results obtained from Dublin City Council for monitored St. John's Road. Looking at the *figure 3.5* it is evident that the results of $PM_{2.5}$ are below the recommended EU limit value – 20 μg/m^3. The exception is the 1st of December, where values, as seen in *Figure 3.5*, are reaching 23 μg/m^3 which is above the EU limit value. Only the days that were assessed during the research were observed in more detail and were transferred into the graph (workings can be found in *Appendix - Table H.1*). Estimated average for the assessed days of the study for Dublin City Council readings - 6.1 μg/m^3 .

3.6. Survey Results

- Q1

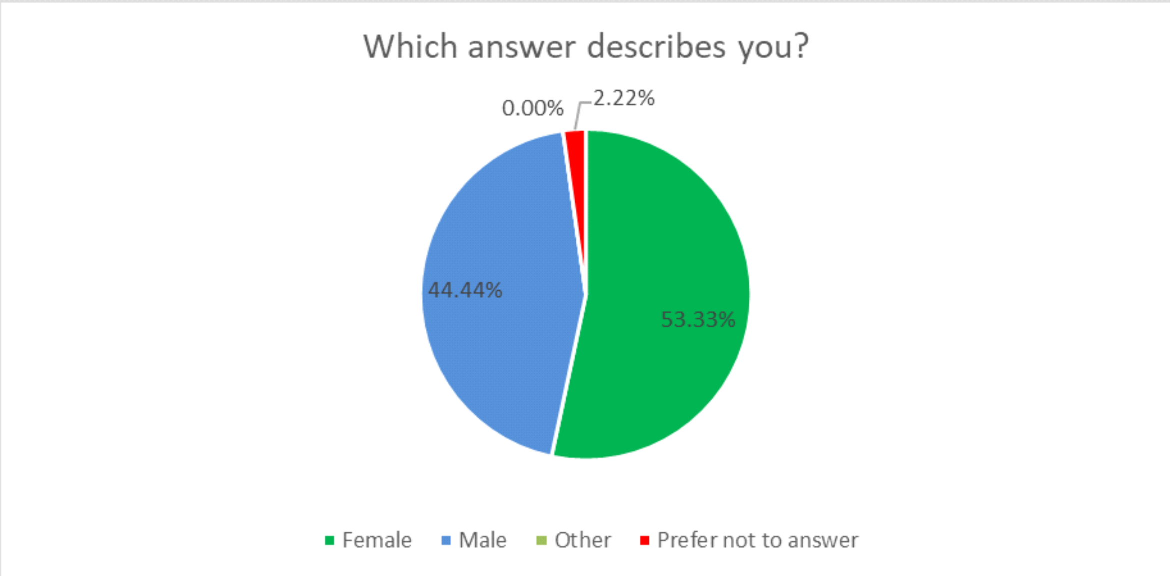


Figure 3.6.: Q1 – Survey results show the percentages of different gender taking part in this study

This graph indicates that more respondents were females (53%) than males (44%). 2% of the respondents preferred not to answer to which gender they belong. No respondents selected "Other" as their answer. This question gathered a total of 90 responses.

- Q2

The majority of the respondents were aged 18-24 (30%), second to aged 45-54 (22%) and third to 25-34 (21%). The least responses were gathered from ages 65+ (3%) and 55-64 (4%). This could be the case indicating that the younger and middle-aged adults are more frequent on social media. This question gathered a total of 90 responses (Graph can be found in *Appendices G*).

- Q3

From this question, it was gathered that nearly 70% of respondents work or study in Dublin City Centre, while the remaining 24% does not. 2% of the respondents preferred not to state their answer, whereas 4% of respondents had other answers, which included: "I live in Dublin City Centre", “Park West”, “Driver” and “I work around Ireland, 2 days per week in Dublin”. The answers to “Other” state that people either work around Dublin or they live in the City Centre but do not work there. Although, the question may have been misunderstood. This question gathered a total of 90 responses.

- Q4

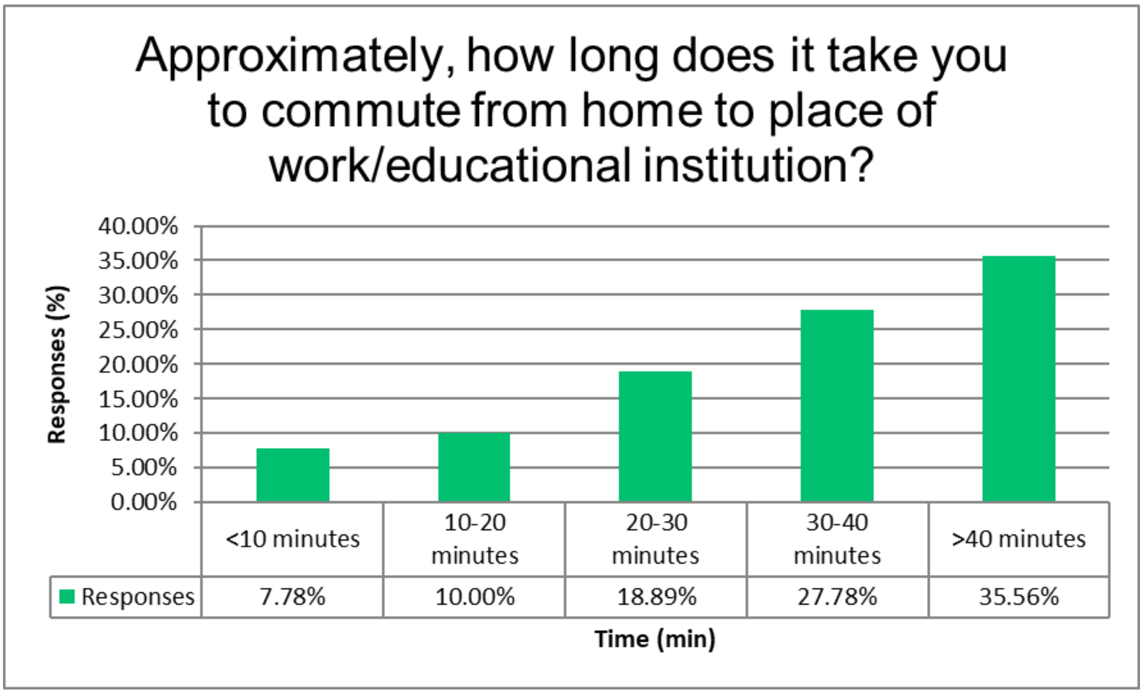
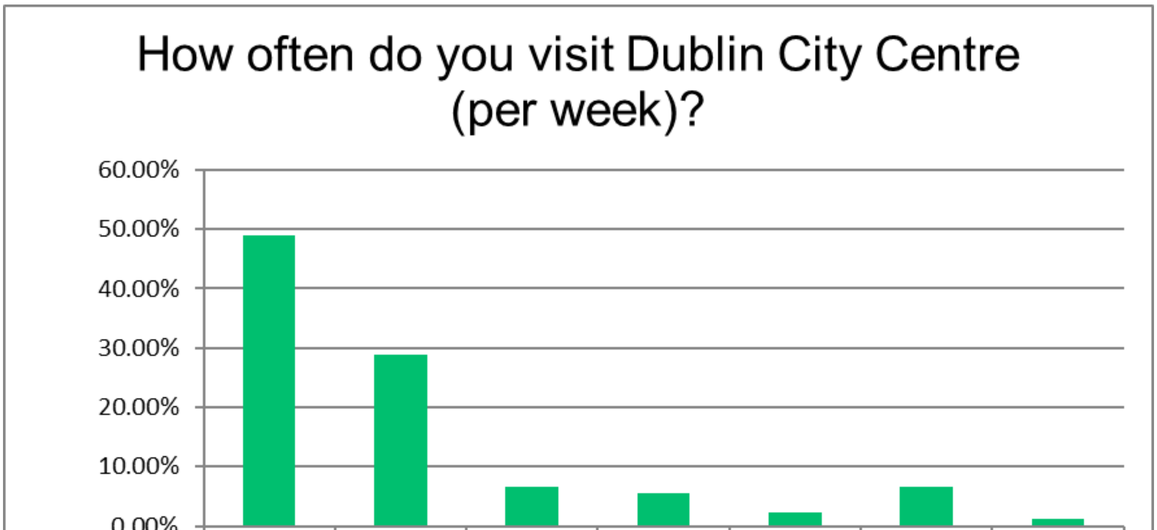


Figure 3.7.: Q4 - Survey results show the percentages of responded time taking to commute from home to place of work/educational institution. The graph indicates that most respondents have to commute >40 minutes to place of work/educational institution.

This graph shows that many of the respondents need to travel to work/educational institution for over 40 minutes (36%), second to 30-40 minutes (28%) and third to 20-30 minutes (19%). Very few respondents need to travel for less than 20 minutes (18%). This question gathered a total of 90 responses.

- Q5



	Every day	A few times a week	About once a week	A few times a month	Once a month	Less than once a month	N/A
Responses	48.89%	28.89%	6.67%	5.56%	2.22%	6.67%	1.11%

Figure 3.8.: Q5 – Survey results show how frequently the participants visit Dublin City Centre per week. It is evident that most of the respondents visit Dublin City Centre daily (49%).

This graph shows that almost every responded needs to travel to Dublin City Centre on a regular basis. Nearly half of the responders (49%) need to travel to Dublin City Centre daily and a third of the respondents – a few times a week (29%). The remainder of the respondents visit Dublin City Centre, but not as regularly and it may not be work/educationally related (e.g. recreational activities on weekends). And to travel, respondents mostly commute. As per Fig. most of the respondents choose Dublin Bus as their means of transportation (58%), second to private vehicle (31%). Light rail (Luas) (23%) and Commuter/DART (21%) both resulted in similar selection percentage. Even less prefer the cleaner options of cycling (8%) and walking (20%). Very few respondents travel on coaches (10%). This question gathered a total of 90 responses.

• Q6

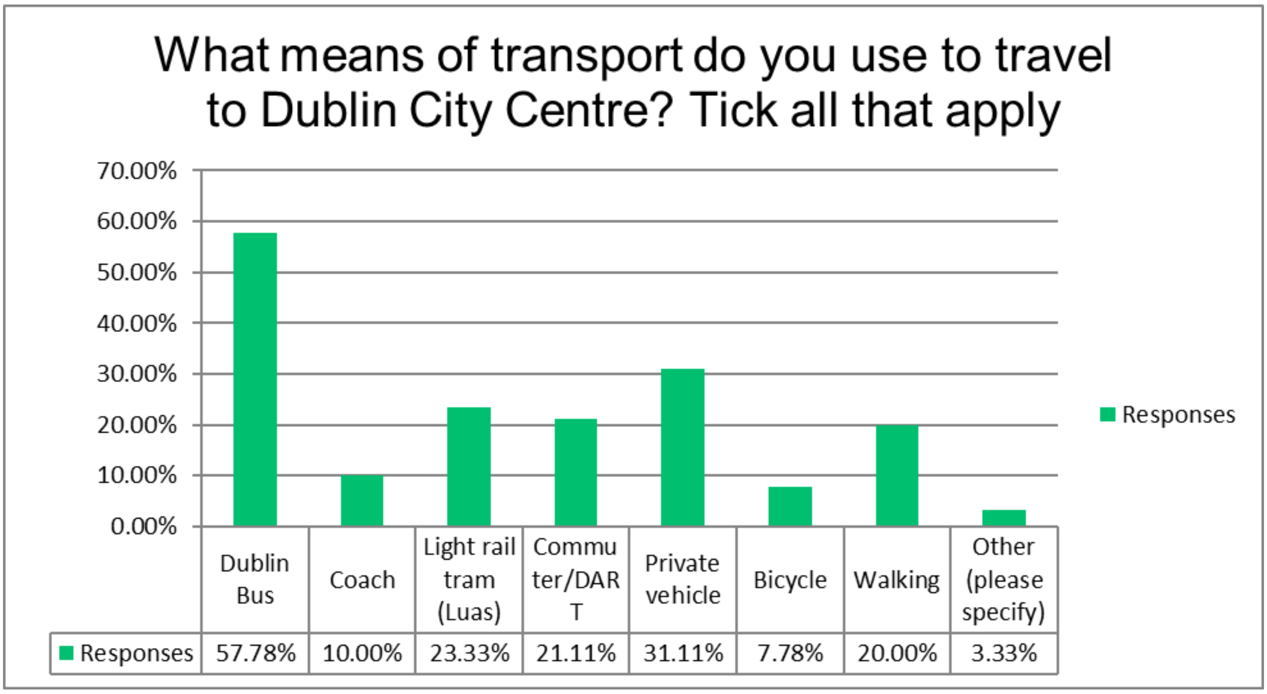


Figure 3.9.: Q6 – Survey results show what means of travel the participants use to travel to Dublin City Centre. Dublin Bus (58%) and private vehicle (31%) are the most popular answers.

From the answers of this question, it is evident that the respondents most popular means of transportation is Dublin Bus (58%), followed by private vehicle (31%) and light rail (Luas) (23%). The least popular means of transport is Cycling (8%), whilst the "Other" answers included:

• Q7

The following question (Q7) asked the respondents to answer how much money they approximately spend on public transport to travel to Dublin City Centre (per week). From the graph, it was evident that majority of the respondents pay over €20 on public transport per week (40%), second to €10-20 (19%). Very few respondents pay less than €5 to travel to Dublin City Centre per week (10%) and this could be due to their close living proximity to Dublin City Centre. However, 17% chose to answer "N/A" which could indicate that the respondents who selected this answer do not need to spend any money in order to travel to Dublin City Centre. This question gathered a total of 90 responses.

- Q8

Majority of the respondents felt that they are neither satisfied nor dissatisfied with travelling on public transport (32%), whereas 29% of the respondents felts they are dissatisfied and 7% were very dissatisfied. 24% were quite satisfied with public transport and 6% were very satisfied. This question gathered a total of 90 responses.

The next series of questions were medical/health related. Because it was a different topic, the questions were separated onto a different page. This was done for survey to give a more structured appearance as well as save any data that may not have been previously answered. However, as a result, less responses were gathered. The reason for this was probably due to the extensive questions and the progress bar which shows a total of 5 separate pages, which more than likely put off the respondents from answering the following questions.

- Q9

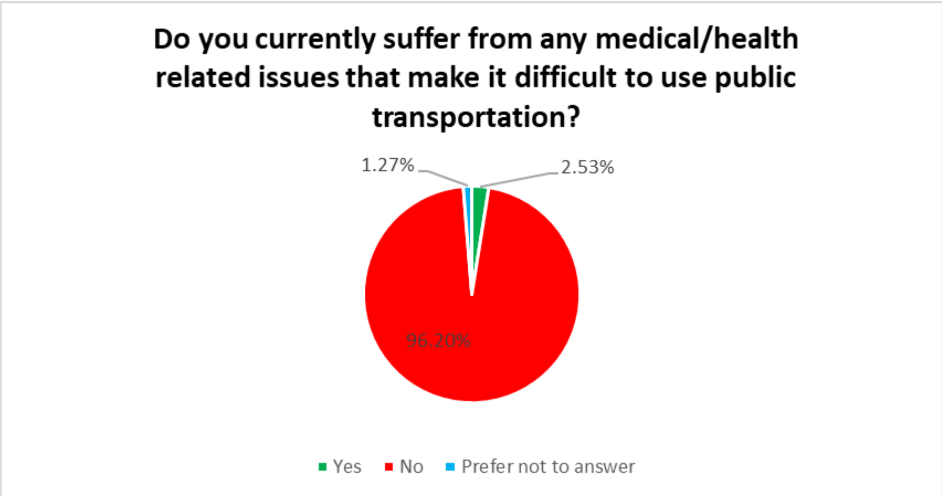


Figure 3.10: Q9 – Survey results show if any of the participants currently suffer from any medical/health related issues that make it difficult to use public transportation. It is evident that most of the respondents do not have any medical/health related issues preventing them from using public transportation (96%).

The graph was created from the responses gathered from 79 people. 11 people skipped the question. Majority of the respondents (96%) do not suffer from any medical/health related issues that make it difficult to use public transport. However, 3% of respondents do suffer from medical/health related issues.

- Q10

When asked if the public has experienced any medical/health related issues in the past which may have prevented from accessing public transportation, predominant answer was “No” (96%), however, 4% of respondents have suffered in the past (e.g. broken leg, respiratory issues etc). None of the respondents selected “Prefer not to answer”.

- Q11

This question was created with the hopes of understanding the numbers of people who suffer from respiratory issues versus those who do not. 86% of respondents said they do not suffer from respiratory issues, whereas 14% of respondents do. This is a great indication that there are people who may be more sensitive to air pollutants in Dublin City Centre than those who do not have any respiratory complications.

The following questions were related to air quality and were created to understand if the public is aware current air quality in Dublin City Centre and to see if they are mindful regarding the possible complications air pollution may cause. As the questions were related to a different topic, the questions were again separated onto a different page. As a result, 79 respondents answered the questions and 11 decided to skip the following questions.

- Q12

There is a clear evidence that many of the respondents believe there is an issue with air quality in Dublin City Centre (68%). 27% of respondents do not think there is anything wrong with air quality in Dublin City Centre.

- Q13

The respondents answered differently for Q13. A total of 84% of respondents believe increased action should be taken to minimize air pollution in Dublin and 10% disagree with this proposal.

- Q14

70% of respondents think that private vehicle access into Dublin City Centre should be minimized. The following 22% of respondents disagree, which could indicate that the respondents who disagree may or may not be using private vehicles to get to the City Centre or may simply not see an issue with current traffic in Dublin City Centre. 8% of respondents preferred not to answer this question.

- Q15

The exact number of respondents (22%) as per previous question, believe that more streets in Dublin City Centre should be pedestrianized. This could be the same respondents who disagreed with the minimizing access to private vehicles. But a greater number of respondents (77%) think that more streets should be pedestrianized. This is a very clear indication that majority of the public wants less exposure to vehicles and more pedestrian-friendly streets.

- Q16

Many respondents agree that air quality in Dublin City Centre poses a risk to our health. It is a similar question to Q12, however, reworded and made into a statement. Very few disagree (5%) and strongly disagree (1%), whereas majority of the respondents (35%) strongly agree and agree (28%) with this statement. Many respondents selected "Neither agree nor disagree as their answer, which could be simply indicating uncertainty to the possible issue with air quality in Dublin City Centre.

- Q17

Many respondents (71%) think that there should be additional safety measures applied to pedestrian footpaths exposed to traffic in Dublin City Centre to protect pedestrians from air pollution. This is a similar question to Q13, Q14 and Q15 but interpreted differently. The only way the streets really could be safe to pedestrians from air pollution related to traffic is if the streets were pedestrianized and private vehicle numbers were lowered in Dublin City Centre or safer fuels considered for public transport and private vehicles. The answers for these questions vary. 20% think that no safety measures are needed to be implemented for pedestrian safety and 9% preferred not to answer this question.

- Q18

From a collective 79 responses, it was established that a total of 6 was achieved from this question on how the public is satisfied with the pedestrianized walking space in Dublin City Centre (from 1 to 10). The average number speaks that the public is quite satisfied with the pedestrianized street structure in Dublin City Centre. However, the number does vary greatly to different questions such as Q15 when asked if more streets should be pedestrianized or Q17 where respondents agreed for more safety measures for pedestrians against air quality are needed.

The further questions will be focused to understand if the public has the knowledge about air quality and air pollution sources and consequences. As the questions were sectioned onto a different page, a lower total respondent number was seen – 73 respondents and 17 skipped the questions.

- Q19

From the responses gathered, it is clear that the public does not consider air quality when using various modes of transport (41%). "A moderate amount" was selected by 32% of respondents which indicates that the public is looking into alternatives to prevent air pollution but the number for very concerned is quite low (5% - "a great deal" and 3% for "a lot"). Nonetheless, the numbers indicate that the public is somewhat thinking about the air quality and considering other means of transport to reduce air pollution.

- Q20

Most of the respondents agree with this statement and understand that human activities contribute to poor air quality (59% - strongly agree and 33% - agree). This estimates a total of 92% of respondents agreeing with this statement. Only 3% of respondents disagree with this statement.

- Q21

Broader questions were asked regarding the possible air pollution sources In Dublin. Many of the respondents think that the main contributors to poor air quality in Dublin is the modes of transport (88%), followed by factories and industries (71%) and construction activities (68%). Very little selected natural causes (23%) and mining operations (25%) and agricultural activities (34%), which in theory these three options do contribute to air pollution, but not so relevant in Dublin.

- Q22

This question was very comprehensive and asked the general public to answer which of the following questions they believe is the cause of air pollution. This question did not focus on a specified area, instead asked for a general opinion. From this question, it was gathered that majority of the respondents believe that the major result from air pollution is increased indoor/outdoor air pollution (75%), temperature increase (73%), increased smog and soot (67%), depletion of ozone layer (60%) and increased adverse health effects (60%). Very little respondents think increased epidemics (34%), increased pest infestation (37%) and impacts on agricultural industry have little impact from air pollution.

- Q23

The respondents have a great understanding of the main contributors to air pollution. The most popular selections included petrol car (85%), diesel car (84%), bus (82%), coach (79%) and train (63%). The question may have been clearer and asked the public to select the modes of transport which they believe contribute to air pollution instead of influence air quality as the burning fuels may contribute to adverse air pollution whereas cleaner transport options such as walking or cycling may also influence air quality and reduce air pollution, this may explain why some selected “walking” or “cycling” as their answer.

- Q24

This question was very straightforward and asked the public to tick all the times of the day which they believe are the worst for air pollution. Many selected morning (75%) and evening (86%)

times, which could be due to the personal experience of getting in and out of Dublin City Centre. 25% of the respondents also believe that afternoon time (2-4pm) is also poor for air pollution.

The following series of questions focused on climate change and understanding whether the public understand the cause and effects it. The question was included in the survey to see if the public may see the difference as well as similarities between climate change and air pollution (being the contributor to climate change). As a result of segregating these questions into a new page, the total respondent number dropped by 1, making it a total of 72 respondents and 18 skipping the questions.

- Q25

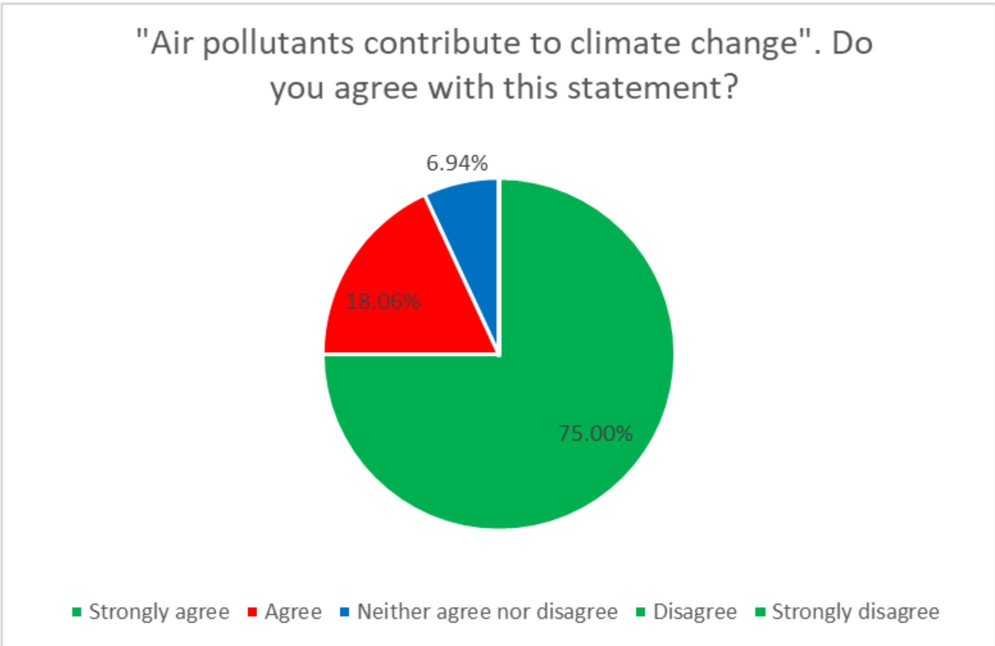


Figure 3.11: Q25 – Survey results show if the respondents agree with the statement – "Air pollutants contribute to climate change". Most of the respondents agree with this statement (75%).

Interestingly, no one disagrees with this statement. Small number of respondents (7%) selected "Neither agree nor disagree", whereas a total of 93% of respondents agree with this statement (75% - strongly agree and 18% agree). This indicates that the public is air pollution acting as a contributor to climate change.

- Q26

This question has the same questions as per Q22, however, focuses on the impacts from climate change to humans, animals and the environment. Majority of the respondents selected all the answers apart from increased epidemics (39%). The top selections included temperature increase (87%), increased wildfires (77%), sea-level rise (75%), snow and ice melting (72%), increased droughts (70%) and increased storms and rainfall (70%). The selection of the top answers can be highly related to the recent news worldwide regarding the recent catastrophic events related to climate change (more details about this in “Discussion” section).

- Q27

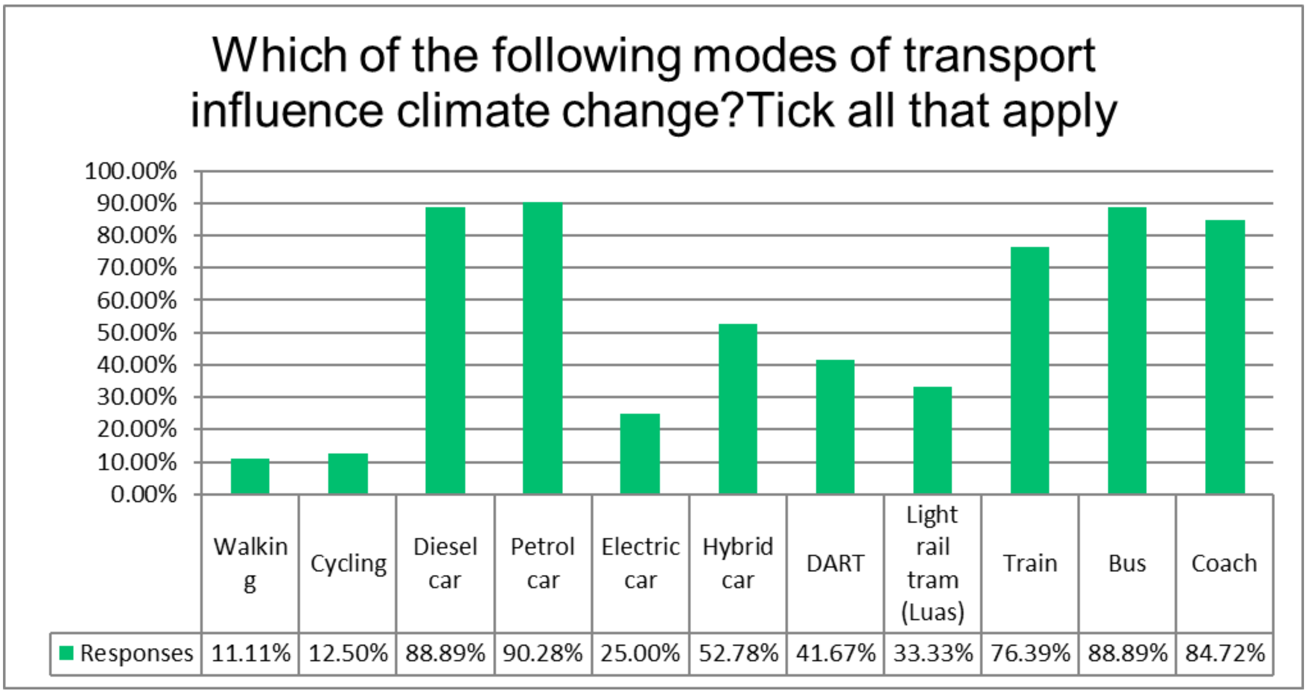


Figure 3.12: Q27 - Survey results show the respondent answers to which mode of transportation, in their opinion, influence climate change. The most popular results are petrol car (90%), diesel car (89%), bus (89%), coach (85%) and train (76%).

The questions asked to be answered by respondents are the same as in Q23 but instead of asking about air quality, the questions are focusing on climate change. The answers vary very little from Q23, many respondents believe that the main contributors to climate change are the petrol car (90%), diesel car (89%), bus (89%), coach (85%) and train (77%). Walking (11%) and cycling (13%), however, were selected the least.

The following questions aim to understand if the public believes the mitigation of air pollution in Dublin City Centre could be beneficial or instead, a waste of resources. This is the last section (5) and asked the public to answer 3 last questions. Total number of respondents to these questions was 71, whereas 19 decided to skip these questions.

- Q28

Many of the respondents (63%) believe that mitigation of ambient air pollution is expensive and the following 31% are not sure if it is expensive or not. 7% of respondents do not think it costly issue.

- Q29

80% of the respondents think that mitigating air pollution may be economically beneficial and 15% of respondents are unsure about this. The remaining 4% of respondents do not think that incorporating air pollution mitigation measures may be economically profitable.

- Q30

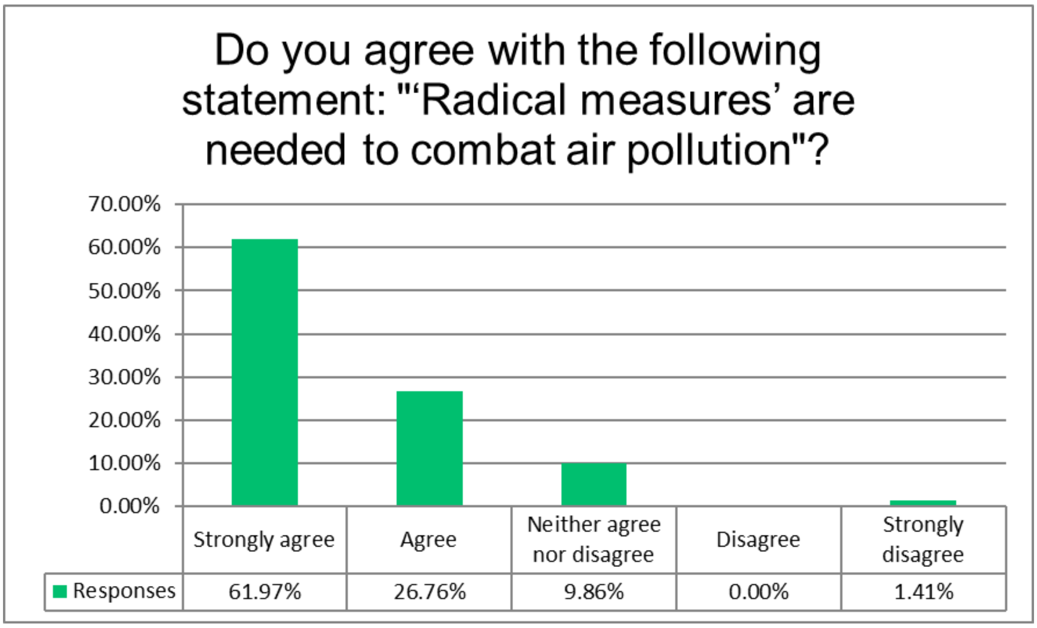


Figure 3.13: Q30 – Survey results show if the participants agree or disagree with the statement – "Radical measures' are needed to combat air pollution". Most of the participants strongly agree (62%) with this statement.

The last question of this survey asks a very straightforward question, do they agree with the given statement. A total of 89% of all the respondents agree with the statement, of which 62% strongly agree with it. 10% of the respondents are unsure about the statement or do not have a definite opinion, whereas 1% of the respondents strongly disagree with the statement. No one selected “disagree” option as their answer.

More details on the survey results can be found in *Appendices G*.

Chapter 4: Discussion

In this chapter, results will be discussed in greater detail, and recommendations for future research will be highlighted. The purpose of this study was to monitor the $PM_{2.5}$ (Fine) and $PM_{0.5}$ (UFP) levels using Dylos DC1700 air quality monitor in Dublin City Centre assessing the pedestrianised and traffic induced streets, which students may use to reach Kevin Street and Grangegorman TU Dublin campuses from Cathal Brugha Street in order to attend classes. As a result, this investigation can be applied to the general public as the main purpose of this study is to compare the gathered data for fine and ultrafine particulate matter against the set guidance levels of the WHO and EPA for these particulates and establish whether the outdoor air pollution is of concern to human health. In this section, the results of the survey gathered using Survey Monkey will be also explained in more detail concentrating on the aspect whether the general public is aware of the air quality health and environmental impacts. Unfortunately, there is little to no data regarding the recommended daily values for ultrafine particulate matter. Therefore, it was not possible to base the results against the average recommended values.

The results which were compared against DCC $PM_{2.5}$ collected data, will be discussed in detail. The main purpose of doing this is to see if the obtained data from this investigation is not only compliant with the EPA recommended daily value limits for $PM_{2.5}$, but also to see if there is varying data from a nearby area in Dublin City Centre, which DCC monitors, matches the figures or differs. By doing so, it is easier to understand whether Dublin city centre poses greater risk for pedestrians with exposure to PM or on the contrary, does not. Also, this may serve as an aid to recommend additional measures in order to reduce PM exposure and investigate any issues that were experienced in this study regarding collected data. The data provided by DCC is provisional data and will be subjected to full data analysis in 2020 before release to the EU Commission.

4.1. Results gathered from Dylos DC1700

The results were gathered throughout randomly selected times of the month in 2019. This was done to capture various particulate matter concentrations at varying temperatures and humidity levels. The following days of the year 2019 were assessed (providing a total of number of days the data was gathered each month):

- May– 15th, 17th, 19th, 26th and 28th = total of 5 days
- June– 1st, 19th, 20th, 21st and 26th = total of 5 days
- July – 1st, 2nd, 3rd, 10th and 11th = total of 5 days
- August – 11th, 18th, 21st, 24th, 25th, 26th, 27th and 28th = total of 8 days
- September – 2nd, 3rd, 10th, 11th, 12th, 15th, 17th, 19th, 20th and 23rd = total of 10 days
- November – 3rd, 4th, 5th, 7th, 10th, 11th, 14th, 15th, 18th, 26th, 27th and 29th = total of 12 days
- December – 1st, 4th, 5th, 6th, 7th and 8th = total of 6 days

Total of days walked while collecting data totals to 51 days. No data was collected for October.

It was estimated that it takes approximately 30-35 minutes to collect data from pedestrianized street (one way), whereas mixed route took around 20-30 minutes. It was quicker to walk via mixed route as pedestrianized routes were taking slight detours to avoid traffic induced streets.

The instrument used measured "Small particle counts" and "large particle counts". "Small particle count" refers to the number of particles 0.5µm or greater in .01 cubic foot of air. The "large particle count" refers to the number of particles 2.5µm or greater in 0.01 cubic foot. In conjunction with relative humidity measurements these readings were converted into PM2.5 concentrations (the concentration of particles less than 2.5µm in diameter).

In this study, fine particulate matter levels were higher in cold days than in warm days, suggests that PM levels increase with temperature decrease and increased solid fuel heating serves as PM emission source during colder days. Keatinge (1997) and Nayha (2002) showed that there is a higher occurrence of cardiovascular diseases and increased mortality rates during colder months compared to warmer months. Fang (2017) showed that $PM_{2.5}$ levels were higher in colder days than in warm days and proved that mortality was increased during colder, winter months. A study by Sario (2013), explained in more detail why the mortality and disease transmission rates due to cold weather and air pollution, related to PM, are higher compared with warmer weather: "*Breathing cold air causes the cooling of nasal and bronchial mucosa, seriously impairing ciliary motility and consequently reducing the immune system's resistance to respiratory infections. Exposure to cold air may also increase the number of granulocytes and macrophages in the lower airways in healthy subjects and induce bronchoconstriction, suggesting that cold exposure could be involved in the pathogenesis of the asthma-like condition. Part of the increase in respiratory outcomes during cold periods may also be attributed to cross-infections from increased indoor crowding during winter*". Therefore, humans are naturally more susceptible to diseases related to poor air quality during cold days.

From the results obtained from the Dylos DC1700 air quality monitor, it is evident that mixed route fine particular matter concentration levels in the morning were much higher compared to evening levels. The reason for increased PM could be the increased inversion rates, which is the quick ground cooling during the night, that lifts heat directly from the air above it (Sutherland, 2019). Therefore by morning, it results in warmer air being higher up, atop of cooler air near the ground, trapping the PM particles near the ground and it is evident that meteorological factors also play a role in PM increase as the most intense inversions occur in the winter, due to the longer nights and colder ground (Sutherland, 2019).

The concentration levels were seen especially elevated during colder, drier periods of November and December. The reason for elevated figures could indicate the increased demand for municipal solid fuel burning (heating) in Dublin City Centre once temperatures drop below 5°C. The temperatures were seen to vary in the morning times in December between 6°C to 11°C and November mornings experienced temperatures between 2°C to 9°C. The temperature decreased more closely to December. During the times of investigating pm concentration in Dublin City Centre.

Unusual elevation of PM was seen at the end of August when $PM_{2.5}$ concentration levels reached 39.58 $\mu g/m^3$ during the 30 min walk to Kevin street campus from Cathal Brugha Street using mixed route. The levels of concentration are way above the recommended maximum daily value for

$PM_{2.5}$ established by the European Commission under Directive 2008/50/EC, which is 20 μg/m^3 for $PM_{2.5}$. The main reason for this high figure could be the increased humidity factors that contributed to poor scarcity of $PM_{2.5}$ in the atmosphere. The main sources of the $PM_{2.5}$ was traffic emissions, road works, industrial activity and construction activity observed in the city. September month also seen elevated figures (20.51 μg/m^3 on 10th September and 31.28 μg/m^3 on 19th September) which could also relate to humidity and the same sources. Generally, the PM concentrations levels are expected to be higher during morning hours due to the inversion when calm or light wind will increase poor air quality by repressing the mixing of air in the atmosphere, while keeping the air dormant on the surface due to the warm layer of air between the layers of cooler air (Garcia, 2019).

Aerosols and water vapour could also elevate the $PM_{2.5}$ results mixing in the atmosphere to create $PM_{2.5}$, escaping these premises. Volatile organic compounds (VOCs) could also contribute to the total $PM_{2.5}$ concentration, which could result from odours, gas industries and traffic emissions (Bari, 2015).

4.2. Humidity and Temperature

From gathering fine and ultrafine particulate matter, it is established that particulate matter concentration is much higher during the days when humidity is high (between 75% – 100%). The temperature as well as time of the day showed to be an additional factor to the total particulate matter concentration.

Overall, it was observed that the particulate matter levels were greater on milder day and higher humidity weather than in extreme weather (e.g. high winds, rainfall). This may indicate that people will not be exposed to high PM levels due to the tendency of staying indoors during extreme weather conditions. However, this does not demonstrate lower vehicular activity during extreme weathers. It was observed that more people prefer to take public or private vehicle during extreme weather conditions than in moderate weather. Particulate matter emission would increase in the atmosphere in this case, however, the particles will disperse in the air instead of concentrating in one area in high winds or plummet to the surface of the roads/ground during heavy rainfall which will correspond to lower PM levels. According to the study by Xin Fang (2017) published in PLOS One scientific journal, it states that people tend to spend more time outdoor on pleasant days, which may subsequently lead to greater likelihood of exposure and larger dose of fine and ultrafine particular matter.

According to Vanos (2014) and Vaneckova (2008), it was reported that change in weather conditions altered the strength of pollutant during summertime, which as a result increased mortality rate. The findings of the study of Vanos (2014) expressed that on hot and days showed the highest daily mortality rates associated with particular matter emissions, however, it was quite different in this study.

Evening/afternoon concentrations were much lower compared to morning concentrations. The reason for increased fine PM concentration may due to the meteorological conditions such as the built–up of particles under atmospheric inversion conditions which exist in the morning. This can result in higher concentrations compared with evening/afternoon concentrations. (Srimuruganandam, 2010; Nagendra, 2018). Most of the collected values were not breaching the maximum recommended value for $PM_{2.5}$ proposed by the European Commission (EC) (20 µg/m^3) and were broadly similar at all locations in the morning times and evening times respectively. This is a good sign, indicating that even though the increased traffic during the morning and evening rush hour may pose increased fine particulate matter levels, overall the figures show that it is not of immediate concern and the exposure to such levels may be of concern if an individual was exposed to these levels over prolonged amount of time on a continuous basis. This is not, however, a good indication that air pollution does not exist in Dublin City Centre as the data was not collected throughout the full 12-month period and on a 24-hour basis to see the varying and concise data. It is expected that the concentration levels of PM would increase during drier winter period due to the factors such as increased combustion processes from heating and traffic emissions.

The temperature varied greatly with the location and season as well as day to night. The temperature variations and its influence on PM was observed during late spring, summer, early and late autumn and start of winter. Previous study done by Jayamurugan (2013) investigated influence of temperature and relative humidity and seasonal variability on ambient air quality in a coastal urban area in India, proved that atmospheric temperatures near the earth's surface were increased and this enhanced mixing and its height for PM. The study concluded that PM levels will always be higher during temperature increase. However, the report published by Air Quality Expert Group (2012), investigated the relation between weather/temperature relation with $PM_{2.5}$, explained that $PM_{2.5}$ levels were higher during winter due to increased heating processes than during summer.

Therefore, the location greatly impacts the different PM exposures.

The concentrations were declining in summertime (May, June) and increased in mid-late August at random intervals. The concentrations then remained similar throughout September and November with elevated concentrations particularly during the temperature drop in early November. This pattern suggests that greater emissions of contributing factors to fine PM concentrations, reducing the overall dispersion. The decrease in fine PM during summer could suggest the decrease of volatile organic compound emissions contributing to PM from heating sources (municipal solid fuel combustion).

The data was collected walked from campus to campus, therefore, wind could have altered (increased) the total collected PM count. It is unknown from this study if PM levels are higher for individuals concentrating at a certain place, e.g. waiting at the bus stop. Scientific guess would be that static continuous figures would present higher figures as the desired location for monitoring would focus of the location would not alter showing accurate results and fluctuation of the results would be identified easier.

It is established that PM exposures for pedestrians are higher on high-traffic (mixed) (6.88 $\mu g/m^3$) routes than on low-traffic routes (5.03 $\mu g/m^3$) due to less exposure to traffic. Additionally, similar studies have found that the health benefits of walking and cycling can increase individual's health, hence, should be encouraged.

This being said, In the study done in Dublin City by Nyhan (2013), suggested that exercise (e.g. walking, cycling) while commuting has an influence on inhaled PM and PM long deposited dose which in return may affect cardiovascular and respiratory complications, including morbidity and mortality. This may be true for individuals who frequently use high-traffic induced routes and are near various motorised transport on continuous basis, as the levels from this study proved that throughout short walks of 20-30 min using high traffic routes would not be of major concern instantaneously, however, further researched on this topic could of benefit.4.3. Wind and Rainfall

4.3. Wind and Rainfall

Atmospheric wind speed and wind direction could have greatly affected PM levels too. As the wind speed and direction varies from place to place, from morning to afternoon, the levels of PM, it potentially increases the average PM.

Wind can often be partially responsible for temporal deviation in particulate matter concentrations. As per study by Guerra (2006), it is established that PM concentrations are usually higher during the days with calm, fluctuating winds from the south, than the north winds. The strong winds were predominantly recognized during rainfall, which decreased the number of PM.

The rainfall coincided with the PM concentration levels. This explains the low levels during the busiest times of the day-morning and evening rush hours while assessing PM exposure to pedestrians via traffic induced streets. Furthermore, increase of humidity and rainfall established low PM. The reason for this is the increased dispersion of particulate matter in the atmosphere, showing lower levels of PM compared to non-rainy days due to the failure of dispersion in the air. This is true for the months of August and September when rainfall was observed to be the heaviest, which corresponds to the PM levels positively. The driest month was May, June and July, which showed average numbers of PM. September and November saw rainfall, however, the months were relatively dry and cold. However, the morning figures were higher for humidity than those in the evening. In the morning, the humidity is expected to be higher as the relative humidity is usually highest around sunrise when the overnight low temperature is frequently close to the dew point (Skilling, 2014).

Although it is expected that PM levels would be elevated during summertime due to higher temperature in ambient air and lower due to winter. The previous study done by Gamo (1994) showed that the mixing height is low during winter due to lower temperature (sensible heat flux) and higher during warm season due to higher surface heat flux. Additionally, Gamo (1994) stated that heating of the earth surface from the sun encourages thermal turbulence in summer resulting in higher particulate matter numbers.

This was observed only in late August and mid-July when the PM levels were erratically high across high-traffic route morning walks compared to other days during these months. The reason, as confirmed by the previous studies, was the dry and hot weather with absent rainfall and lower humidity levels.

Zhang (2018), confirmed that fine PM concentrations decreased when wind speed increased (nearly 60 and 15% when the wind speed was up to 6 m/s), which indicated negative impact on PM concentration under stronger winds. The same study also confirmed that dispersion of $PM_{2.5}$ was increased under rainfall.

4.4. Weekdays vs weekend PM exposure to pedestrians

As per results, it is evident that the PM levels dropped greatly during weekends compared to weekdays (Monday to Friday) due to decreased overall public transport. Public transport is decreased as weekends are the time when most of the population is not in work or attending an educational institution thus the public transport has also a decreased frequency of the transport times and operating hours. However, during this time it was observed that private vehicle numbers have increased, which could be due to decreased. The streets assessed have a few restrictions for private vehicles in Dublin City Centre (e.g. College Green/Westmoreland street), therefore, this is another contributing factor for low PM levels during weekends. PM levels during weekend mornings in high-traffic routes were seen very low compared to weekday rush hour mornings. The pedestrianised streets showed similar PM levels during weekday and weekends time, however, the results were slightly lower during weekends due to low operational activities from the surrounding businesses, construction and road work around the routes.

Weekdays PM levels proved to be much higher than weekend levels due to increased traffic.

4.5. Health Effects

Because fine particles are small and light in nature, they tend to stay longer in the atmosphere than larger particles (>PM_{10}). As a result, individuals and animals exposed to fine particles have a greater chance of inhaling these particles. These particles can penetrate deeper into our lungs and some may also reach the circulatory system, which as a result may cause heart or respiratory diseases and complications, and in some cases even death (BlissAir, n.d.). Fine particles have known to worsen the existing chronic diseases such as asthma, bronchitis, heart attack or even increase chances of premature death in people with present heart and respiratory issues (EPA, 2017).

According to a study published by American Medical Association, long-term exposure to $PM_{2.5}$ may influence deposit build up in arteries (Atherosclerosis) in any part of our bodies (e.g. heart, brain, legs, arms, kidneys etc.) leading to vascular inflammation and artery hardening which as a result may lead to heart attack and stroke (BlissAir, n.d.; NHLBI, 2019). Additionally, this study estimated that for every 10 micrograms per cubic meter (µg/m^3) increase, there is a 4-8% possibility of increase mortality due to cardiopulmonary and lung cancer (BlissAir, n.d.).

According to the research published by American Medical Association:
"*Exposure to PM $_{<2.5}$ µm in diameter ($PM_{2.5}$) over a few hours to weeks can trigger cardiovascular disease-related mortality and nonfatal events; longer-term exposure (e.g, a few years) increases the risk for cardiovascular mortality to an even greater extent than exposures over a few days and reduces life expectancy within more highly exposed segments of the population by several months to a few years.*" (Brook, 2010)

However, it is established that the current PM concentration levels are not of concern now. The average was higher on high-traffic (mixed) (6.88 µg/m3) routes than on low-traffic routes (5.03 µg/m3), but it does not exceed the recommended daily value limits by EU Commission (20 µg/m3). These values could be threatening to human health if the person was exposed to these values over a long period of time.

4.6. Comparing Results with Dublin City Council Findings

The figures provided by Air Quality Monitoring and Noise Quality Unit in Dublin City Council are much lower compared to the figures that were gathered throughout this study (as seen in *Figure 3.10*) The exception is 1st of December, when the $PM_{2.5}$ levels reached 23 µg/m^3, however this value does not correspond to the value gathered from the study on the same day – 1.11 µg/m^3 in the morning and 4.16 µg/m^3 was observed in the evening. Apart from this value, other values seem to be much lower than the collected values throughout the study, indicating elevated $PM_{2.5}$ levels in the City Centre. The possible reason for this is that the study was carried out accessing various streets where traffic pollution is of higher concentration compared to where the meter from DCC is currently located -St John's Road. This is the only monitor closest to the study's PM monitoring routes which monitors $PM_{2.5}$. The monitor that would have been even closer – Winetavern Street, Wood Quay, however, it only monitors PM_{10}. The street where DCC monitor is currently located was assessed on spare time to see its location and a few things were noted:

- The meter was located on the street that allows various transport – private vehicles, buses, coaches and trains.
- Heavy traffic was not observed to be as congested as in the Dublin City Centre.
- Wider roads allow larger and easier transport flow. Dublin City Centre roads are quite narrow, therefore resulting in heavy traffic

Therefore, the routes chosen to walk for this study are quite different to the street where DCC monitors its $PM_{2.5}$ concentration levels. However, this does serve to understand that private vehicles contribute greatly in addition to the buses, coaches and other means of transport, to the overall air pollution in Dublin. As per results obtained from DCC, the $PM_{2.5}$ concentration levels, similarly to this study, do not pose great and immediate concern to public health, however, and with a steady annually increase in private vehicles this could change soon.

4.7. Comparing Results Against Air Quality Index for Health Tool

The AQIH provides information about poor air quality and gives health related advice in the case of poor air quality to better manage your health.

EPA uses automatic air quality monitors to measure how much pollutants there currently is in the environment (µg/m^3) per hour.

As per results obtained from this research, it is evident that majority of the readings fall into Good air quality index 1 (0-11 (µg/m^3)).

As per identified air quality results for $PM_{2.5}$ in Dublin falls primarily into good air quality region, there are no further precautionary measures applied to public in Dublin as per air quality index table above. However in the cases of days such as 25th August (39.68 µg/m^3) when the PM fell into the fair air quality category, the public is cautioned that adults and children with respiratory and cardiovascular issues with experiencing symptoms should consider reducing strenuous work which include physical activities, especially while outdoors. However, the overall population may enjoy the usual activities.

This study showed that the overall PM average values are safe for pedestrians. However, this could change. Every year, Dublin experiences more private vehicles as well as an increased population. With these increased, it is becoming a serious concern for air quality.

4.8. Survey Structure

Based on the evidence gathered from the survey, public prefers the streets in Dublin City Centre to be safer, and have better functionality supports such as sidewalks. Study setting was primarily urban, populated area. Participants in this survey was public aged 18+. Different ages may have different opinions on the transport mode selection behaviour and knowledge on air quality and climate change than the younger adult populations, on which this study aims to find more diverse opinions. The survey is mainly comprised of multiple-choice and single-choice questions, and one question has a slider bar where a participant can drag a bar to indicate their preference level from 1-10.

The survey described as “Air Quality in Dublin City Centre” was comprised of a total of 31 questions. The survey was specifically split into 5 categories:

- General profile information (gender, age group, living location, travel time, transport preference and approximate cost of travel)
- Health/medical - questions in this section were carefully constructed to ask the respondent whether they have any medical/health issues at the moment or had any in the past that made it difficult to access nodes of transport, whether the responded is satisfied or dissatisfied with available public transport in Dublin City Centre
- Air quality - the questions in this section were asking the responded to answer a series of questions anticipating understanding whether the public is aware of the general knowledge of air quality (e.g. sources, results of air pollution etc). The questions were constructed this way to gather data about public perception on air quality and air pollution.
- Climate change – the questions asked the public to answer a series of opinion questions related to climate change (e.g. sources, results of climate change etc). The questions were created this way to see if the public understands what climate change

is and whether it is of concern.

- Mitigation – the questions (3) in this section were targeting the mitigation of the air pollution, asking the respondents opinion whether mitigation of air pollution would be beneficial, or it would not make a difference monetarily. The last question of this survey in this section asks the respondent to answer the question whether they believe a radical change needs to be implemented in order to combat air pollution.

The survey was specifically split into 5 categories to make it easier to respondent to answer the questions, give the survey a structured appearance by sectioning into topic related questions, and to save the questions in case the respondent decided to leave the survey at any time. If the respondent decided to leave at any given time during the survey completion, and if the questions were not sectioned, it would increase a chance of the previous answers not being saved which would have resulted in lost data.

4.8.1. Details on Survey Findings

Majority of the respondents were female second to male. A minority of the respondents answered to "Other". Most of the respondents were aged 18-24, which is the popular age group to attend college/university and the perfect age group for this study aiming for university students. Second most popular age group was 45-54 (22%) and third was 25-34 (21%). The least responses were gathered from ages 65+ (3%) and 55-64 (4%). This could be the case indicating that the younger and middle-aged adults are more frequent on social media and may have not been aware of the survey invitation as a result. This provided a better insight for the assessor to understand the young adult's preference on modes of transport, knowledge on air quality and climate change and concerns for health and environment.

Overall, the results gave a great insight that the general public believes that there is an air quality issue in Dublin City Centre that needs an immediate action for mitigation. There is great understanding of the air quality and climate change as per results, however, it is evident that this particular subject is not often thought of considering reducing the ambient air pollution when selecting the means of transport to get to the City Centre. It is understandable that most of participants live >40 mins away from the city centre which creates a difficult obstacle to consider air quality due to limited transport options. Many respondents, therefore, choose a bus as a means of transport which is more flexible in Ireland and may reach various locations or prefer to use a private vehicle. The distance matters when it comes to monetary expenses, therefore most of the participants must spend over €20 to get to their desired location in Dublin City Centre. Many of the correspondents believe that as a mitigation option, pedestrianizing the streets and creating safer environment for pedestrians in Dublin City Centre would be a great option to reduce air pollution, however, majority believe that it would be a great expense for Dublin, but would be monetarily beneficial long term.

Survey findings imply that it may be possible to encourage the public to choose a cleaner transport mode such as walking or cycling providing there is a greater choice for high quality, pedestrianized streets and safety for pedestrians, instead of choosing a transport mode due to the perception that majority is aware that air quality and climate change is of significant issue. However, due to the time most of the participants are required to travel, it is unlikely that any changes combating air pollution will be implemented soon. Although it is evident that participants in this survey are quite aware of the air pollution effects on health, they do seem to lack understanding of the sources of air pollution and climate change. A further educational campaign or programme focusing on the dangers of air pollution and introducing news ways of recommending people to consider alternative ways of reducing air pollution, such as choosing walking as a means of transport for short distances instead of using public transport, and understand the benefits of choosing such alternatives in return, e.g. walking – reduce air pollution, does not cost anything and will improve fitness.

4.9. Recommendations for Air Quality Mitigation

In August 2019, The Journal issued a poll survey asking the public whether they believe the number of vehicles should be reduced.

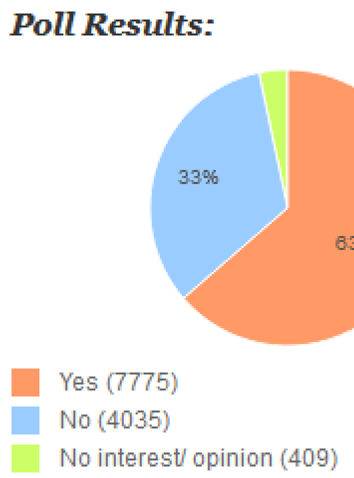


Figure 4.1: Poll results on public's perception on vehicle number reduction (Daly, 2019).

As per results shown in *Figure 4.1*, 7775 people (63.6%) agree that the vehicle numbers should be reduced, the following 4035 people (33%) disagree and 409 people (3%) do not have an opinion or interest in this.
"Legislation for low-emission vehicle zones in our cities and towns must be provided. It doesn't make sense to allow dirty diesels from the last century to travel on inner-city streets," Ciarán Cuffe said (Daly, 2019).

Air Pollution Act 1987 highlights the measures which local authorities consider are necessary to prevent or limit air pollution in their area, such as monitoring emissions, assessing compliance with relevant legislation, enforcing the law and establishing educational programmes. To compliment the Air Pollution Act 1987 in order to reduce air pollutants in Dublin City Centre, the first step would be to implement stricter regulations for cleaner fuel and access for private vehicles.

Newspapers in Ireland, such as The Irish Examiner and The Journal, have already published articles on proposed petrol and diesel ban by 2030 under proposed Climate Action Bill, however, this is not an officially agreed legal action and may be altered or annulled. It is already been discussed that this idea might be pushed to 2040 instead of 2030 (Irish Examiner, 2020).

This is a very strict and straightforward idea, many could disagree with the given time limit. A better approach would be the reduction in cost for cleaner fuels (e.g. biofuels) and electric vehicles as well as offering further discounts on car insurance and providing premium grants for those wishing to purchase an environmentally friendly vehicle. Current situation with electrical cars would be the charging time for the engine and the insufficient number of charging points available in Dublin

City. With increasing demand for electrically powered vehicles, more charging points should be readily available.

Promoting public transport and carpooling is another effective way of reducing private vehicles numbers and traffic emissions. To attract the public to use more public transport, it is advisable to create more public transport options and routes for easier access with adequate transport availability and increased reliable times for efficiency and reliability.

From seeing that Dublin City has minimized access for private vehicles on the roads such as on College Green and Westmoreland street, this could be considered in the future in hopes to reduce air pollution. The high volumes of traffic not only increase the air pollution, particular matter being one of the major pollutants, but also is a great nuisance with traffic congestion during rush hours.

Implementing air quality and climate change topics and programmes/campaigns into the educational institutions, such as schools, and work could educate people to better understand the rising issues of possible adverse health and environmental effects, especially for younger children. This could also help people to better understand the alternative ways to travel “cleaner”, saving money, increasing wellbeing and health and reducing the carbon footprint.

Chapter 5: Conclusion

The report has been made in order to investigate the outdoor levels of $PM_{2.5}$ (fine particulate) and $PM_{0.5}$ (ultrafine particulate) in Dublin City Centre. The primary idea of this research was to measure particulate matter exposure to students who navigate between various TU Dublin campuses in Dublin City Centre to attend classes on foot using Dylos DC1700 air quality monitor and examine whether the current PM levels are safe for pedestrians and are within the recommended EU limit value.

The investigation showed that the current $PM_{2.5}$ levels are not of immediate concern. Pedestrianized routes proved to be of lower $PM_{2.5}$ concentration values than traffic induced (mixed) routes. However, pedestrianized routes are longer to walk due to the route selections avoiding the motorized vehicles. There are various ways to encourage walking pedestrians choosing the pedestrianized route over the heavily trafficked streets. Apart from raising awareness of the air pollution and health benefits of walking, some other ways include structuring the city's urban land and road use and implementing more greenery such as parks to relax along the pedestrianised streets and incorporating more shops and food premises such as cafes, restaurants etc. and including more benches, litter bins which could naturally make it more comfortable, attractive and interesting for the person to consider using the pedestrianised street over a motorized street.

There are various factors that may alter PM values. Temperature, humidity, wind and rainfall all can affect the PM levels respectively. The results were compared with DCC $PM_{2.5}$ results and showed similarities but were much lower. The reason for the much lower emission values from DCC results could indicate the air monitors location, which focuses on private vehicles instead of various transport modes.

A survey was created to gain information on the public's choice for transport and understand public perception on air quality. The survey results showed that the respondents are aware of the air quality and climate change, majority of the respondents believe there is an issue with the current air quality in Dublin City Centre and air quality mitigation measures should be considered and implemented mainly to complement the pedestrians, e.g. such as pedestrianize the streets. The results suggest that participants who took part in the survey do not lack awareness in understanding that air quality can pose serious health effects and it may be an issue currently in Dublin City Centre but may lack understanding of its sources and future environmental consequences. A new launched awareness campaign or educational programme aiming to teach people of the dangers of air pollution. The proposed campaign/programme could eventually be integrated in schools to educate young children at a young age on how to make smart choices such as selecting clean transportation alternatives to reduce air pollution.

According to the air quality index, the levels mostly fall into the "good air quality" category where no further health related actions are advised to the public. Few exceptions

Although Dublin City Centre PM concentrations are currently acceptable and are below the EU limit value on $PM_{2.5}$ of 20 $\mu g/m^3$ and do not pose great danger to health, the concentration levels may increase due to increasing population and annual demand for private vehicles. The PM concentration levels are also advised to be measured for 24-hour basis continuously to see varying data to see differences during the night, early morning and evening times in addition to the morning and afternoon times. It is also advisable to measure the PM Concentration levels for other months, which this study did not cover – January, February, March, April and October.

The study findings may suggest that there are strong associations between ambient PM levels and increased transport, furthermore relationship between PM and meteorological factors such as temperature, humidity, rainfall and wind speed. Time of the day is also seen to have greatly affected the levels of PM, suggesting that the meteorological factors also play an important role in this. The findings indicate that further limiting PM concentrations in Ireland may be effective to reduce possible adverse health effects, particularly those associated with cardiovascular and respiratory problems.

Chapter 6: Recommendations

- From this research, some recommendations may be considered in order to improve accuracy for gathering data. For a better understanding of the current PM levels in Dublin City Centre, it is strongly advised to relocate the current air quality monitor, which Dublin City Council currently uses, to a more transport diverse area such as O’Connell street, O'Connell bridge or Westmoreland street where varying transport passes by pedestrians in heavy traffic. It is also advisable to consider monitoring more than one location in the city centre for better data observation and creating an overall idea of the present-day air quality status in Dublin City Centre.

- It is advisable to carry out a research work regarding PM levels throughout the entire 24 hours to inspect how air quality changes during this interval. The weekends are often expected to have lower PM emissions due to reduced public transport service schedules and due to the many working and educational institutions not operating during weekends resulting in fewer numbers of private vehicles and public overall.

- Increased Dublin Bike and station availability – as the popularity for cycling and healthy lifestyle increases, Dublin Bikes are also gaining popularity. As the popularity increases for these bikes increases, the demand also increases. This makes it difficult at times to attain of the bicycle in the City Centre and avoiding public transportation. It is highly advisable to provide more bicycles such as Dublin Bikes and safe parking availability not only for these bikes, but for personal bicycle too in order to increase cycling and in long run, improve air quality in Dublin City Centre.

- Space for cycling - implementation of a better, safer cycling network in Dublin City Centre. Cycling is an ideal way to exercise and improve air pollution in Dublin City Centre, however, cyclists often must share the same roads infrastructure as other motorized transports such as cars, buses, coaches, heavy-duty vehicles etc. This may lead to serious and even catastrophic consequences related to safety and health, often discouraging other people to cycle. By implementing safer and wider space for cycling, not only it will be beneficial for human health and the environment, it will also encourage more people to consider cycling.

- Ultra-Fine Particulate Matter (<PM0.5 $\mu g/m^3$) EU limit values – Currently, there are no official limit values available for UFP. As previously discussed in this report, UFP are extremely dangerous

for human and animal health. UFPs have ability to penetrate deep into the bodies due to their microscopic size, potentially affecting inner organs and entering the bloodstream as a result causing various health related issues.

UFPs are currently only measured indoors and not outdoors. Due to no available EU limits and due to lack of research and monitoring of these particles, it is difficult to establish the safe levels of the specific area. Importance of UFPs should be stressed in the future.

- Traffic – motorized vehicle fuel change. Fuel change may be incorporated to move from diesel and petrol to a natural, clean fuel such as electricity and biofuels to reduce emissions and lower operating costs. In 2018, transport was responsible for 20.2% for greenhouse gas (GHG) emissions, making it the second largest contributor for GHG in Ireland, according to the EPA (EPA, 2020). Ireland can reduce the carbon footprint in transport and avoid a fine from the EU if the air quality limits are not met (Irish Times, 2017).

- Increased space for public footpaths to allow and encourage walking over public transport would be a beneficial idea in order to increase physical health, safe money on travel and also reduce PM and other pollutant emissions in the atmosphere.

- Increasing space for recreational areas for the public, such as parks, may reduce overall air pollutants, which are emitted from motorized transport in the atmosphere. This idea may contribute to positive wellbeing and health of the pedestrian. This may encourage healthy lifestyle and increase walking and cycling as well as spending more time outdoors.

- More research should be done on PM, with more focus on pedestrianised and heavily trafficked streets. Although this research already addressed this topic, additional research should be conducted for a total of 12 months to see data across varying meteorological factors (e.g. wind speeds, temperature, humidity and rainfall). To strengthen the research, it could be done on full 24 hour basis, but instead of walking, multiple PM monitors could be placed on pedestrianised and heavily trafficked streets to distinguish the PM difference and see the full analysis if there are changes throughout the times of the day and months respectively.

- Singular PM monitors could also be placed at specific locations at the same time to monitor the

PM exposure for a better understanding of possible adverse health effects to pedestrians. It was highlighted in this study that it is uncertain if PM levels are higher for individuals concentrating at a certain place such waiting at the bus or train stop. Therefore, further research could monitor PM of a specific location to see if the results alter when remaining static versus walking and compare which results produce higher PM data resulting in higher exposure to individuals.

- A similar research to this could be also carried out in different parts of Ireland, e.g. comparison of Urban versus rural PM exposure. Or the study could focus on two similar locations, e.g. comparing two urban cities or two rural areas and their PM emissions.

- A similar research, including walking, can be also carried out in the housing estates to see if the PM is of concern to human health. This research could show great results during winter months, when more solid fuels are burned for heating.

- A similar study could be carried out focusing specifically on cardiovascular or respiratory diseases. The research findings could also focus on mortality rates and people who were admitted to the hospitals from such diseases as a result of PM exposure.

- Additional, thorough research should be carried out to understand the public’s choice for choosing transport modes. This research could provide beneficial information as to way people in Dublin City Centre prefer to choose a particular mode of transport over the other. The research can also focus on gender and age and how certain factors such as safety, distance etc. may affect the choice of transport.

- In the future, ultrafine particulate matter could be monitored in more detail. Therefore, more research concerning UFP should be considered, especially focusing on the particle possible adverse health effects to humans and its sources.

References

1. Adel Ghorani-Azam, B. R.-Z. a. M. B.-M., 2016. Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of Research in Medical Science*, pp. 1-12.

2. Airlief, 2017. *Why Is Air Pollution Worse During Winter?* [Online] Available at: https://airlief.com/2017/12/15/air-pollution-during-winter/ [Accessed 10 November 2019].

3. Airlief, 2018. *Why Do Chinese Wear Masks?* [Online] Available at: https://airlief.com/2018/04/23/why-do-chinese-wear-masks/ [Accessed 10 November 2019].

4. AirNow., 2017. *Older Adults and Air Quality.* [Online] Available at: https://airnow.gov/index.cfm?action=aqifor.olderadults [Accessed 8 November 2019].

5. Air Quality Expert Group, 2018. *Air Pollution from Agriculture,* s.l.: Defra.

6. Air Quality Expert Group, 2012. *Fine Particulate Matter (PM2.5) in the United Kingdom,* London: Crown.

7. American Lung Association, 2019. Particle Pollution. [Online]

   Available at: https://www.lung.org/our-initiatives/healthy-air/outdoor/air-pollution/particle-pollution.html
   [Accessed 10 September 2019].

8. Ann Y. Watson., R. R. B. a. D. K., 1988. Atmospheric Transport and Dispersion of Air Pollutants Associated with Vehicular Emissions. In: *Air Pollution, the Automobile, and Public Health.* Washington: National Academies Press (US), pp. 77-98.

9. Aodha, G. N., 2017. *Burning fuel is the biggest threat to Ireland's air quality.* [Online] Available at: https://www.thejournal.ie/fossil-fuel-burning-ireland-3678388-Nov2017/ [Accessed 2 March 2020].

10. AQEG, 2005. *Particulate Matter in the United Kingdom (Summary),* London: Department for the Environment, Food and Rural Affairs.

11. Ask About Ireland, n.d. *Air Pollution Act 1987.* [Online] Available at: http://www.askaboutireland.ie/enfo/irelands-environment/air-quality/air-pollution-act-1987/
[Accessed 13 November 2019].

12. Ask About Ireland, n.d. *Air Quality Standards.* [Online] Available at: http://www.askaboutireland.ie/enfo/irelands-environment/air-quality/air-quality-standards/
[Accessed 7 November 2019].

13. Ask About Ireland, *Nationwide Smoky Coal Ban.* [Online] Available at: http://www.askaboutireland.ie/enfo/irelands-environment/health-and-well-being/air/nationwide-smoky-coal-ban/
[Accessed 13 November 2019].

14. Atkins, G. L. a. S., 1988. The influence of personal security fears on women's travel patterns. Transportation, Issue 15, pp. 257-277.

15. Australian Government: Department of Agriculture, Water and the Environment, n.d. Particulate matter (PM10 and PM2.5). [Online]

Available at: http://www.npi.gov.au/resource/particulate-matter-pm10-and-pm25
[Accessed 12 September 2019].

16. Aynul Bari, W. B. A. J. M.-È. H. L. A., 2015. Source apportionment of indoor and outdoor volatile organic compounds at homes in Edmonton, Canada. *Building and Environment,* Volume 90, pp. 114-124.

17. Barclay, T., 2017. Trachea (Windpipe). [Online]

Available at: https://www.innerbody.com/image_card06/card13.html
[Accessed 11 September 2019].

18. Barclay, T., 2018. Nose, Sinuses and Smell. [Online]

Available at: https://www.innerbody.com/anim/nasal.html
[Accessed 11 September 2019].

19. Barnard, W. M. H. a. W. R., n.d. *Evaluating the Contribution of PM2.5 Precursor Gases and Re-entrained Road Emissions to Mobile Source PM2.5 Particulate Matter Emissions,* Miami: Environmental Protection Agency.

20. Bathmanabhan Srimuruganandam, S. N. a. S. M., 2010. Analysis and interpretation of particulate matter – PM10, PM2.5 and PM1 emissions from the heterogeneous traffic near an urban roadway. Atmospheric Pollution Research, 1(3), pp. 184-194.

21. Bhargava, D. S. B. a. S., 2013. Ecological consequences of The Acid rain. *IOSR Journal of Applied Chemistry,* October, pp. 19-24.

22. Bilkis A. Begum, S. K. B. a. M. N., 2010. TREND AND SPATIAL DISTRIBUTION OF AIR PARTICULATE MATTER POLLUTION IN DHAKA CITY. *Journal of Bangladesh Academy of Sciences*, pp. 33-48.

23. BlissAir, n.d. *What is PM2.5 and Why You Should Care.* [Online] Available at: https://blissair.com/what-is-pm-2-5.htm [Accessed 16 February 2020].

24. Boen Zhang, L. J. G. X. S. Z. X. T. Y. Z. a. G. C., 2018. Influences of wind and precipitation on different-sized particulate matter concentrations (PM2.5, PM10, PM2.5–10). *Meteorology and Atmospheric Physics,* 130(3), pp. 383-392.

25. Borkhataria, C., 2018. *Chemicals in household cleaning products, pesticides and perfumes are now as big an air pollution threat as cars.* [Online] Available at: https://www.dailymail.co.uk/sciencetech/article-5395871/House-products-big-air-pollution-threat-vehicles.html
[Accessed 12 February 2020].

26. California Air Resources Board, 2020. *Sulfate & Health.* [Online] Available at: https://ww2.arb.ca.gov/resources/sulfate-and-health [Accessed 3 February 2020].

27. CBS, S. N. -., n.d. *Particulate matter emissions by agriculture.* [Online] Available at: https://www.cbs.nl/en-gb/society/nature-and-environment/green-growth/environmental-efficiency/indicatoren/particulate-matter-emissions-by-agriculture

28. Citizens Information, 2016. *Air quality and pollution.* [Online] Available at: https://www.citizensinformation.ie/en/environment/environmental_protection/air_pollution.html
[Accessed 13 November 2019].

29. CliniMed, 2019. Structure and Function Of The Skin. [Online]

Available at: https://www.clinimed.co.uk/wound-care/wound-essentials/structure-and-function-of-the-skin
[Accessed 11 September 2019].

30. Commission, U. S. C. P. S., n.d. *The Inside Story: A Guide to Indoor Air Quality.* [Online] Available at: https://www.cpsc.gov/Safety-Education/Safety-Guides/Home/The-Inside-Story-A-Guide-to-Indoor-Air-Quality

31. Daly, A., 2019. Poll: Should the number of vehicles entering Dublin city centre be restricted? [Online]

Available at: https://www.thejournal.ie/poll-should-the-number-of-vehicles-entering-dublin-every-day-be-restricted-4753271-Aug2019/
[Accessed 28 February 2020].

32. Daniela Dias, O. T. A. C. A. I. M. a. C. B., 2012. Particulate Matter and Health Risk under a Changing Climate: Assessment for Portugal. *The Scientific World Journal,* Issue 2.

33. Department of Communications, C. A. a. E., 2019. *Smoky Coal Ban.* [Online] Available at: https://www.dccae.gov.ie/en-ie/environment/topics/air-quality/smoky-coal-ban/Pages/default.aspx
[Accessed 7 November 2019].

34. Dewi, A. U., 2010. *RESEARCH ON FACTORS AFFECTING TRAVEL BEHAVIOR ON CHOICE of TRANSPORTATION MEANS FOR WORKING ACTIVITY,* Karlstad: Karlstad University .

35. Duffy, M. A., 2019. Eye Health: Anatomy of the Eye. [Online]

Available at: https://www.visionaware.org/info/your-eye-condition/eye-health/anatomy-of-the-eye/125
[Accessed 11 September 2019].

36. Environmental Protection Agency, 2018. *http://www.epa.ie/newsandevents/news/pressreleases2018/name,65137,en.html.* [Online]
Available at: http://www.epa.ie/newsandevents/news/pressreleases2018/name,65137,en.html
[Accessed 10 November 2019].

37. Environmental Protection Agency, 2015. Environmental Protection Agency - National Ambient Air Quality Monitoring Programme 2017 - 2022. [Online]

Available at: http://www.epa.ie/pubs/reports/air/quality/National-Ambient-Air-Quality-Monitoring-Programme-2017-2022.pdf
[Accessed 1 November 2018].

38. Environmental Protection Agency, 2019. AIR. [Online]

Available at: http://www.epa.ie/irelandsenvironment/air/
[Accessed 5 September 2019].

39. Environmental Protection Agency, 2017. *Air pollution.* [Online]
Available at: https://www.eea.europa.eu/themes/air/intro
[Accessed 2 November 2019].

40. Environmental Protection Agency, 2019. *Air quality in Europe — 2019 report,* Copenhagen: European Environment Agency.

41. Environmental Protection Agency, 2019. *Clean Air For Europe programme (CAFE).* [Online]
Available at: https://www.eea.europa.eu/themes/air/links/research-projects/clean-air-for-europe-programme-cafe
[Accessed 8 November 2019].

42. Environmental Protection Agency, 2016. *Chapter 2: Air - Air Quality and Transboundary Air Emissions,* s.l.: Environmental Protection Agency.

43. Environmental Protection Agency, 2019. *Air Quality Standards.* [Online]
Available at: https://www.epa.ie/air/quality/standards/
[Accessed 7 November 2019].

44. Environmental Protection Agency, 2019. *AQIH - Information for Health Professionals.* [Online]

Available at: http://www.epa.ie/air/quality/pro/
[Accessed 8 November 2019].

45. Environmental Protection Agency, 2019. *Air Quality in Ireland 2018,* Wexford: Environmental Protection Agency.

46. Environmental Protection Agency, 2019. *What is the Air Quality Index for Health?.* [Online] Available at: http://www.epa.ie/air/quality/index/
[Accessed 8 November 2019].

47. Environmental Protection Agency, 2017. *National Ambient Air Quality Monitoring Programme 2017-2022.* [Online]
Available at: https://static.rasset.ie/documents/news/2017/11/epa-air-quality-programme-2017-22.pdf
[Accessed 8 November 2019].

48. Environmental Protection Agency, 2019. *The Environmental Protection Agency: Who We Are - What We Do,* Wexford: Environmental Protection Agency.

49. Environmental Protection Agency, 2020. TRANSPORT. [Online]
Available at: http://www.epa.ie/ghg/transport/
[Accessed 3 March 2020].

50. Environmental Protection Agency, 2019. *What We Are Responsible For.* [Online] Available at: https://www.epa.ie/about/roles/
[Accessed 11 November 2019].

51. Environmental Protection Agency United States, 2019. *Air Quality and Climate Change Research.* [Online]
Available at: https://www.epa.gov/air-research/air-quality-and-climate-change-research
[Accessed 2 February 2020].

52. Environmental Protection Authority Victoria, 2016. Air: PM10 particles in air. [Online]
Available at: https://www.epa.vic.gov.au/your-environment/air/air-pollution/pm10-particles-in-air
[Accessed 12 September 2019].

53. Erika von Schneidemesser, K. S. E. C. W. B. B. H. G. J. Q., 2019. Air pollution at human scales in an urban environment: Impact of local environment and vehicles on particle number concentrations. Science of the Total Environment, Volume 688, pp. 691-700.

54. European Commission, 2010. Air Pollution and Climate Change. *Science for Environment Policy - DG Environment News Alert Service ,* Issue 24, pp. 3-4

55. European Environmental Agency, 2017. Air Quality in Europe - 2017 Report, Copenhagen: European Environment Agency (EEA).

56. Farris, P. K., n.d. SKIN ANATOMY AND PHYSIOLOGY. [Online]

Available at: https://www.nuskin.com/en_ZA/corporate/company/science/skin_care_science/skin_anatomy_andphysiology.html
[Accessed 11 September 2019].

57. F.C. Hodgson, M. P. a. M. T., 2004. *A review of factors which influence pedestrian use of the streets: Task 1 report for an EPSRC funded project on measuring pedestrian accessibility,* Leeds: University of Leeds.

58. Fenger, J., 2009. Reduction of Visibility. In: J. C. Tjell, ed. Air Pollution: From a Local to a Global Perspective. 1 ed. Lyngby: RSCPublishing; Polyteknisk Forlag, pp. 359-362.

59. Finn, C., 2019. *Enniscorthy to become the New Delhi of Ireland if smoky coal ban not rolled out, Dáil hears.* [Online]
Available at: https://www.thejournal.ie/smoky-coal-ban-2-4678249-Jun2019/
[Accessed 11 November 2019].

60. Foody, M., 2019. *The key air pollution problems in Ireland.* [Online]
Available at: https://greennews.ie/key-air-pollution-issues-ireland/

61. Furuyama A., K. S. K. T. a. H. S., 2009. Extrapulmonary translocation of intratracheally instilled fine and ultrafine particles via direct and alveolar macrophage-associated routes. Archives of Toxicology, 83(5), pp. 429-437.

62. Gang Tan, J. L. Q. Y. A. W. D.-Y. Q. Y. W. L. Y. J. B. &. Y. S., 2018. Air pollutant particulate matter 2.5 induces dry eye syndrome in mice. Scientific Reports, 13 December, Issue 8.

63. Garcia, U., 2019. *Air Quality in the Winter.* [Online] Available at: https://www.wmdt.com/2019/02/air-quality-in-the-winter/ [Accessed 10 November 2019].

64. Georg Strasser, S. H. a. M. N., 2018. Commuter exposure to fine and ultrafine particulate matter in Vienna. Environmental Health Perspectives, 130(1), p. 62–69.

65. German Hernandez, T.-A. B. S. L. W. &. D. P., 2017. Temperature and Humidity Effects on Particulate Matter Concentrations in a Sub-Tropical Climate During Winter. International Proceedings of Chemical, Biological and Environmental Engineering, 102(8), pp. 41-47.

66. Government of Ireland, 1987. *AIR POLLUTION ACT, 1987,* Dublin: Irish Statute Book.

67. Gregor Kiesewetter, W. S. C. H. a. M. A., 2015. Modelling PM2.5 impact indicators in Europe: Health effects and legal compliance. *Environmental Modelling and Software,* Volume 74, pp. 201-211.

68. Healthline's Medical Network, 2015. Iris. [Online]

Available at: https://www.healthline.com/human-body-maps/iris-eye#1
[Accessed 11 September 2019].

69. Healthline's Medical Network, 2015. Retina. [Online]

Available at: https://www.healthline.com/human-body-maps/retina#1
[Accessed 11 September 2019].

70. HEART, 2017. *Pollution and Poverty.* [Online] Available at: https://www.heart-resources.org/reading_pack/pollution-and-poverty/ [Accessed 8 November 2019].

71. Heiting, G., 2017. The Retina: Where Vision Begins. [Online]

Available at: https://www.allaboutvision.com/resources/retina.htm
[Accessed 11 September 2019].

72. Helmenstine, D. A. M., 2019. Structure and Function of the Human Eye. [Online]

Available at: https://www.thoughtco.com/how-the-human-eye-works-4155646
[Accessed 11 September 2019].

73. Hindy, J., 2019. *10 best pedometer apps and step counter apps for Android!.* [Online] Available at: https://www.androidauthority.com/best-pedometer-apps-step-counter-apps-

for-android-852651/
[Accessed 12 November 2019].

74. Hoffman, M., 2019. Human Anatomy: Picture of the Lungs. [Online]
Available at: https://www.webmd.com/lung/picture-of-the-lungs#1
[Accessed 11 September 2019].

75. Hoffman, M., 2019. Human Anatomy: Picture of the Skin. [Online]
Available at: https://www.webmd.com/skin-problems-and-treatments/picture-of-the-skin#1
[Accessed 11 September 2019].

76. irCELine, n.d.. *Is domestic heating an emission source of particulate matter?.* [Online] Available at: https://www.irceline.be/en/documentation/faq/is-domestic-heating-an-emission-source-of-particulate-matter
[Accessed 2 March 2020].

77. IQWiG, I. f. Q. a. E. i. H. C., 2009. InformedHealth.org: How does the eye work? Cologne: Institute for Quality and Efficiency in Health Care (IQWiG).

78. J. Gordon Betts, P. D. E. J. J. E. J. O. K. D. K. B. P. J. A. W. M. W. &. K. A. Y., n.d. Anatomy and Physiology: Hypodermis, Houston: Rice University.

79. J. Keary, S. G. J. T. C. O. B. M. &. M. L., 1998. PM10 Concentration Measurements in Dublin City. *Environmental Monitoring and Assessment,* Issue 52, pp. 3-18.

80. Jennifer K. Vanos, C. H. a. S. C., 2014. Risk assessment for cardiovascular and respiratory mortality due to air pollution and synoptic meteorology in 10 Canadian cities. *Environmental Pollution,* Volume 185, pp. 322-332.

81. JM, L., 1986. Industrial airborne irritant or allergic contact dermatitis. Contact Dermatitis, 14(3), pp. 137-145.

82. K. Donaldson, V. S. A. C. L. R. &. W. M., 2001. Ultrafine particles. Occupational & Environmental Medicine, 58(3), pp. 211-216.

83. Keatinge, G. D. a. W. R., 1997. Early increases in ischaemic heart disease mortality dissociated from and later changes associated with respiratory mortality after cold weather in south east England.. *Journal of Epidemiology & Community Health,* 51(6), pp. 643-648.

84. Kelly Berube, D. B. T. J. T. M. P. H. K. S. M. H. L. M. C. T. A. S. a. B. M., 2006. Chapter 4: Characteristics of Airborne Particulate Matter and Related Mechanisms of Toxicity: An Experimental Approach. Air Pollution and Health, pp. 69-71.

85. Klopfer, J., 1989. Effects of environmental air pollution on the eye. Journal of American Optometric Association, 60(10), pp. 773-778.

86. Kuo, E. M.-Y. W. a. S.-L., 2013. A Study on the Use of a Statistical Analysis Model to Monitor Air Pollution Status in an Air Quality Total Quantity Control District. Atmosphere, Volume 4, pp. 349-364.

87. L. Hendrickx, C. V. a. H. C., 1992. Effects of frequency and scenario. In: D. S. Gochman, ed. *Handbook of Health Behavior Research I: Personal and Social Determinants.* s.l.:Springer US, pp. 256-275.

88. Lafond, A., 2019. The Environmental Impact of Particle Pollution. [Online]

Available at: https://foobot.io/guides/environmental-impact-of-particle-pollution.php
[Accessed 20 September 2019].

89. Laskowski, E. R., 2017. *Does air pollution make outdoor exercise risky? What if you have asthma or another health problem?* [Online]
Available at: https://www.mayoclinic.org/healthy-lifestyle/fitness/expert-answers/air-pollution-and-exercise/faq-20058563
[Accessed 8 November 2019].

90. Le Thi Nhu Ngoc, D. P. Y. L. a. Y.-C. L., 2017. Systematic Review and Meta-Analysis of Human Skin Diseases Due to Particulate Matter. International Journal of Environmental Research and Public Health, 14(12).

91. Lifeline Cell Technology, L. L. C., n.d. Anatomy of the Skin. [Online]

Available at: https://www.lifelinecelltech.com/herpes-simplex-virus-nerve-damage-melanoma-tumor-pathogenesis/
[Accessed 11 September 2019].

92. Lindberg, C. A. a. E., 2000. *Perceived Risk, Feelings of Safety and Worry Associated with Different Travel Modes,* Linköping: University of Linköping.

93. Li Wang, F. Z. E. P. J. Y. C. N. J. H. L. Y. Y. L. W. W. S. V. a. T. K., 2018. Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities. *International Journal of Environmental Research and Public Health,* 2(15).

94. Luc LR Int Panis, B. D. G. G. V. H. W. B. D. N. B. V. M. I. T. a. R. M., 2010. Exposure to Particulate Matter in Traffic: A Comparison of Cyclists and Car Passengers. Atmospheric Environment, June, pp. 2263-2270.

95. MacNee, K. D. &. W., 1998. The Mechanisms of Lung Injury Caused by PM10. Air Pollution and Health, 10(N/A), pp. 21-32.

96. Madaan, S., n.d. *Various Causes of Air Pollution.* [Online] Available at: https://www.eartheclipse.com/pollution/primary-causes-of-air-pollution.html

97. Magda Cepeda, J. S. R. F.-P. C. K. K. D. W. M. B. a. O. H. F., 2016. Levels of ambient air pollution according to mode of transport: a systematic review. Lancet Public Health, 2(1), pp. 23-34.

98. Marguerite Nyhan, A. M. a. B. M., 2013. Comparison of particulate matter dose and acute heart rate variability response in cyclists, pedestrians, bus and train passengers. *Science of The Total Environment,* pp. 821-831.

99. Martin, A., 2006. *Factors Influencing Pedestrian Safety: Literature Review,* London: TRL.

100. Marzia Simoni, S. B. S. M. S. C. G. S. a. G. V., 2015. Adverse effects of outdoor pollution in the elderly. *Journal of Thoracic Disease,* 7(1), p. 34–45.

101. Maurizio Manigrasso, C. N. M. V. C. P. a. P. A., 2017. Pedestrians in Traffic Environments: Ultrafine Particle Respiratory Doses. International Journal of Environmental Research and Public Health, 14(3).

102. M. De Sario, K. K. a. P. M., 2013. Climate change, extreme weather events, air pollution and respiratory health in Europe. *European Respiratory Journal,* pp. 826-843.

103. Moniek Zuurbier, G. H. M. O. V. L. K. M. P. v. d. H. a. B. B., 2010. Commuters' Exposure to Particulate Matter Air Pollution Is Affected by Mode of Transport, Fuel Type, and Route. Environmental Health Perspectives, 118(6), p. 783–789.

104. Morelli, X., 2016. Air pollution, health and social deprivation in an urban setting, Grenoble: Université Grenoble Alpes.

105. Moyer, N., 2018. Epidermis Function: Get to Know Your Skin. [Online]

Available at: https://www.healthline.com/health/epidermis-function#function
[Accessed 11 September 2019].

106. Murphy, J. G. &. J., 2012. The science of smog: a chemical understanding of ground level ozone and fine particulate matter. Metropolitan Sustainability, pp. 205-230.

107. Mutlu, R. B. H. &. G. M., 2018. Particulate Matter Air Pollution: Effects on the Cardiovascular System. Frontiers in Endocrinology, 680(9), p. N/A.

108. Nagendra, J. S. M. a. S. S., 2018. Personal exposure to fine particulate matter concentrations in central business district of a tropical coastal city. *Journal of the Air & Waste Management Association,* 68(5), pp. 415-429.

109. NASA, 2003. Particulates Effect on Rainfall. [Online]

Available at: https://svs.gsfc.nasa.gov/20010
[Accessed 14 September 2019].

110. Natalia D. Magnani, X. M. M. G. B. F. C. C. S. A. P. M. T. M. P. E. a. G. V., 2015. Skin Damage Mechanisms Related to Airborne Particulate Matter Exposure. *Toxicological Sciences*, 5 December, p. 227–236.

111. National Heart, L. a. B. I., 2019. *Atherosclerosis.* [Online] Available at: https://www.nhlbi.nih.gov/health-topics/atherosclerosis
[Accessed 16 February 2020].

112. Näyhä, S., 2002. Cold and the risk of cardiovascular diseases. A review. *International Journal of Circumpolar Health,* 61(4), pp. 373-380.

113. Newair, 2019. *Air Pollution: Understanding the Problem and Ways to Help Solve It.* [Online]
Available at: https://www.newair.com/blogs/learn/air-pollution-understanding-the-problem-and-ways-to-help-solve-it
[Accessed 2 February 2020].

114. Nuno Durães, L. A. C. C. E. F. S., 2018. Distribution, Transport and Fate of Pollutants. In: *Soil Pollution: From Monitoring to Remediation.* Porto: Academic Press, pp. 29-57.

115. Nuria Galindo, M. V. J. G.-M. E. Y. &. J. N., 2010. The Influence of Meteorology on Particulate Matter Concentrations at an Urban Mediterranean Location. *Water, Air, & Soil Pollution,* Issue 215, p. 365–372.

116. Nel, J. A. A. a. A. E., 2009. Particulate matter and atherosclerosis: role of particle size, composition and oxidative stress. Particle and Fibre Toxicology - BMC, 18 September, p. N/A.

117. Newman, T., 2018. An introduction to eyes and how they work. [Online]

Available at: https://www.medicalnewstoday.com/articles/320608.php
[Accessed 11 September 2019].

118. O'Hanlon, H., 2016. An Investigation of Smoking Areas in the North Dublin Area and an Assessment of the Particulate Matter 2.5 Concentrations at Indoor and Outdoor Levels, Dublin: Dublin Institute of Technology.

119. Pavla Vaneckova, M. A. H. P. J. B. &. R. J. d. D., 2008. Synoptic analysis of heat-related mortality in Sydney, Australia, 1993–2001. *International Journal of Biometeorology,* p. pages 439–451.

120. Philippe Apparicio, J. G. M. C. M.-È. M. a. S. K., 2018. Exposure to noise and air pollution by mode of transportation during rush hours in Montreal. Journal of Transport Geography, Volume 70, pp. 182-192.

121. Pražnikar, Z. J. P. a. J., 2012. The effects of particulate matter air pollution on respiratory health and on the cardiovascular system. *Slovenian Journal of Public Health,* 3(51), pp. 190-199.

122. Quality.org, A., n.d.. Urban Air Pollution in World Megacities. [Online]

Available at: http://www.air-quality.org.uk/11.php
[Accessed 21 September 2019].

123. Ragettli, M. S., 2015. Measurement and modeling of short- and long-term commuter exposure to traffic-related air pollution, Basel: University of Basel.

124. Ralph J. Delfino, C. S. ,. a. S. M., 2005. Potential Role of Ultrafine Particles in Associations between Airborne Particle Mass and Cardiovascular Health, s.l.: Environmental Health Perspectives (EHP).

125. Ramasamy Jayamurugan, B. K. S. P. a. M. P. C., 2013. Influence of Temperature, Relative Humidity and Seasonal Variability on Ambient Air Quality in a Coastal Urban Area. *International Journal of Atmospheric Sciences.*

126. Ro-Poulsen, I. J. &. H., 2009. Biological effects. In: J. F. &. J. C. Tjell, ed. Air Pollution: From Local to Global Perspective . Lyngby: RSCPublishing; Polyteknisk Forlag, pp. 363-386.

127. Robert D. Brook, B. F. W. C. Y. H. G. H. M. L. R. L. M. M. J. S. S. C. S. a. I. T., 2004. Air Pollution and Cardiovascular Disease: A Statement for Healthcare Professionals From the Expert Panel on Population and Prevention Science of the American Heart Association. *Circulation,* 109(21), p. 2655–2671.

128. Robert D. Brook, S. R. C. A. P. J. R. B. A. B. A. V. D.-R. F. H. Y. H. R. V. L. M. A. M. A. P. D. S. S. C. S. L. W., 2010. Particulate Matter Air Pollution and Cardiovascular Disease. *Circulation*, 10 May, p. 2331–2378.

129. Rohan Jayaratne, X. L. P. T. M. D. a. L. M., 2018. The influence of humidity on the performance of a low-cost air particle mass sensor and the effect of atmospheric fog. *Atmospheric Measurement Techniques.*

130. Ryan, K. S. &. P. B., 1988. Assessment of Human Exposure to Air Pollution: Methods, Measurements, and Models. In: S. R. R. B. M. a. D. K. P. Ann Y. Watson, ed. Air Pollution, the Automobile, and Public Health. Washington (DC): Health Effects Institute. National Academy Press, Washington, D.C.

131. Samuel Sigaud, C.-A. W. G. H. Z. Z. Y. A. F. A. I. L. K., 2007. Air pollution particles diminish bacterial clearance in the primed lungs of mice. *Toxicology and Applied Pharmacology,* 223(1), pp. 1-9.

132. Samson, P. J., 1988. Atmospheric Transport and Dispersion of Air Pollutants Associated with Vehicular Emissions. In: *Air Pollution, the Automobile, and Public Health.* Danvers: Paperback, pp. 77-94.

133. Schwartz, M. F. a. J., 2008. The Impact of Secondary Particles on the Association between Ambient Ozone and Mortality. Environmental Health Perspect, 116(4), p. 453–458.

134. Sergio A. Guerra, D. D. L., G. A. M., R. E. C., C. M. H. &. R. W. B., 2006. Effects of wind direction on coarse and fine particulate matter concentrations in southeast Kansas. Journal of the Air & Waste Management Association, 56(11), pp. 1525-1531.

135. S.Ghafghazi, T. S. X. a. S., 2011. Particulate matter emissions from combustion of wood in district heating applications. *Renewable and Sustainable Energy Reviews,* 15(6), pp. 3019-3028.

136. Sharma, S., 2019. *Factors influencing travel behavior and mode choice.* [Online] Available at: https://www.geospatialworld.net/blogs/factors-influencing-travel-behavior-and-mode-choice/
[Accessed 18 March 2020].

137. Simone Simões Amaral, J. A. d. C. J. M. A. M. C., 2015. An Overview of Particulate Matter Measurement Instruments. Atmosphere, Issue 6, pp. 1327-1345.

138. Skilling, T., 2014. *Ask Tom: Why is humidity higher in mornings?.* [Online] Available at: https://www.google.ie/amp/s/www.chicagotribune.com/weather/ct-wea-1005-asktom-20141004-column.html%3foutputType=amp
[Accessed 23 February 2020].

139. Smith, Y., 2019. What is the Dermis? [Online]

Available at: https://www.news-medical.net/health/What-is-the-Dermis.aspx
[Accessed 11 September 2019].

140. Stakeeva, B. O. a. B., 2013. Personal exposure of commuters in public transport to PM2.5 and fine particle counts. Atmospheric Pollution Research, 4(3), pp. 329-335.

141. Stefanie Uibel, C. S. D. M. D. K. D. M. L. H. M. T. A. F. M. F. S. V. U. D. Q. a. D. A. G., 2012. Mobile air quality studies (MAQS) in inner cities: particulate matter PM10 levels related to different vehicle driving modes and integration of data into a geographical information program, N/A: Journal of Occupational Medicine and Toxicology.

142. Sutherland, S., 2019. *Winter air quality is often worse than in summer. Here's why.* [Online]
Available at: https://www.theweathernetwork.com/news/articles/winter-air-quality-can-be-just-as-bad-as-summer/122739
[Accessed 18 March 2020].

143. Teresa Moreno, C. R. I. R. M. C. M. V. M. C. V. G. B. J. P. M. P. M. B. M. E. A. S. F. F. A. G. S. M. C. E. M., 2015. Urban air quality comparison for bus, tram, subway and pedestrian commutes in Barcelona. Environmental Research, Volume 142, pp. 495-510.

144. The Guardian, 2015. *Air pollution in China is killing 4,000 people every day, a new study finds.* [Online]
Available at: https://www.theguardian.com/world/2015/aug/14/air-pollution-in-china-is-killing-4000-people-every-day-a-new-study-finds

145. The Irish Examiner, 2020. New petrol and diesel cars to be banned by 2030 under proposed Climate Action Bill. [Online]
Available at: https://www.irishexaminer.com/breakingnews/ireland/new-petrol-and-diesel-cars-to-be-banned-by-2030-under-proposed-climate-bill-973833.html
[Accessed 28 February 2020].

146. The Irish Times., 2017. Amid diesel backlash and bans, transport firms look to natural gas. [Online]
Available at: https://www.irishtimes.com/life-and-style/motors/amid-diesel-backlash-and-bans-transport-firms-look-to-natural-gas-1.3155109
[Accessed 3 March 2020].

147. Tjell, J. F. a. J. C., 2009. Air Pollution - from a local global perspective. 1st ed. Lyngby: RSCPublishing; Polyteknisk Forlag .

148. Tjell, J. F. &. J. C., 2009. Impacts. In: J. F. &. J. C. Tjell, ed. Air Pollution: From Local to Global Perspective. 1 ed. Lyngby: RSCPublishing; Polyteknisk, pp. 327-351.

149. United States Environmental Protection Agency, 2019. *About EPA.* [Online]
Available at: https://www.epa.gov/aboutepa
[Accessed 8 November 2019].

150. United States Environmental Protection Agency, 2018. Health and Environmental Effects of Particulate Matter (PM). [Online]

Available at: https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
[Accessed 10 September 2019].

151. United States Environmental Protection Agency, 2018. Particulate Matter (PM) Basics. [Online]

Available at: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics
[Accessed 6 September 2019].

152. United States Environmental Protection Agency, 2017. *Course Outline and Key Points for Particle Pollution.* [Online]
Available at: https://www.epa.gov/particle-pollution-and-your-patients-health/course-outlinekey-points
[Accessed 16 February 2020].

153. Wenchang Zhao, J. C. D. L. Y. D. H. W. J. W. W., 2013. Urban ambient air quality investigation and health risk assessment during haze and non–haze periods in Shanghai, China. Atmospheric Pollution Research, 4(3), pp. 275-281.

154. World Health Organization, 2018. Air pollution: WHO Global Ambient Air Quality Database (update 2018). [Online]

Available at: https://www.who.int/airpollution/data/cities/en/
[Accessed 12 September 2019].

155. World Health Organization, 2018. Exposure to ambient air pollution from particulate matter for 2016, Geneva: World Health Organization.

156. World Health Organization, 2019. Air pollution. [Online]

Available at: https://www.who.int/airpollution/en/
[Accessed 19 September 2019].

157. World Health Organization, 2006. *Health Risks of Particulate Matter from Long-Range Transboundary Air Pollution,* Copenhagen: World Health Organization.

158. World Health Organization, 2020. *Household air pollution: Pollutants.* [Online] Available at: https://www.who.int/airpollution/household/pollutants/en/

159. World Health Organization, 2006. *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global Update 2005: Summary of risk assessment ,* Geneva: World Health Organization.

160. World Health Organization, 2018. *Air pollution and child health: prescribing clean air.* [Online]
Available at: https://www.who.int/ceh/publications/air-pollution-child-health/en/
[Accessed 8 November 2019].

161. World Health Organization, 2018. *Air pollution.* [Online] Available at: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
[Accessed 2 November 2019].

162. Wynd, 2018. *What are the effects of air pollution on children's health?* [Online] Available at: https://medium.com/@hellowynd/what-are-the-effects-of-air-pollution-on-childrens-health-5f42eed7b673
[Accessed 8 November 2019].

163. Xiaoyan Chen, J. L. J. Z. J. W. C. C. Y. S. J. P., 2018. Urban particulate matter (PM) suppresses airway antibacterial defence. *Respiratory Research,* 8 January.5(19).

164. Xin Fang, B. F. C. W. T. X. M. B. F. F. a. Y. C., 2017. Relationship between fine particulate matter, weather condition and daily non-accidental mortality in Shanghai, China: A Bayesian approach. PLoS ONE, 12(11).

165. Yang, S.-I., 2019. Particulate matter and childhood allergic diseases. *Korean Journal of Pediatrics*, January, pp. 22-29.

166. Yaohua Tian, H. L. Y. W. Y. S. M. L. Y. W. X. W. M. W. L. C. C. W. T. W. P. G. Y. H., 2019. Ambient particulate matter pollution and adult hospital admissions for pneumonia in urban China: A national time series analysis for 2014 through 2017. *PLOS Medicine,* 16(12).

167. Yixing Du, X. X. M. C. Y. G. a. J. W., 2016. Air particulate matter and cardiovascular disease: the epidemiological, biomedical and clinical evidence. Journal of Thoracic Disease, 8(1), pp. 8-19.

168. Ziyue Chen, X. X. J. C. D. C. B. G. B. H. N. C. a. B. X., 2018. Understanding meteorological influences on PM2.5 concentrations across China: a temporal and spatial perspective. *Atmospheric Chemistry and Physics,* Issue 18, p. 5343–5358.

Appendices

Appendix A

Examples below show how to accurately calculate the AQIH:

- Example 1:

Pollutant	Measurement	Index
Ozone	80	3
Nitrogen Dioxide	35	1
Sulphur Dioxide	10	1
$PM_{2.5}$ Particles	45	5
PM_{10} Particles	71	6

The AQIH is 6 - Fair

- Example 2:

Pollutant	Measurement	Index
Ozone	80	3
Nitrogen Dioxide	35	1
Sulphur Dioxide	10	1
$PM_{2.5}$ Particles	25	3
PM_{10} Particles	50	3

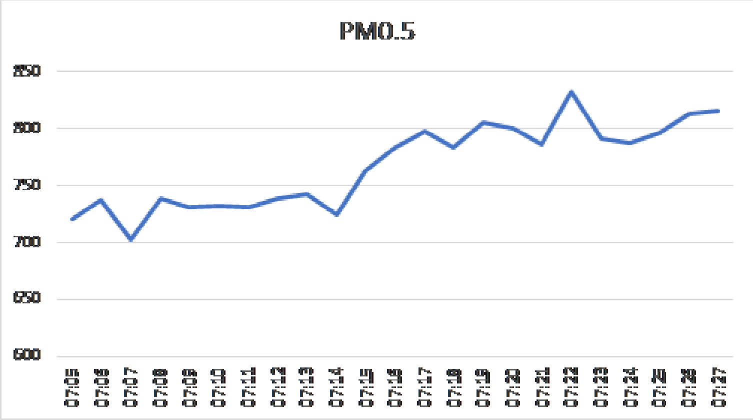
The AQIH is 3 – Good

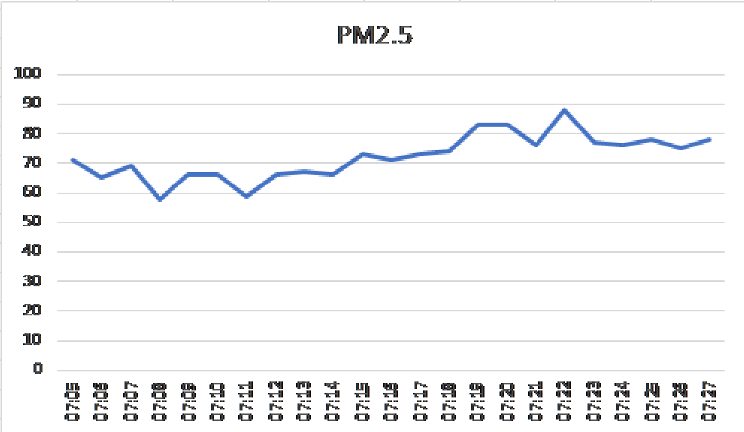
Table A.1 & Table A.2: Examples on how to calculate the AQIH (EPA, 2019).

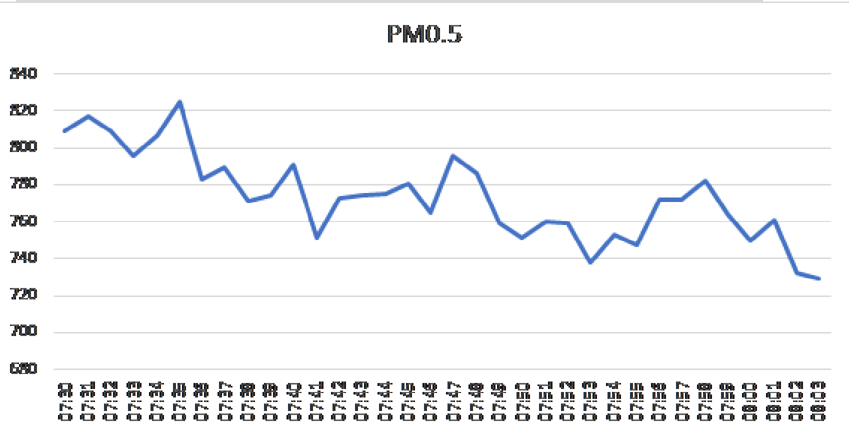
Appendix B

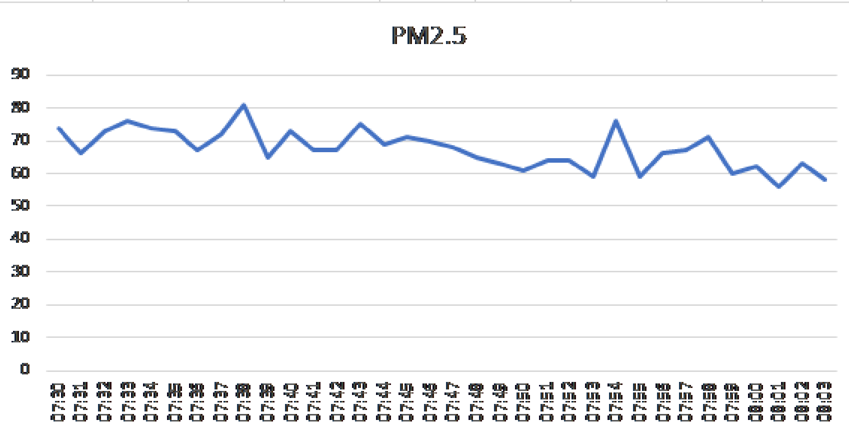
Collected PM particle count readings for each day (15th May, 2019 to 8th December, 2019) (Read $PM_{0.5}$ – Ultrafine particles and $PM_{2.5}$ – Fine particles) per minute:

	Date:15/05/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:05	721	71
	07:06	737	65
	07:07	702	69
	07:08	738	58
	07:09	731	66
	07:10	732	66
	07:11	731	59
	07:12	738	66
	07:13	743	67
	07:14	724	66
	07:15	763	73
	07:16	784	71
	07:17	798	73
	07:18	784	74
	07:19	805	83
	07:20	800	83
	07:21	786	76
	07:22	832	88
	07:23	791	77
	07:24	788	76
	07:25	796	78
	07:26	813	75
	07:27	816	78
	Average:	767.5217	72.08696
	07:30	809	74
	07:31	817	66
	07:32	809	73
	07:33	796	76
	07:34	807	74
	07:35	825	73
	07:36	783	67
	07:37	789	72
	07:38	771	81
	07:39	774	65
	07:40	791	73
	07:41	751	67
	07:42	773	67
	07:43	774	75
	07:44	775	69
	07:45	781	71
	07:46	765	70
	07:47	796	68
	07:48	786	65
	07:49	759	63
	07:50	751	61
	07:51	760	64
	07:52	759	64
	07:53	738	59
	07:54	753	76
	07:55	747	59
	07:56	772	66
	07:57	772	67
	07:58	782	71
	07:59	764	60
	08:00	750	62
	08:01	761	56
	08:02	732	63
	08:03	729	58
	Average:	773.5588	67.5

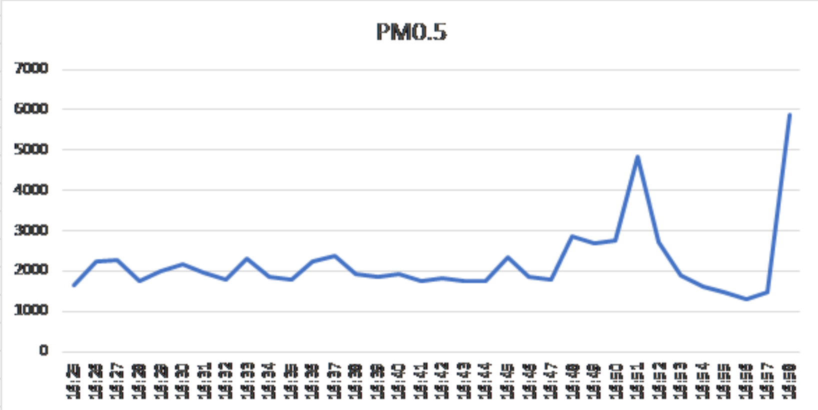


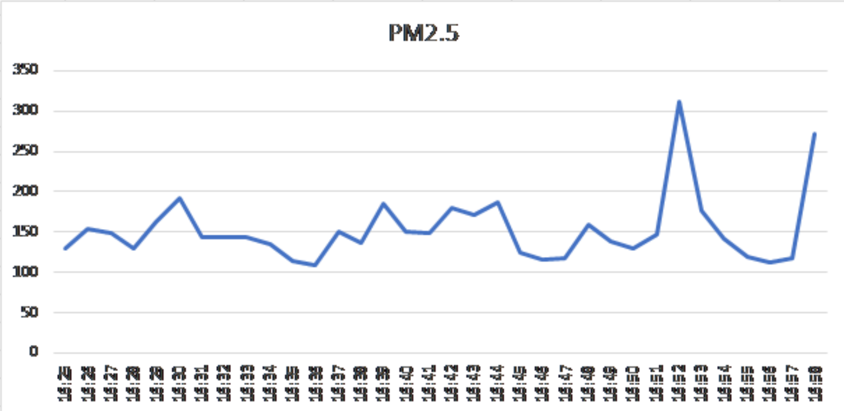


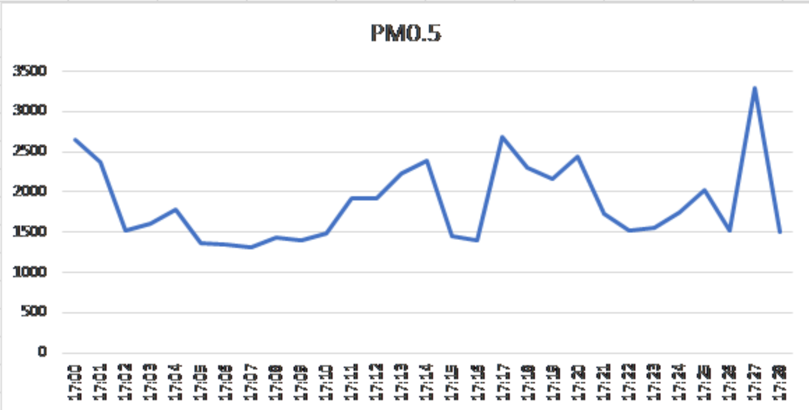


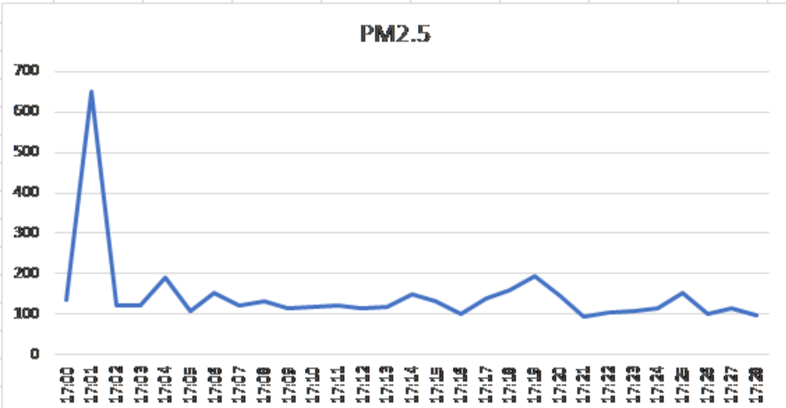


Evening			
1st	Time:	PM0.5	PM2.5
	16:25	1668	130
	16:26	2252	154
	16:27	2271	149
	16:28	1739	129
	16:29	2003	162
	16:30	2156	192
	16:31	1963	144
	16:32	1778	144
	16:33	2310	143
	16:34	1864	135
	16:35	1805	114
	16:36	2257	109
	16:37	2388	150
	16:38	1930	136
	16:39	1867	185
	16:40	1912	150
	16:41	1760	148
	16:42	1832	180
	16:43	1746	172
	16:44	1744	187
	16:45	2334	124
	16:46	1855	116
	16:47	1807	118
	16:48	2877	160
	16:49	2688	139
	16:50	2753	130
	16:51	4854	147
	16:52	2732	312
	16:53	1888	176
	16:54	1614	142
	16:55	1490	120
	16:56	1322	113
	16:57	1466	117
	16:58	5875	272
	Average:	2200	152.9118
2nd	17:00	2644	136
	17:01	2368	653
	17:02	1514	120
	17:03	1610	122
	17:04	1778	191
	17:05	1364	109
	17:06	1351	151
	17:07	1319	120
	17:08	1430	133
	17:09	1408	115
	17:10	1492	118
	17:11	1918	122
	17:12	1927	115
	17:13	2230	118
	17:14	2392	150
	17:15	1458	133
	17:16	1408	102
	17:17	2678	140
	17:18	2300	158
	17:19	2160	193
	17:20	2437	147
	17:21	1724	93
	17:22	1528	105
	17:23	1553	109
	17:24	1741	114
	17:25	2032	152
	17:26	1515	99
	17:27	3298	116
	17:28	1513	98
	Average:	1865.172	145.931

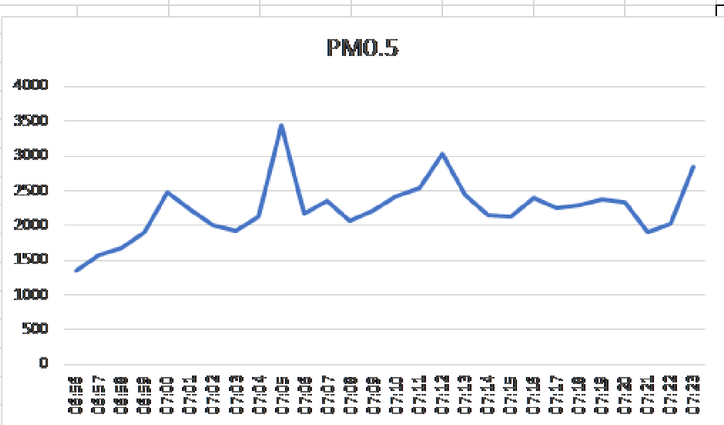


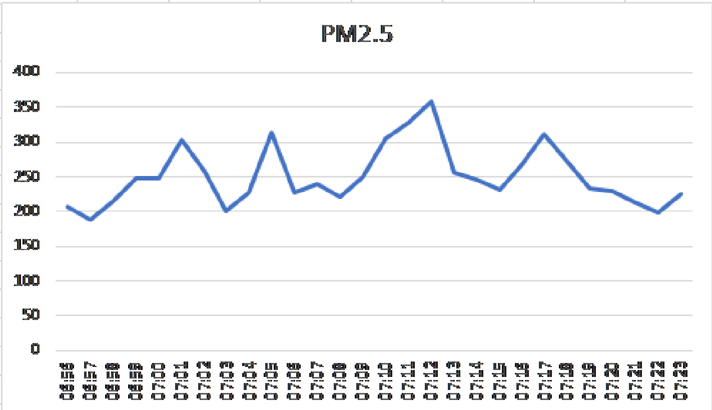


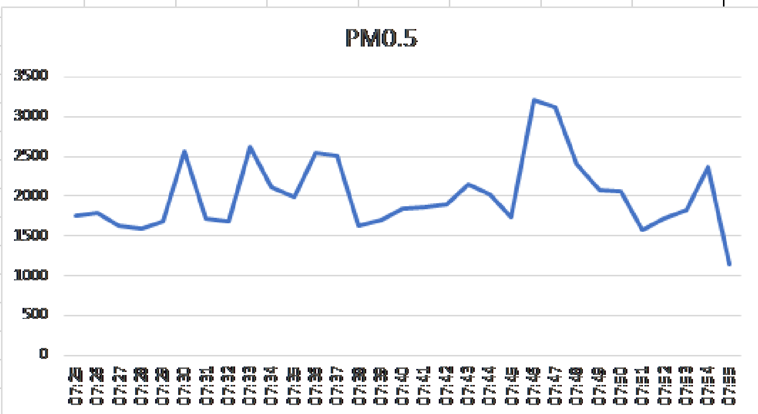


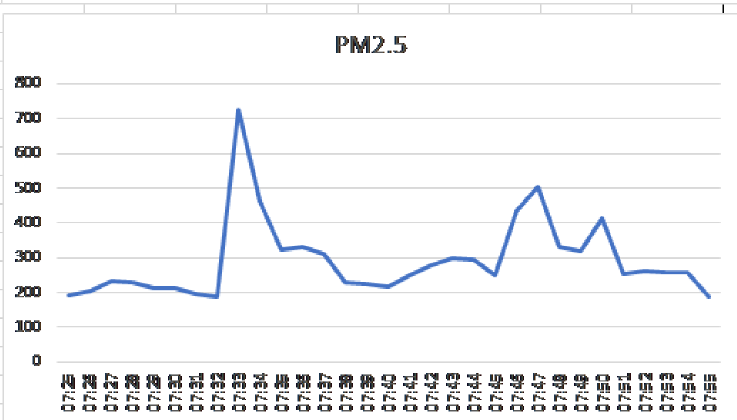


	Date:17/05/19			
	Morning			
1st	Time:	PM0.5	PM2.5	
	06:56	1354	206	CB-KEVIN ST
	06:57	1567	188	
	06:58	1687	216	
	06:59	1909	247	
	07:00	2487	247	
	07:01	2240	304	
	07:02	2009	259	
	07:03	1930	201	
	07:04	2132	227	
	07:05	3445	313	
	07:06	2170	228	
	07:07	2353	240	
	07:08	2061	221	
	07:09	2217	250	
	07:10	2410	305	
	07:11	2544	327	
	07:12	3036	359	
	07:13	2445	257	
	07:14	2160	245	
	07:15	2130	232	
	07:16	2404	267	
	07:17	2254	311	
	07:18	2288	273	
	07:19	2376	234	
	07:20	2330	229	
	07:21	1902	214	
	07:22	2020	199	
	07:23	2840	225	
	Average:	2239.286	250.8571	
2nd	07:25	1758	192	
	07:26	1792	205	
	07:27	1629	234	
	07:28	1600	230	
	07:29	1688	213	
	07:30	2567	214	
	07:31	1723	196	
	07:32	1691	189	
	07:33	2623	724	
	07:34	2123	463	
	07:35	1983	322	
	07:36	2543	330	
	07:37	2517	311	
	07:38	1624	227	
	07:39	1709	226	
	07:40	1839	218	
	07:41	1868	250	
	07:42	1896	277	
	07:43	2158	300	
	07:44	2032	294	
	07:45	1734	251	
	07:46	3209	435	
	07:47	3120	504	
	07:48	2405	331	
	07:49	2087	321	
	07:50	2069	414	
	07:51	1584	253	
	07:52	1715	261	
	07:53	1822	259	
	07:54	2368	258	
	07:55	1140	186	
	Average:	2019.871	293.1613	

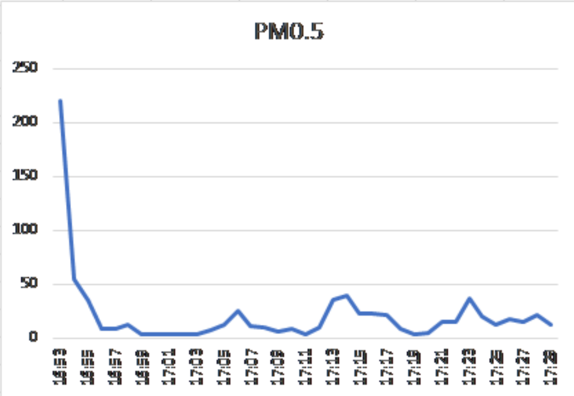


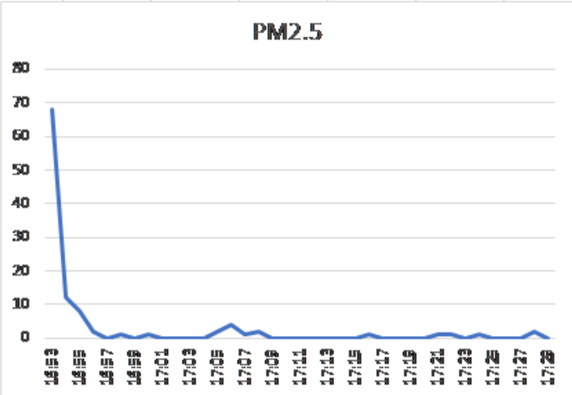


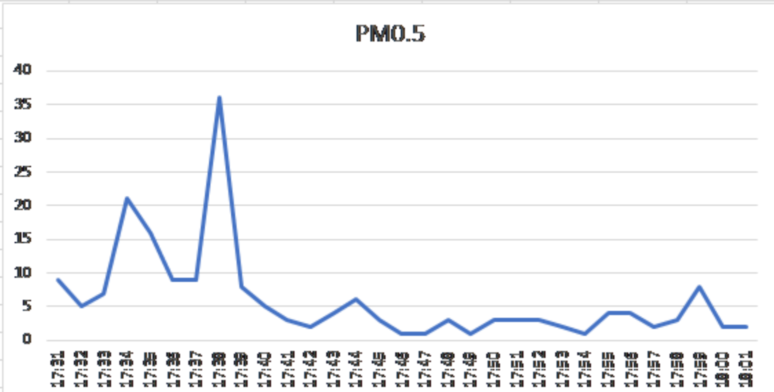


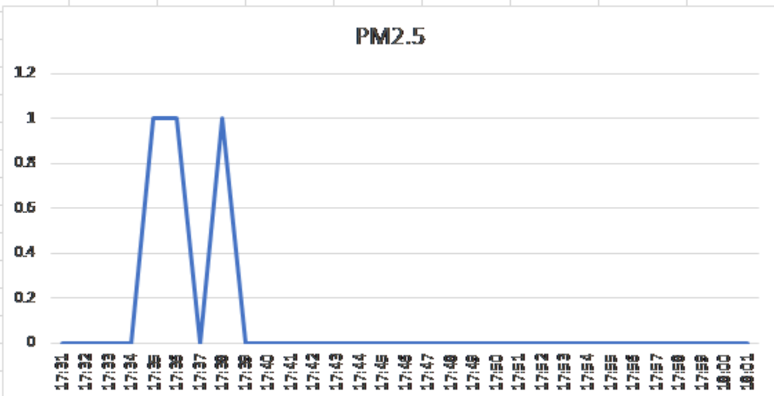


Evening			
1st	Time:	PM0.5	PM2.5
	16:53	221	68
	16:54	55	12
	16:55	36	8
	16:56	8	2
	16:57	8	0
	16:58	12	1
	16:59	4	0
	17:00	4	1
	17:01	3	0
	17:02	3	0
	17:03	3	0
	17:04	7	0
	17:05	12	2
	17:06	25	4
	17:07	11	1
	17:08	10	2
	17:09	6	0
	17:10	8	0
	17:11	4	0
	17:12	10	0
	17:13	35	0
	17:14	40	0
	17:15	23	0
	17:16	23	1
	17:17	21	0
	17:18	9	0
	17:19	3	0
	17:20	5	0
	17:21	15	1
	17:22	15	1
	17:23	37	0
	17:24	20	1
	17:25	13	0
	17:26	18	0
	17:27	15	0
	17:28	21	2
	17:29	13	0
	Average:	20.97297	2.891892
	17:31	9	0
	17:32	5	0
	17:33	7	0
	17:34	21	0
	17:35	16	1
	17:36	9	1
	17:37	9	0
	17:38	36	1
	17:39	8	0
	17:40	5	0
	17:41	3	0
	17:42	2	0
	17:43	4	0
	17:44	6	0
	17:45	3	0
	17:46	1	0
	17:47	1	0
	17:48	3	0
	17:49	1	0
	17:50	3	0
	17:51	3	0
	17:52	3	0
	17:53	2	0
	17:54	1	0
	17:55	4	0
	17:56	4	0
	17:57	2	0
	17:58	3	0
	17:59	8	0
	18:00	2	0
	18:01	2	0
	Average:	6	0.096774

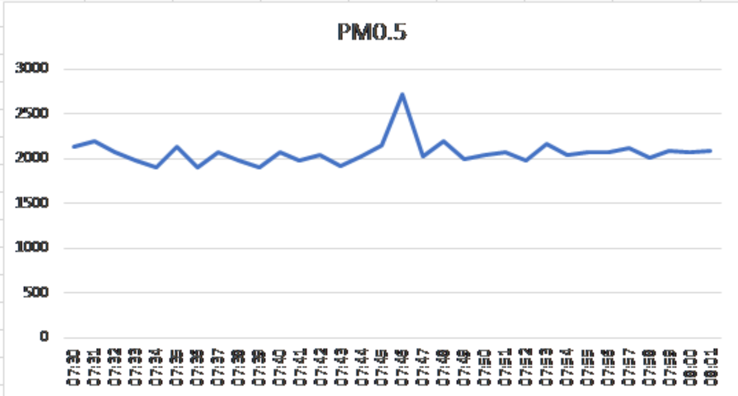


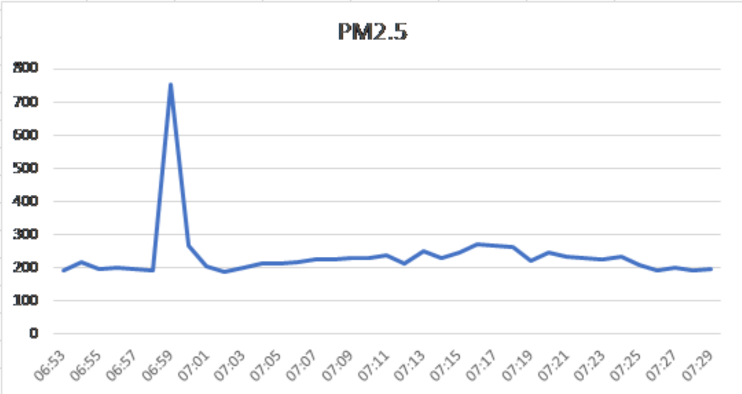


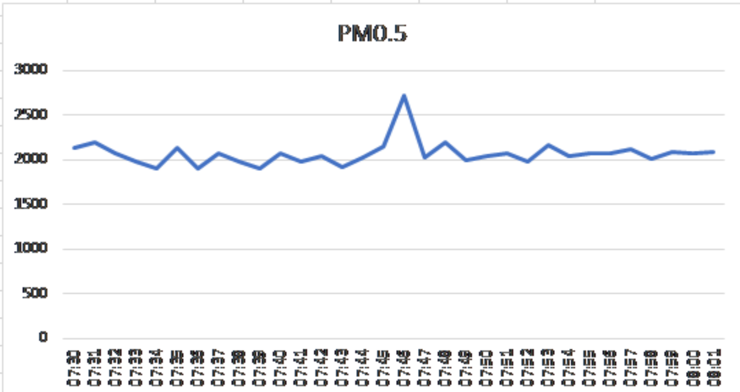


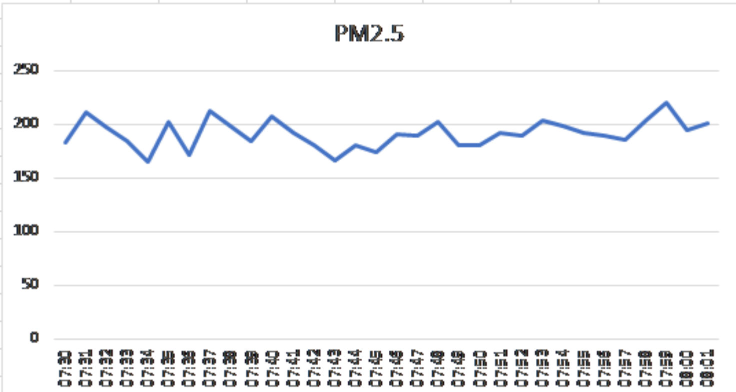


	Morning		
1st	Time:	PM0.5	PM2.5
	06:53	1732	194
	06:54	1851	217
	06:55	1771	199
	06:56	1846	200
	06:57	1816	195
	06:58	1917	193
	06:59	2627	752
	07:00	2173	267
	07:01	2237	204
	07:02	1988	187
	07:03	2379	200
	07:04	2401	215
	07:05	2381	214
	07:06	2429	218
	07:07	2320	226
	07:08	2397	225
	07:09	2547	231
	07:10	2438	232
	07:11	2879	239
	07:12	2524	215
	07:13	3074	249
	07:14	2793	231
	07:15	2798	248
	07:16	2688	273
	07:17	2711	267
	07:18	2760	264
	07:19	2394	220
	07:20	2485	248
	07:21	2792	233
	07:22	2428	229
	07:23	2291	228
	07:24	2377	234
	07:25	2206	211
	07:26	2177	192
	07:27	2254	200
	07:28	2247	194
	07:29	2405	197
	Average:	2365.757	236.2432
2nd	07:30	2144	183
	07:31	2199	211
	07:32	2081	197
	07:33	1990	185
	07:34	1903	165
	07:35	2132	202
	07:36	1912	172
	07:37	2079	213
	07:38	1976	199
	07:39	1912	184
	07:40	2069	208
	07:41	1984	192
	07:42	2043	180
	07:43	1921	166
	07:44	2025	180
	07:45	2149	174
	07:46	2728	191
	07:47	2031	190
	07:48	2191	203
	07:49	1998	181
	07:50	2041	181
	07:51	2069	192
	07:52	1975	189
	07:53	2164	204
	07:54	2045	198
	07:55	2077	192
	07:56	2071	190
	07:57	2123	186
	07:58	2009	204
	07:59	2091	220
	08:00	2068	195
	08:01	2085	201
	Average:	2071.406	191.5

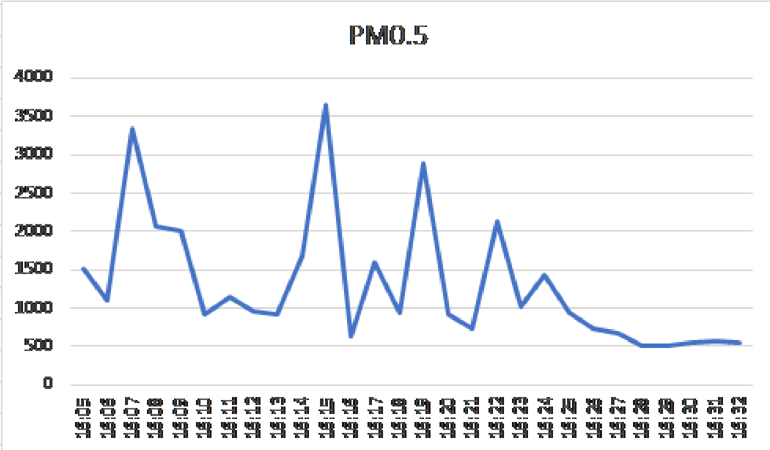


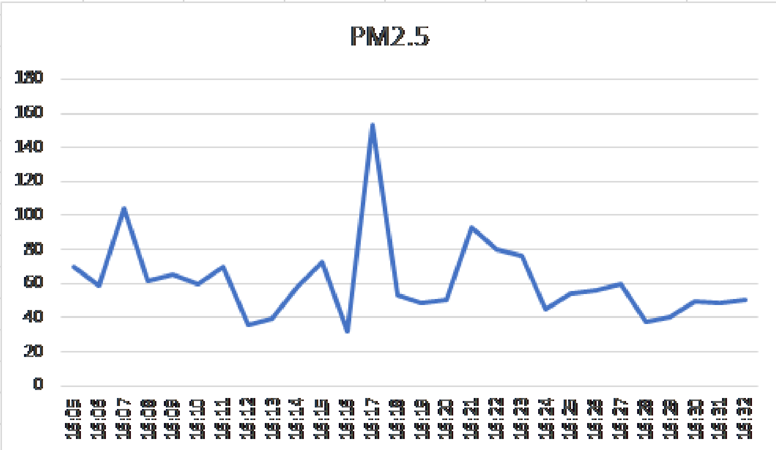


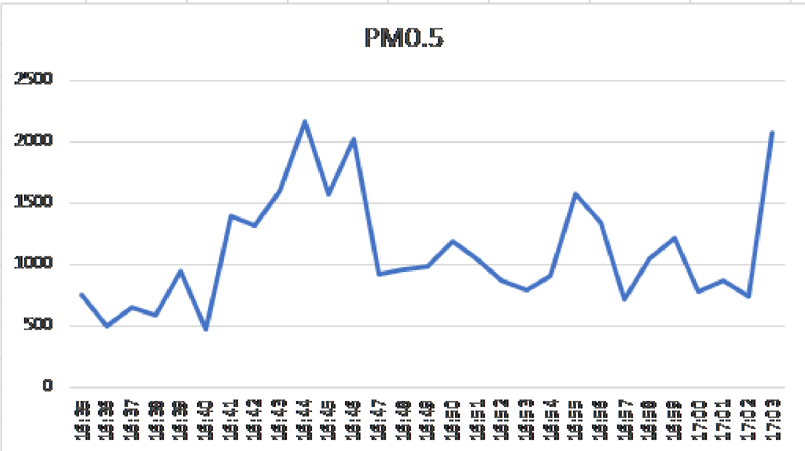


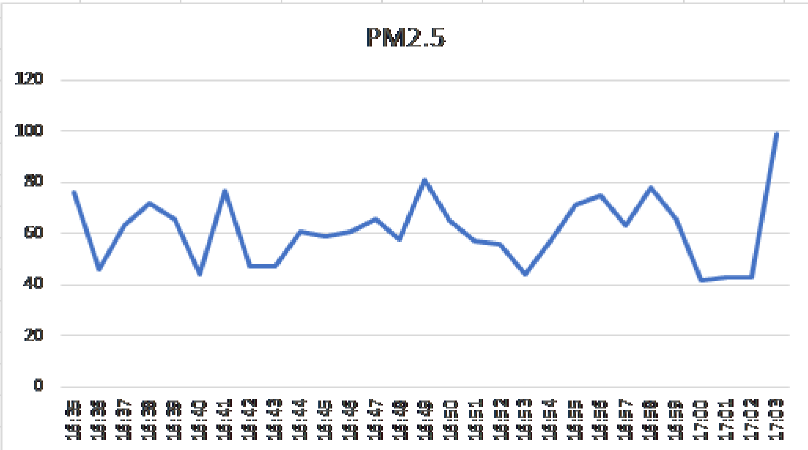


Evening			
1st	Time:	PM0.5	PM2.5
	16:05	1518	70
	16:06	1107	59
	16:07	3346	104
	16:08	2060	62
	16:09	1998	65
	16:10	913	60
	16:11	1141	70
	16:12	968	36
	16:13	920	39
	16:14	1688	58
	16:15	3645	73
	16:16	634	32
	16:17	1604	153
	16:18	946	53
	16:19	2895	49
	16:20	920	51
	16:21	733	93
	16:22	2122	80
	16:23	1022	76
	16:24	1433	45
	16:25	940	54
	16:26	735	56
	16:27	662	60
	16:28	501	38
	16:29	497	40
	16:30	556	50
	16:31	574	49
	16:32	558	51
	Average:	1308.429	61.64286
2nd	16:35	748	76
	16:36	500	46
	16:37	652	63
	16:38	589	72
	16:39	950	66
	16:40	471	44
	16:41	1390	77
	16:42	1312	47
	16:43	1603	47
	16:44	2164	61
	16:45	1581	59
	16:46	2018	61
	16:47	921	66
	16:48	959	58
	16:49	982	81
	16:50	1194	65
	16:51	1049	57
	16:52	865	56
	16:53	793	44
	16:54	905	57
	16:55	1571	71
	16:56	1340	75
	16:57	711	63
	16:58	1049	78
	16:59	1214	66
	17:00	782	42
	17:01	868	43
	17:02	739	43
	17:03	2075	99
	Average:	1103.276	61.48276

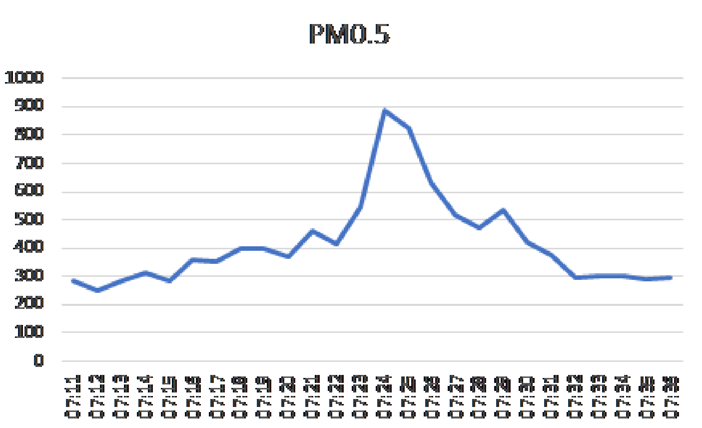


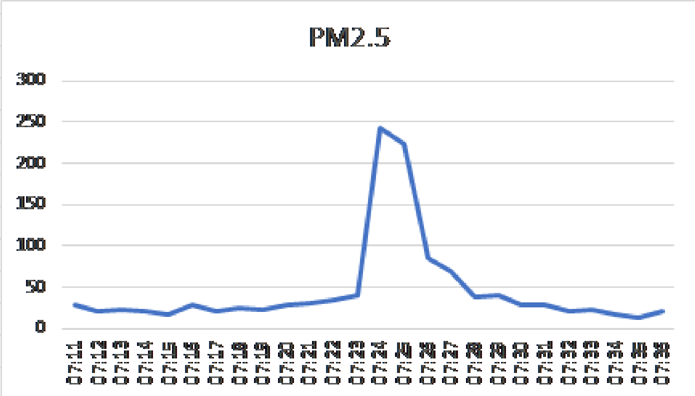


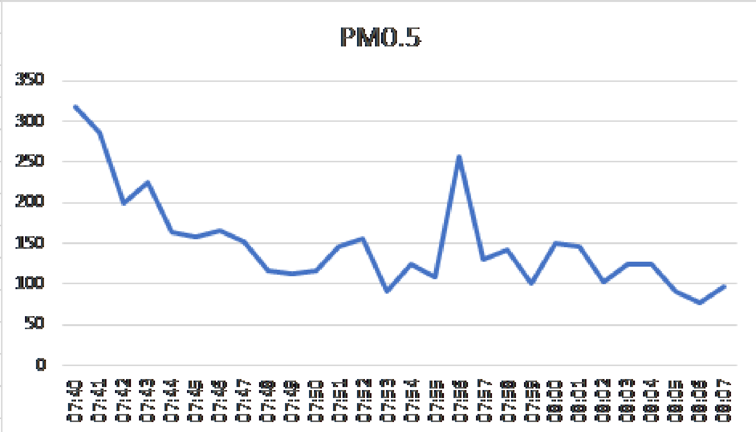


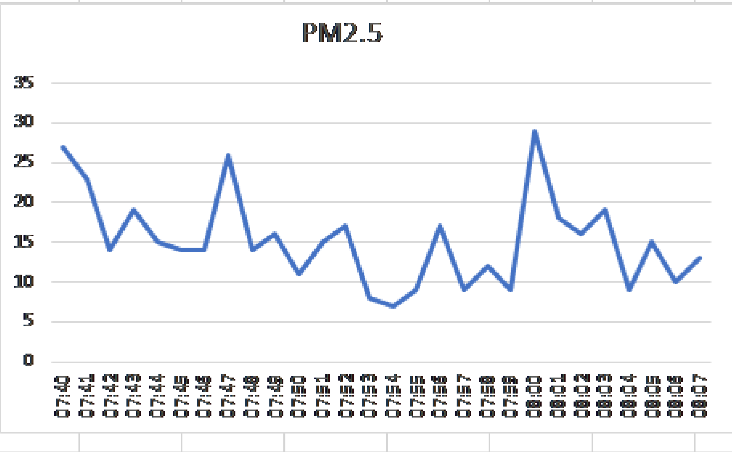


	Date:26/05/19			
	Morning			
1st	Time:		PM0.5	PM2.5
		07:11	285	28
		07:12	251	20
		07:13	282	23
		07:14	311	21
		07:15	282	17
		07:16	357	29
		07:17	353	21
		07:18	399	24
		07:19	397	23
		07:20	368	28
		07:21	459	31
		07:22	413	35
		07:23	545	40
		07:24	886	243
		07:25	828	224
		07:26	634	85
		07:27	517	69
		07:28	473	38
		07:29	533	40
		07:30	423	28
		07:31	378	28
		07:32	299	21
		07:33	304	22
		07:34	302	16
		07:35	289	14
		07:36	294	21
	Average:		417.7692	45.73077
2nd		07:40	319	27
		07:41	287	23
		07:42	200	14
		07:43	226	19
		07:44	164	15
		07:45	159	14
		07:46	167	14
		07:47	152	26
		07:48	116	14
		07:49	112	16
		07:50	116	11
		07:51	147	15
		07:52	156	17
		07:53	92	8
		07:54	124	7
		07:55	109	9
		07:56	256	17
		07:57	131	9
		07:58	143	12
		07:59	100	9
		08:00	151	29
		08:01	147	18
		08:02	103	16
		08:03	124	19
		08:04	124	9
		08:05	91	15
		08:06	78	10
		08:07	98	13
	Average:		149.7143	15.17857

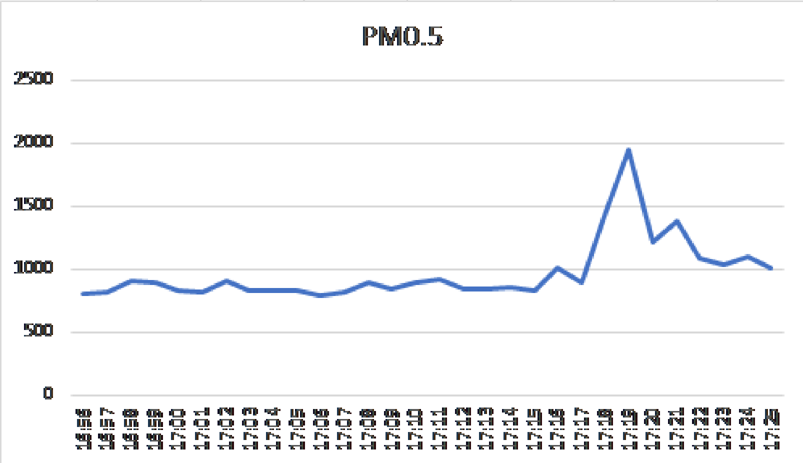


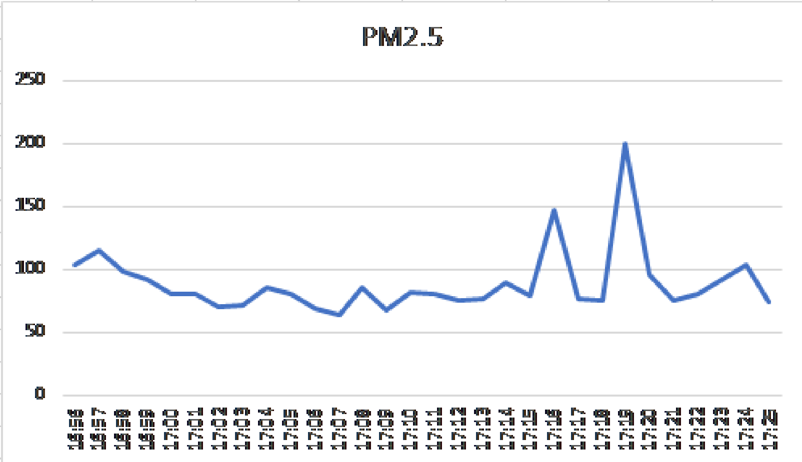


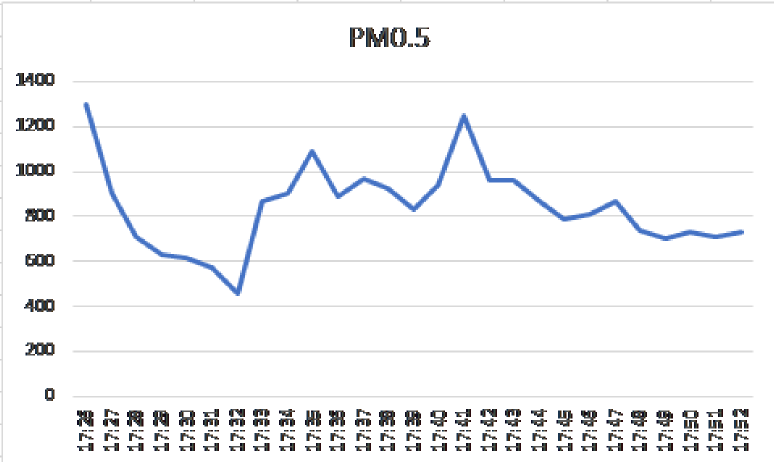


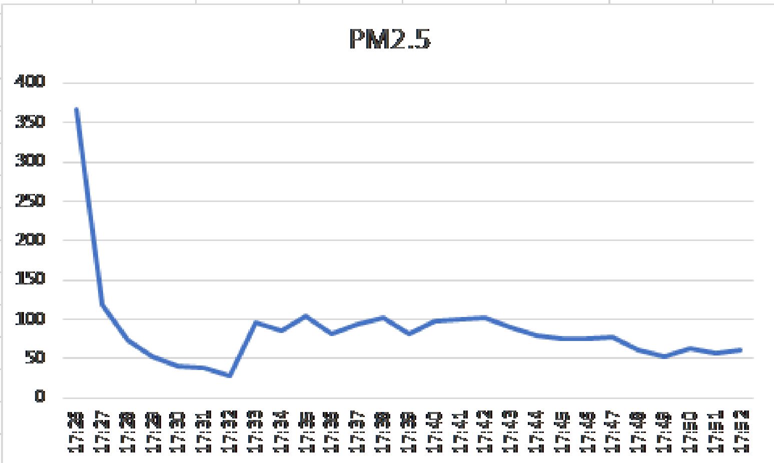


Evening			
1st	Time:	PM0.5	PM2.5
	16:56	807	103
	16:57	821	115
	16:58	911	99
	16:59	893	92
	17:00	826	80
	17:01	817	81
	17:02	909	70
	17:03	830	71
	17:04	829	86
	17:05	835	80
	17:06	788	69
	17:07	817	64
	17:08	901	85
	17:09	845	67
	17:10	899	82
	17:11	917	80
	17:12	838	75
	17:13	844	77
	17:14	850	89
	17:15	833	79
	17:16	1007	147
	17:17	900	77
	17:18	1454	75
	17:19	1947	200
	17:20	1218	96
	17:21	1382	75
	17:22	1082	80
	17:23	1035	92
	17:24	1101	104
	17:25	1011	74
	Average:	971.5667	88.8
2nd	17:26	1301	367
	17:27	900	118
	17:28	710	74
	17:29	627	53
	17:30	618	41
	17:31	575	38
	17:32	458	29
	17:33	866	96
	17:34	907	85
	17:35	1089	105
	17:36	891	82
	17:37	970	94
	17:38	927	102
	17:39	833	82
	17:40	943	98
	17:41	1251	101
	17:42	960	102
	17:43	962	89
	17:44	868	79
	17:45	791	76
	17:46	808	76
	17:47	865	78
	17:48	735	60
	17:49	702	52
	17:50	734	64
	17:51	712	56
	17:52	729	61
	Average:	841.9259	87.33333





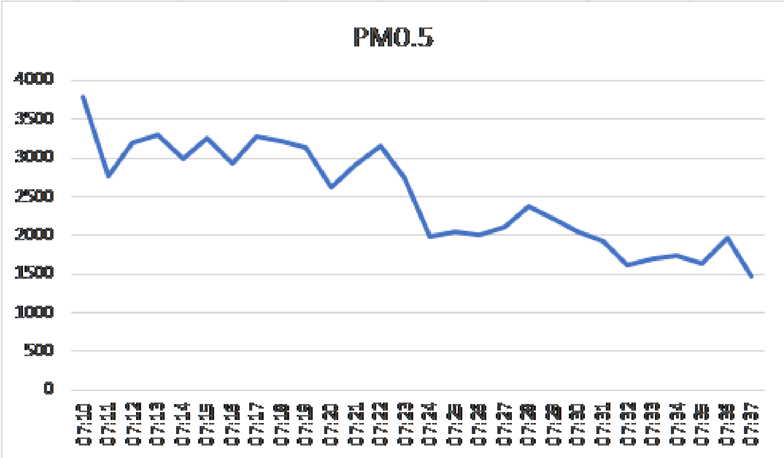


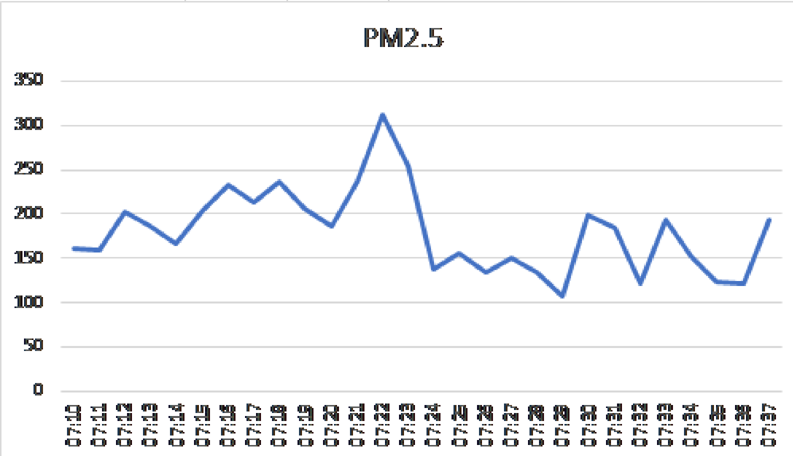


Date:28/05/19

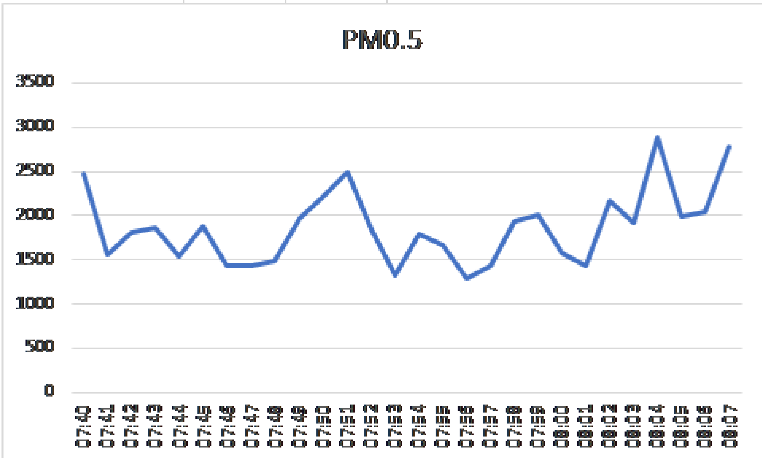
Morning

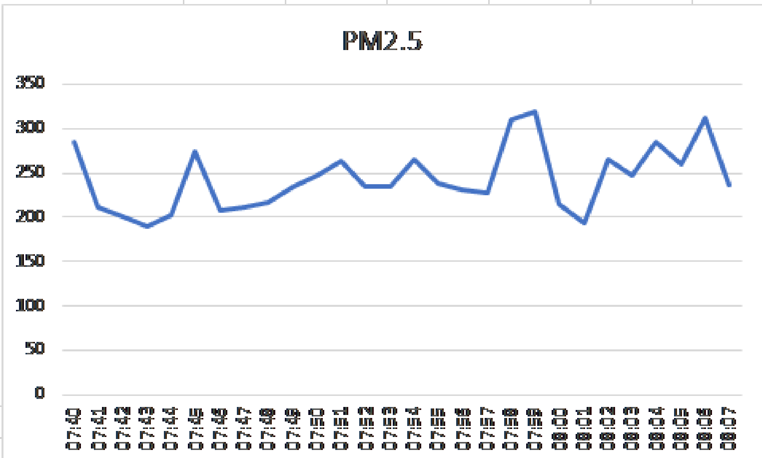
Time:	**PM0.5**	**PM2.5**
07:10	**3787**	**161**
07:11	2767	159
07:12	3208	203
07:13	3293	186
07:14	3001	166
07:15	3267	205
07:16	2930	233
07:17	3285	214
07:18	3217	236
07:19	3130	207
07:20	2625	187
07:21	2919	237
07:22	3150	313
07:23	2739	255
07:24	1982	138
07:25	2048	156
07:26	2012	135
07:27	2101	150
07:28	2384	134
07:29	2213	108
07:30	2041	199
07:31	1933	185
07:32	1615	121
07:33	1706	193
07:34	1745	152
07:35	1643	123
07:36	1970	122
07:37	1477	194
Average:	**2506.714**	**181.1429**



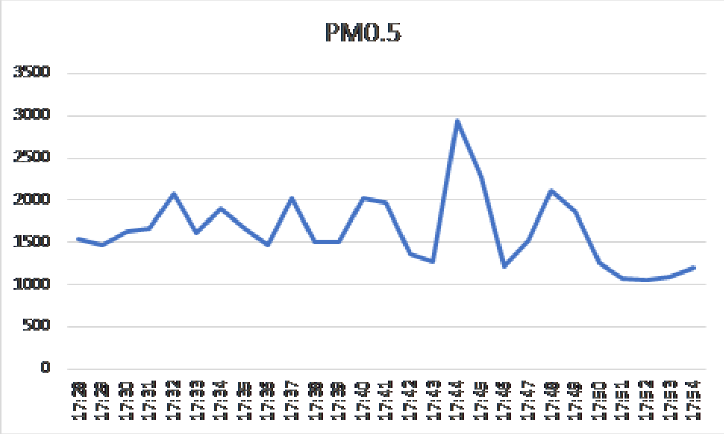


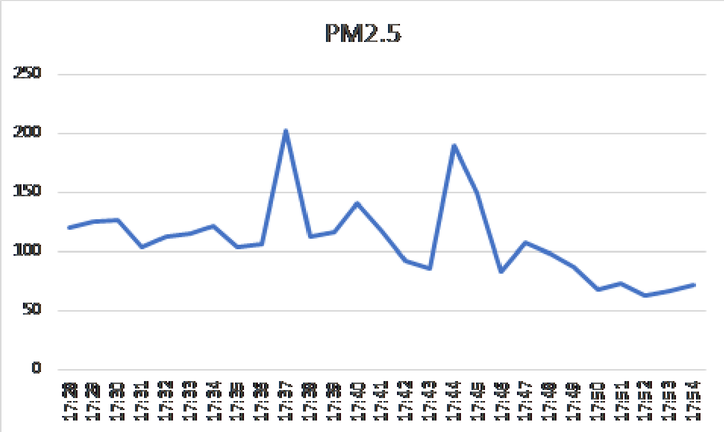
07:40	2483	285
07:41	1560	212
07:42	1810	201
07:43	1855	190
07:44	1536	202
07:45	1888	274
07:46	1433	208
07:47	1424	212
07:48	1492	217
07:49	1966	235
07:50	2217	247
07:51	2493	264
07:52	1838	234
07:53	1326	235
07:54	1785	265
07:55	1659	239
07:56	1295	232
07:57	1432	228
07:58	1928	311
07:59	2016	319
08:00	1574	216
08:01	1437	193
08:02	2167	265
08:03	1916	247
08:04	2880	286
08:05	1994	260
08:06	2035	312
08:07	2787	236
Average:	**1865.214**	**243.75**

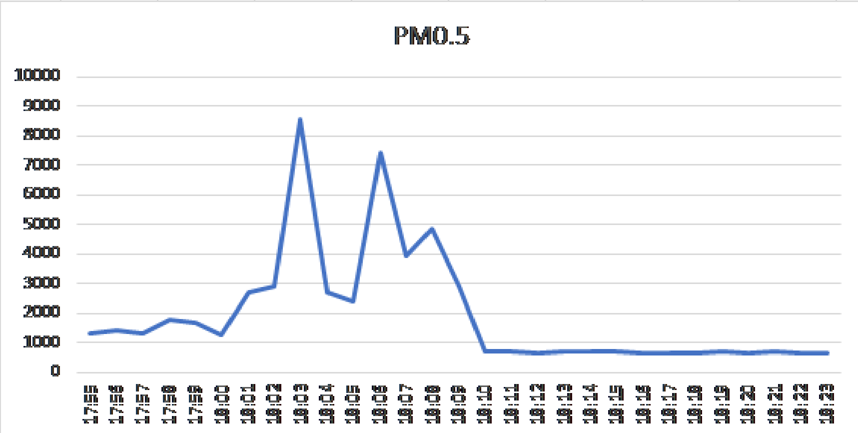


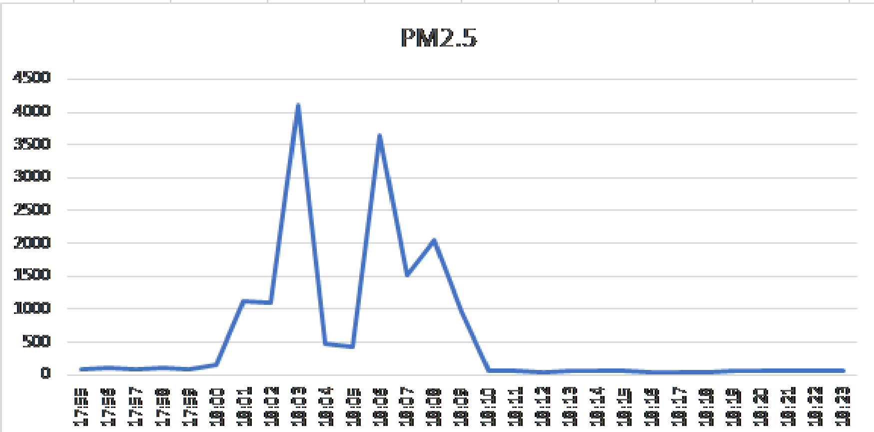


Evening			
1st	Time:	PM0.5	PM2.5
	17:28	1547	120
	17:29	1474	126
	17:30	1635	127
	17:31	1665	103
	17:32	2074	112
	17:33	1620	115
	17:34	1894	121
	17:35	1669	103
	17:36	1475	106
	17:37	2033	203
	17:38	1512	113
	17:39	1503	117
	17:40	2032	141
	17:41	1965	118
	17:42	1365	92
	17:43	1268	85
	17:44	2941	190
	17:45	2271	150
	17:46	1223	83
	17:47	1526	107
	17:48	2123	99
	17:49	1872	87
	17:50	1250	68
	17:51	1071	73
	17:52	1051	62
	17:53	1092	66
	17:54	1207	71
	Average:	1642.889	109.5556
2nd	17:55	1319	75
	17:56	1416	104
	17:57	1322	88
	17:58	1797	115
	17:59	1678	91
	18:00	1260	147
	18:01	2681	1132
	18:02	2932	1104
	18:03	8583	4112
	18:04	2728	471
	18:05	2385	421
	18:06	7415	3653
	18:07	3943	1507
	18:08	4847	2043
	18:09	2910	962
	18:10	700	65
	18:11	696	52
	18:12	669	47
	18:13	685	61
	18:14	692	52
	18:15	677	61
	18:16	671	50
	18:17	674	50
	18:18	632	50
	18:19	677	65
	18:20	658	53
	18:21	683	58
	18:22	654	55
	18:23	668	56
	Average:	1953.517	579.3103

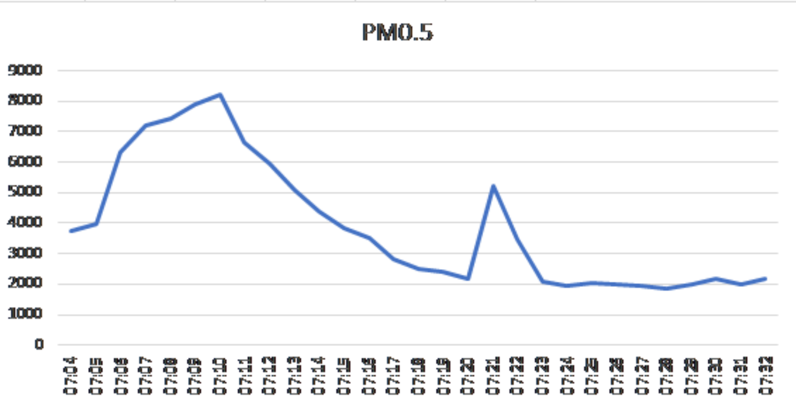


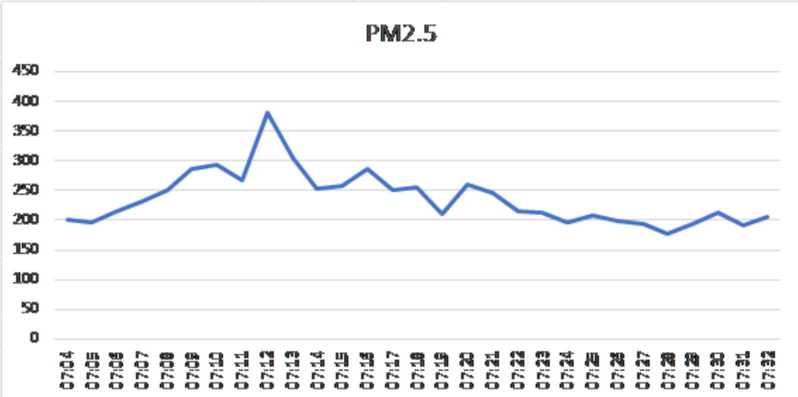


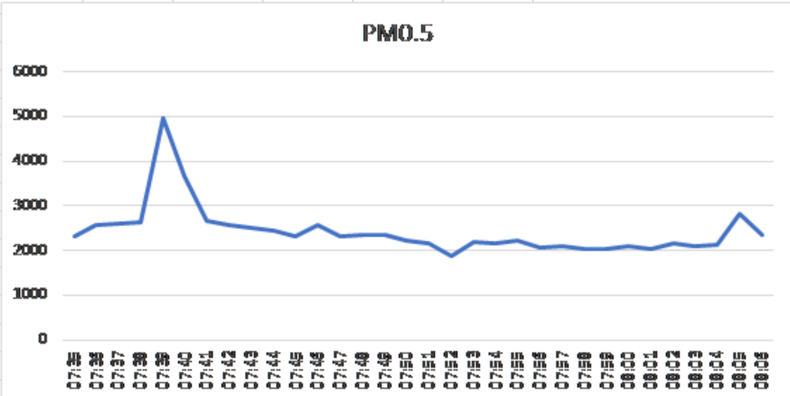


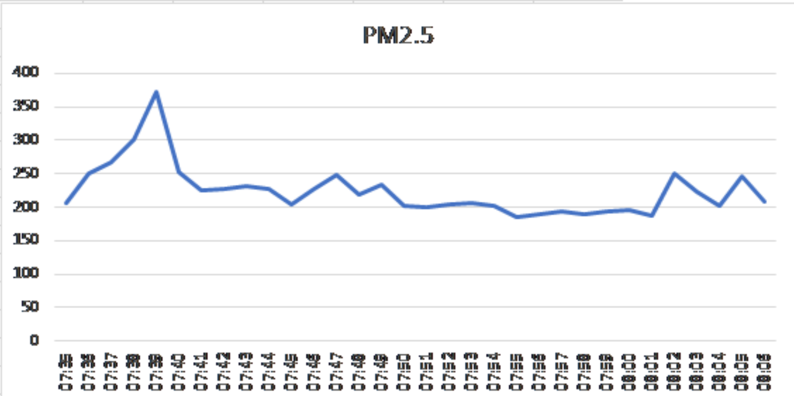


	Date:01/06/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:04	3768	201
	07:05	3959	196
	07:06	6326	215
	07:07	7188	232
	07:08	7428	252
	07:09	7911	287
	07:10	8235	294
	07:11	6672	268
	07:12	5944	382
	07:13	5089	305
	07:14	4404	254
	07:15	3824	259
	07:16	3505	287
	07:17	2806	250
	07:18	2509	255
	07:19	2421	210
	07:20	2193	261
	07:21	5230	247
	07:22	3450	215
	07:23	2078	214
	07:24	1960	196
	07:25	2043	208
	07:26	1976	198
	07:27	1930	193
	07:28	1863	177
	07:29	2009	195
	07:30	2196	213
	07:31	2009	192
	07:32	2192	206
	Average:	3900.621	236.6207
	07:35	2329	207
	07:36	2575	251
	07:37	2601	267
	07:38	2618	300
	07:39	4954	373
	07:40	3686	253
	07:41	2668	225
	07:42	2556	227
	07:43	2505	232
	07:44	2443	228
	07:45	2329	204
	07:46	2562	228
	07:47	2319	248
	07:48	2350	219
	07:49	2359	233
	07:50	2224	203
	07:51	2163	200
	07:52	1885	205
	07:53	2184	206
	07:54	2147	202
	07:55	2239	185
	07:56	2081	190
	07:57	2098	194
	07:58	2037	190
	07:59	2033	194
	08:00	2112	196
	08:01	2028	187
	08:02	2158	250
	08:03	2109	224
	08:04	2137	202
	08:05	2838	246
	08:06	2360	208
	Average:	2427.719	224.2813

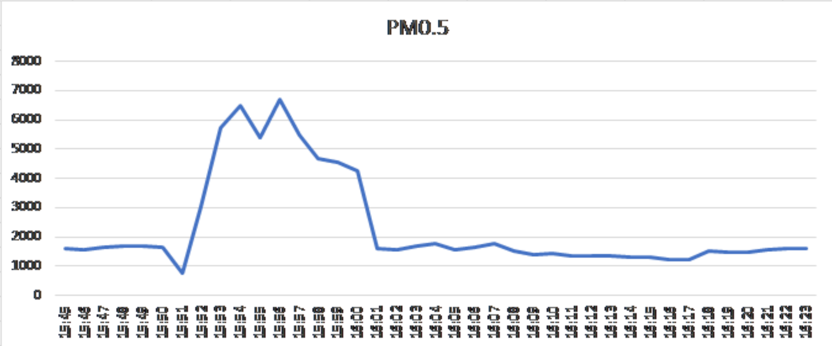


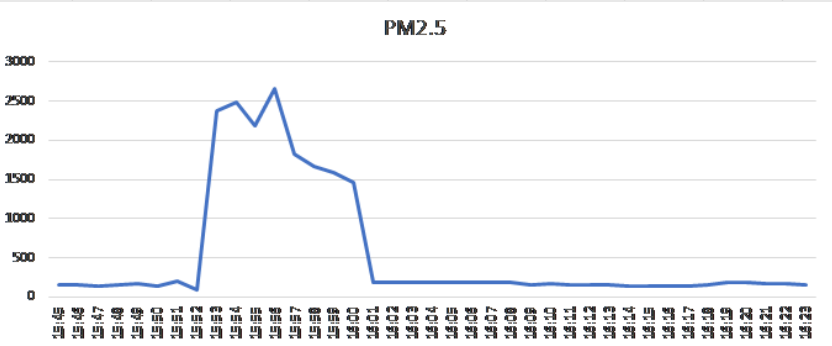


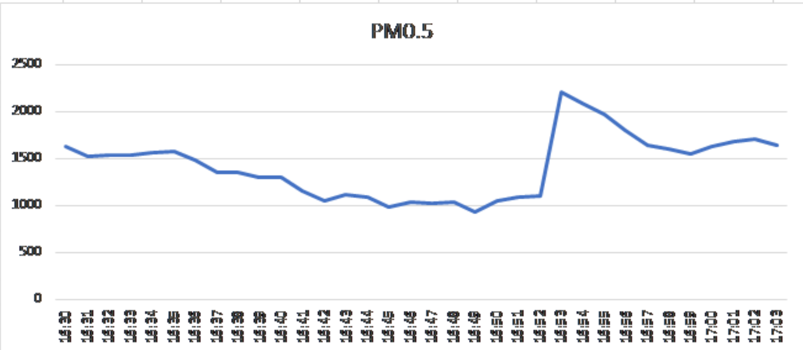


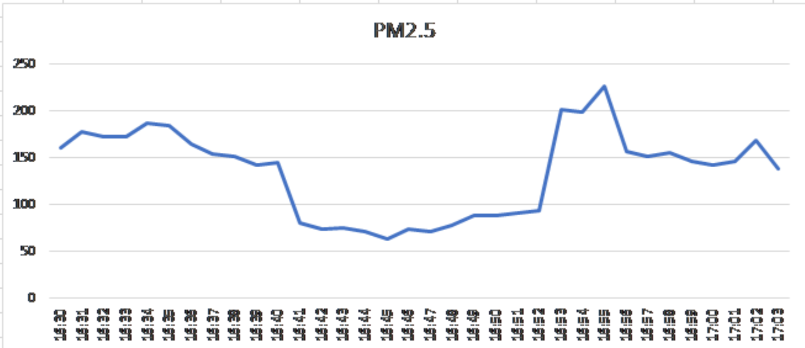


Evening			
1st	Time:	PM0.5	PM2.5
	15:45	1609	156
	15:46	1557	147
	15:47	1625	143
	15:48	1685	147
	15:49	1706	169
	15:50	1643	139
	15:51	778	206
	15:52	3032	87
	15:53	5734	2371
	15:54	6470	2480
	15:55	5405	2187
	15:56	6689	2660
	15:57	5489	1825
	15:58	4696	1666
	15:59	4562	1579
	16:00	4244	1456
	16:01	1609	189
	16:02	1567	187
	16:03	1672	188
	16:04	1765	178
	16:05	1545	182
	16:06	1639	178
	16:07	1763	184
	16:08	1502	181
	16:09	1383	152
	16:10	1439	164
	16:11	1345	156
	16:12	1354	158
	16:13	1365	160
	16:14	1298	143
	16:15	1287	141
	16:16	1234	139
	16:17	1207	138
	16:18	1503	152
	16:19	1489	185
	16:20	1487	184
	16:21	1563	173
	16:22	1623	165
	16:23	1606	160
	Average:	2337.667	545
2nd	16:30	1626	161
	16:31	1530	178
	16:32	1535	172
	16:33	1537	173
	16:34	1563	187
	16:35	1574	185
	16:36	1483	165
	16:37	1352	154
	16:38	1349	151
	16:39	1295	142
	16:40	1303	145
	16:41	1154	81
	16:42	1052	74
	16:43	1120	75
	16:44	1093	71
	16:45	983	63
	16:46	1037	74
	16:47	1028	71
	16:48	1042	78
	16:49	935	88
	16:50	1053	89
	16:51	1085	91
	16:52	1107	94
	16:53	2214	202
	16:54	2093	199
	16:55	1975	227
	16:56	1803	157
	16:57	1641	151
	16:58	1609	156
	16:59	1557	147
	17:00	1625	143
	17:01	1685	147
	17:02	1706	169
	17:03	1643	139
	Average:	1423.147	135.2647

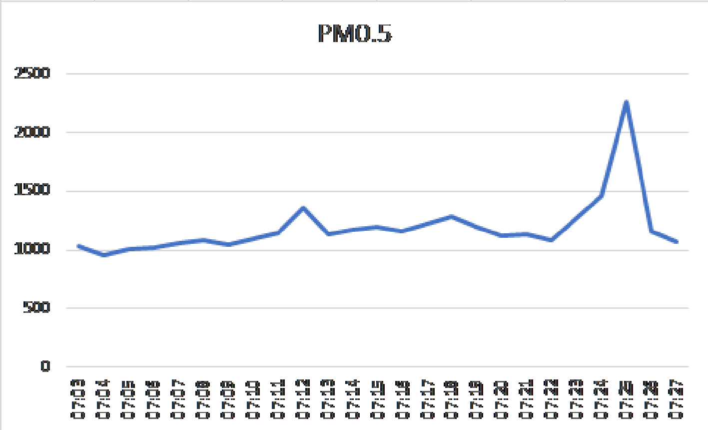


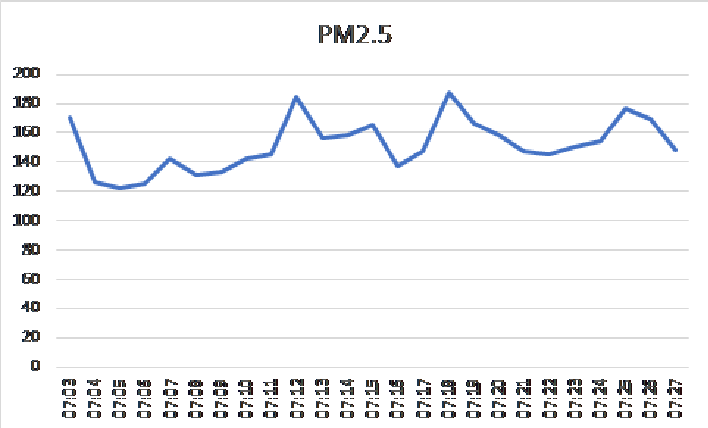


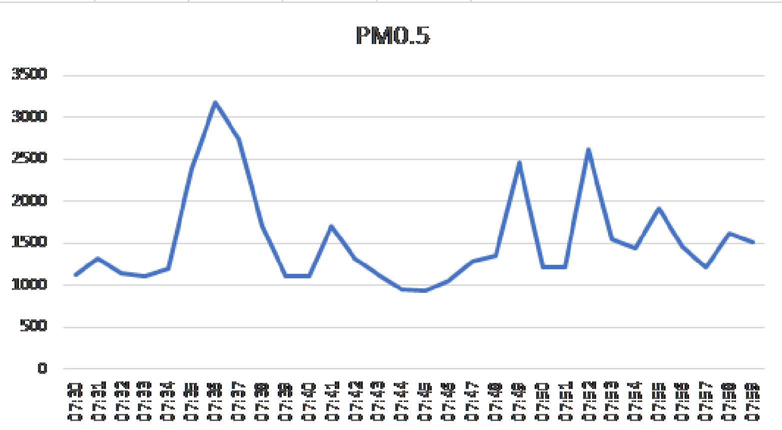


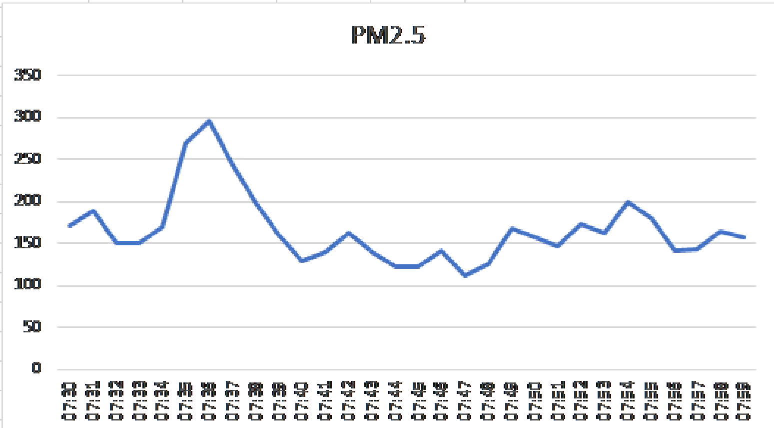


	Date:19/06/19		
	Morning		
1st	**Time:**	**PM0.5**	**PM2.5**
	07:03	1031	171
	07:04	951	126
	07:05	1001	122
	07:06	1017	125
	07:07	1063	142
	07:08	1080	131
	07:09	1042	133
	07:10	1091	142
	07:11	1142	145
	07:12	1360	185
	07:13	1132	156
	07:14	1169	158
	07:15	1190	166
	07:16	1152	137
	07:17	1222	147
	07:18	1279	188
	07:19	1198	167
	07:20	1116	158
	07:21	1139	147
	07:22	1086	145
	07:23	1276	150
	07:24	1464	154
	07:25	2259	177
	07:26	1156	170
	07:27	1064	148
	Average:	**1187.2**	**151.6**
2nd	**07:30**	1120	171
	07:31	1323	189
	07:32	1143	151
	07:33	1104	150
	07:34	1198	169
	07:35	2399	269
	07:36	3188	296
	07:37	2748	243
	07:38	1700	198
	07:39	1116	161
	07:40	1106	129
	07:41	1701	139
	07:42	1326	162
	07:43	1125	140
	07:44	948	122
	07:45	928	122
	07:46	1061	142
	07:47	1288	112
	07:48	1347	126
	07:49	2455	168
	07:50	1213	158
	07:51	1210	147
	07:52	2619	173
	07:53	1555	163
	07:54	1438	199
	07:55	1915	180
	07:56	1454	141
	07:57	1211	144
	07:58	1622	164
	07:59	1510	157
	Average:	**1535.7**	**166.1667**

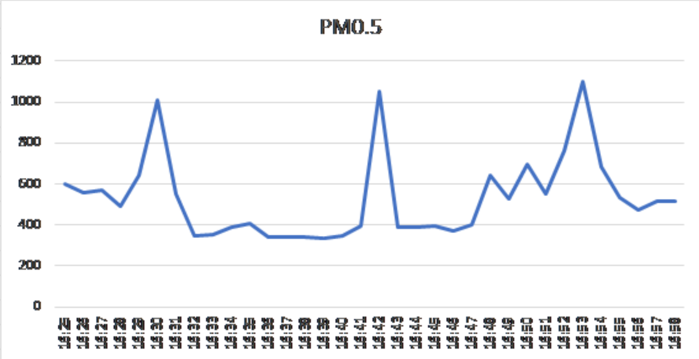


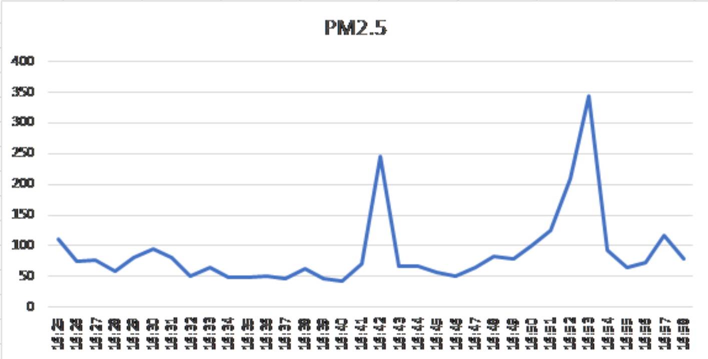


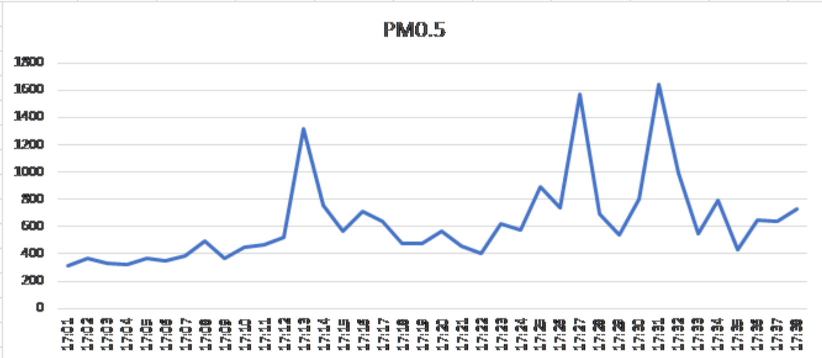


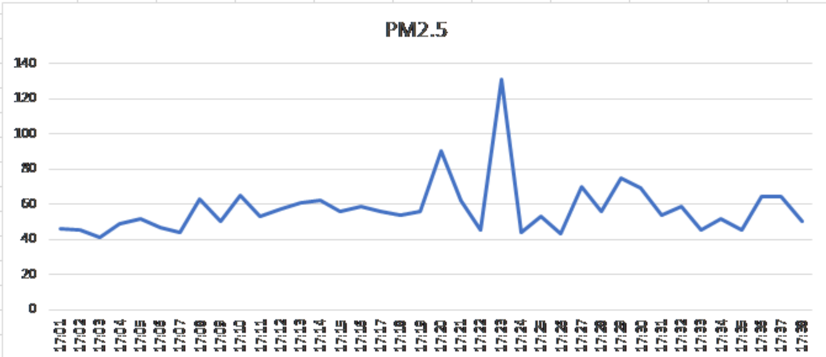


Evening			
1st	Time:	PM0.5	PM2.5
	16:25	602	111
	16:26	555	75
	16:27	571	77
	16:28	489	58
	16:29	644	80
	16:30	1008	95
	16:31	554	81
	16:32	346	51
	16:33	350	65
	16:34	391	49
	16:35	409	49
	16:36	343	51
	16:37	338	47
	16:38	343	63
	16:39	333	47
	16:40	348	42
	16:41	392	70
	16:42	1054	245
	16:43	389	67
	16:44	391	67
	16:45	395	57
	16:46	370	51
	16:47	400	64
	16:48	639	82
	16:49	527	79
	16:50	694	100
	16:51	549	125
	16:52	761	210
	16:53	1102	344
	16:54	682	92
	16:55	536	64
	16:56	476	72
	16:57	518	117
	16:58	515	79
	Average:	529.8235	89
2nd	17:01	447	61
	17:02	310	46
	17:03	364	45
	17:04	334	41
	17:05	319	49
	17:06	365	52
	17:07	352	47
	17:08	382	44
	17:09	498	63
	17:10	370	50
	17:11	450	65
	17:12	464	53
	17:13	520	57
	17:14	1314	61
	17:15	759	62
	17:16	568	56
	17:17	710	59
	17:18	638	56
	17:19	479	54
	17:20	472	56
	17:21	569	90
	17:22	462	62
	17:23	405	45
	17:24	623	131
	17:25	575	44
	17:26	890	53
	17:27	738	43
	17:28	1574	70
	17:29	693	56
	17:30	536	75
	17:31	801	69
	17:32	1645	54
	17:33	988	59
	17:34	550	45
	17:35	792	52
	17:36	435	45
	17:37	652	64
	17:38	642	64
	17:39	726	50
	Average:	625.9231	57.64103

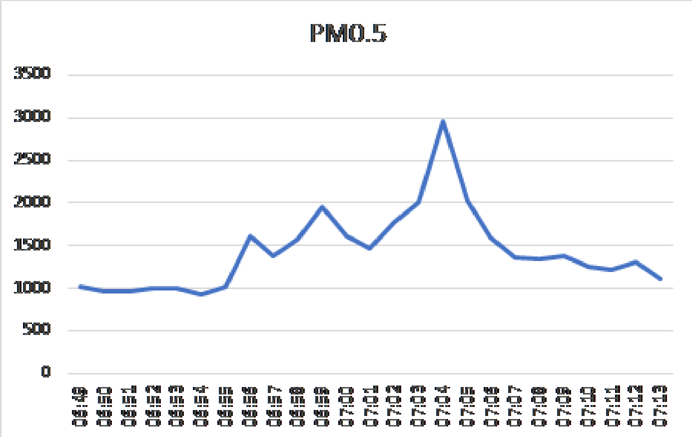


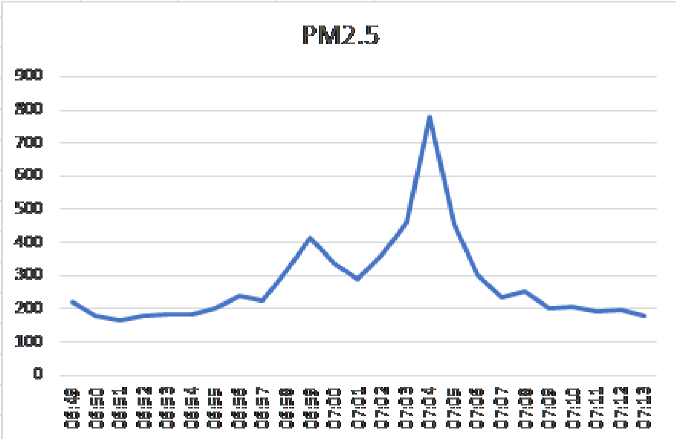


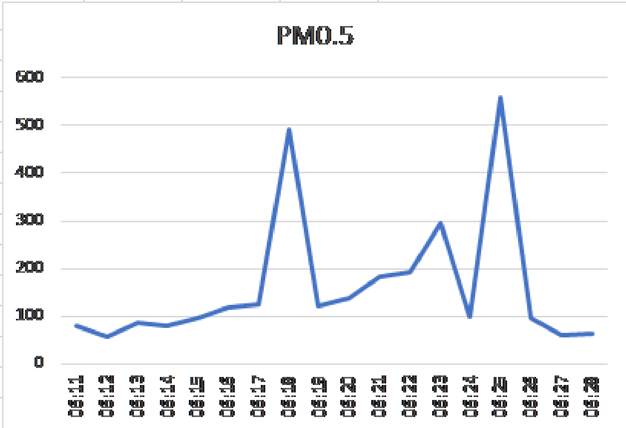


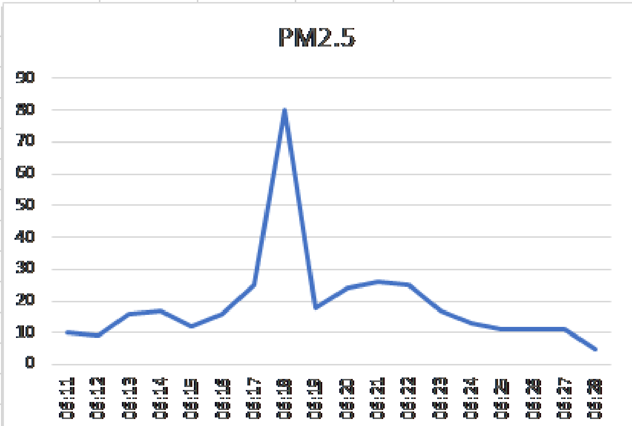


	Date:20/06/19		
	Morning		
2nd	Time:	PM0.5	PM2.5
	06:49	1021	219
	06:50	956	181
	06:51	970	166
	06:52	998	180
	06:53	1007	184
	06:54	933	183
	06:55	1020	201
	06:56	1608	240
	06:57	1381	226
	06:58	1576	317
	06:59	1957	414
	07:00	1603	334
	07:01	1476	290
	07:02	1766	364
	07:03	2014	463
	07:04	2956	781
	07:05	2034	455
	07:06	1587	303
	07:07	1368	232
	07:08	1336	255
	07:09	1387	201
	07:10	1247	206
	07:11	1209	191
	07:12	1300	199
	07:13	1108	178
	Average:	1432.72	278.52
1st	06:11	79	10
	06:12	56	9
	06:13	87	16
	06:14	79	17
	06:15	96	12
	06:16	117	16
	06:17	124	25
	06:18	493	80
	06:19	121	18
	06:20	138	24
	06:21	184	26
	06:22	191	25
	06:23	294	17
	06:24	100	13
	06:25	560	11
	06:26	97	11
	06:27	61	11
	06:28	64	5
	Average:	163.3889	19.22222
	not complete		

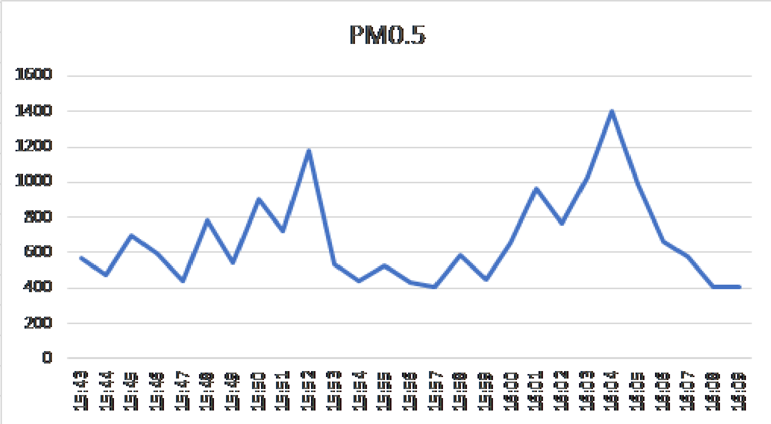


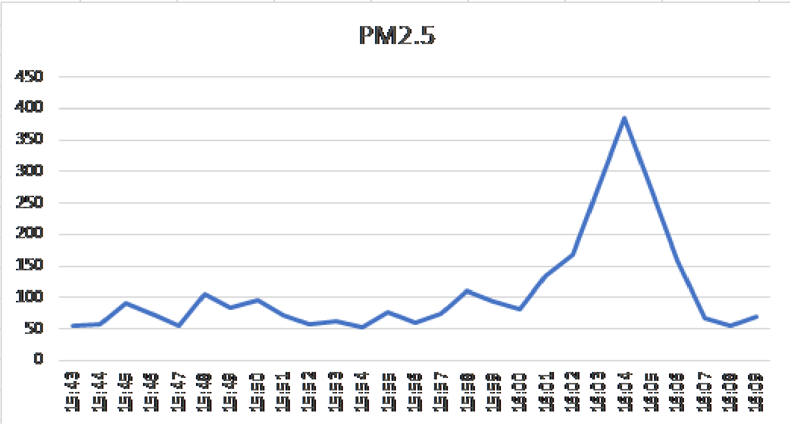


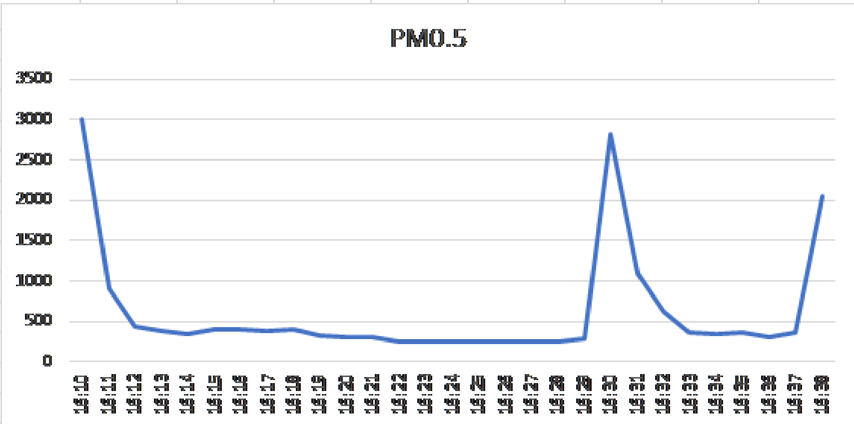


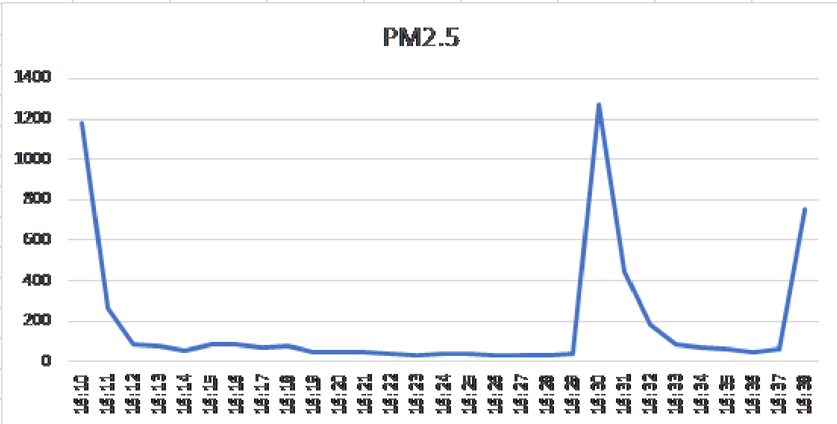


Evening			
1st	Time:	PM0.5	PM2.5
	15:43	571	56
	15:44	476	57
	15:45	696	90
	15:46	594	73
	15:47	443	56
	15:48	785	106
	15:49	540	84
	15:50	908	95
	15:51	726	71
	15:52	1182	57
	15:53	534	63
	15:54	438	52
	15:55	523	77
	15:56	435	59
	15:57	410	75
	15:58	586	110
	15:59	451	94
	16:00	657	81
	16:01	966	134
	16:02	767	169
	16:03	1031	276
	16:04	1403	385
	16:05	994	270
	16:06	666	158
	16:07	581	68
	16:08	407	54
	16:09	406	70
	Average:	673.1852	108.8889
2nd	16:10	3001	1182
	16:11	903	268
	16:12	435	86
	16:13	389	78
	16:14	344	55
	16:15	405	84
	16:16	402	87
	16:17	380	67
	16:18	399	78
	16:19	322	50
	16:20	314	50
	16:21	311	49
	16:22	243	38
	16:23	256	36
	16:24	255	44
	16:25	252	43
	16:26	245	33
	16:27	254	31
	16:28	240	30
	16:29	278	42
	16:30	2828	1271
	16:31	1098	448
	16:32	620	181
	16:33	370	84
	16:34	339	71
	16:35	360	63
	16:36	314	50
	16:37	355	63
	16:38	2054	756
	Average:	619.5172	186.8276

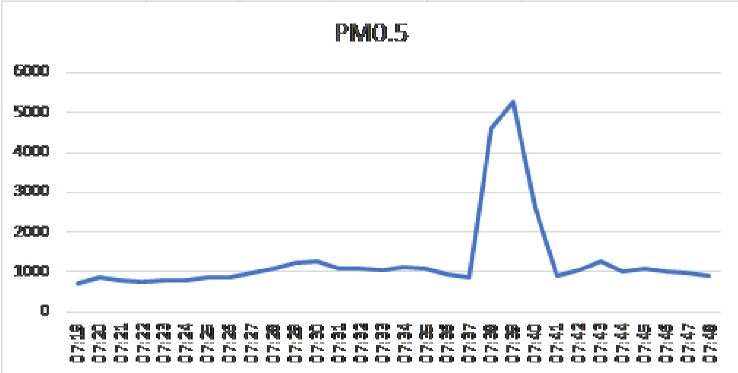


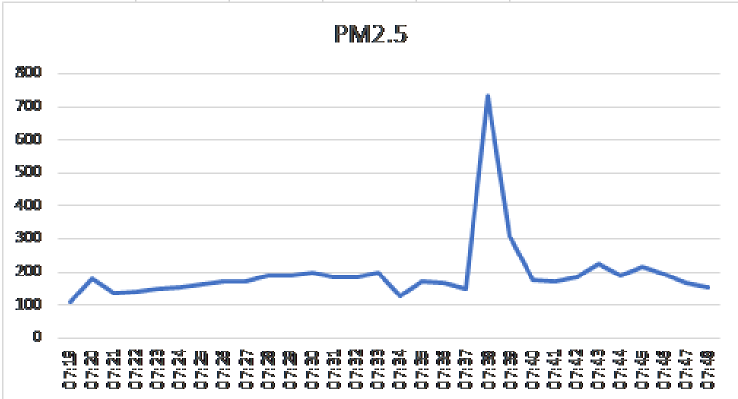


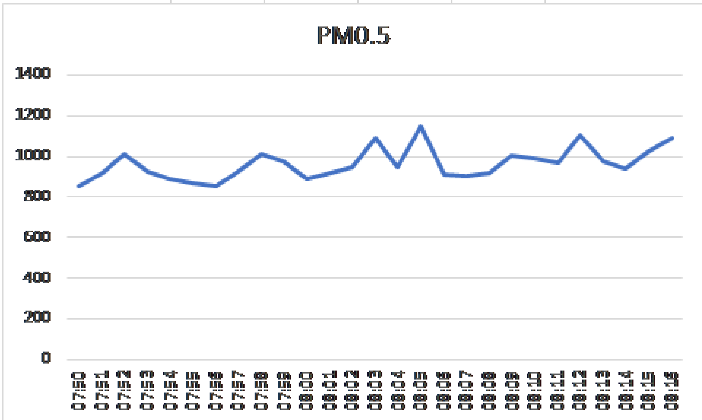


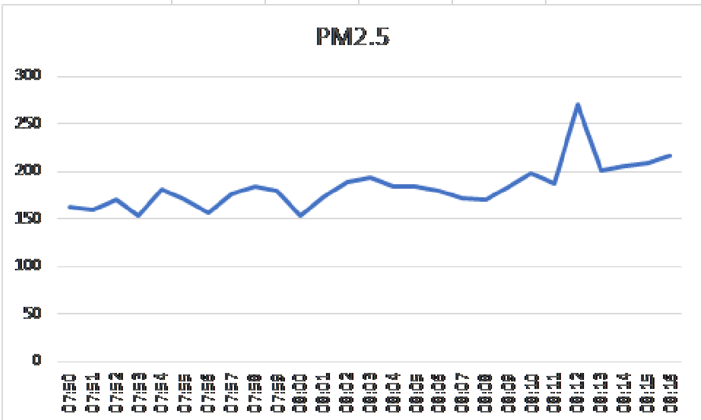


	Date:21/06/19		
	Morning		
	Time:	**PM0.5**	**PM2.5**
	07:19	724	110
	07:20	861	180
	07:21	795	138
	07:22	775	142
	07:23	803	147
	07:24	788	153
	07:25	863	163
	07:26	866	173
	07:27	975	172
	07:28	1074	189
	07:29	1241	187
	07:30	1265	197
	07:31	1089	183
	07:32	1093	183
	07:33	1064	200
	07:34	1134	128
	07:35	1103	172
	07:36	954	168
	07:37	858	147
	07:38	4621	733
	07:39	5278	309
	07:40	2636	176
	07:41	894	172
	07:42	1065	185
	07:43	1281	225
	07:44	1018	191
	07:45	1089	215
	07:46	1009	193
	07:47	990	169
	07:48	905	152
	Average:	**1303.7**	**195.0667**
2nd	07:50	856	163
	07:51	918	159
	07:52	1010	170
	07:53	925	153
	07:54	887	182
	07:55	866	171
	07:56	855	156
	07:57	926	177
	07:58	1008	185
	07:59	976	179
	08:00	891	153
	08:01	920	173
	08:02	949	189
	08:03	1089	194
	08:04	946	184
	08:05	1146	184
	08:06	908	180
	08:07	903	172
	08:08	917	170
	08:09	1006	184
	08:10	991	199
	08:11	967	188
	08:12	1104	271
	08:13	974	202
	08:14	937	206
	08:15	1024	209
	08:16	1094	216
	Average:	**962.7037**	**184.037**

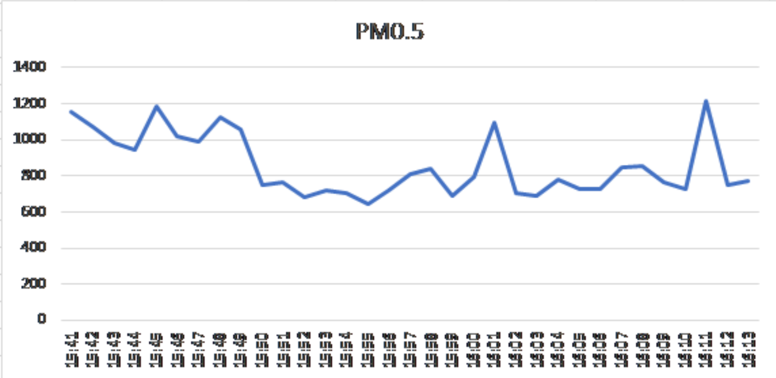


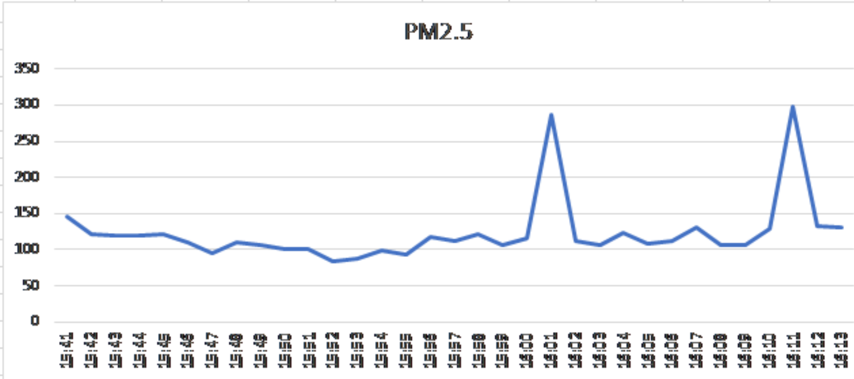


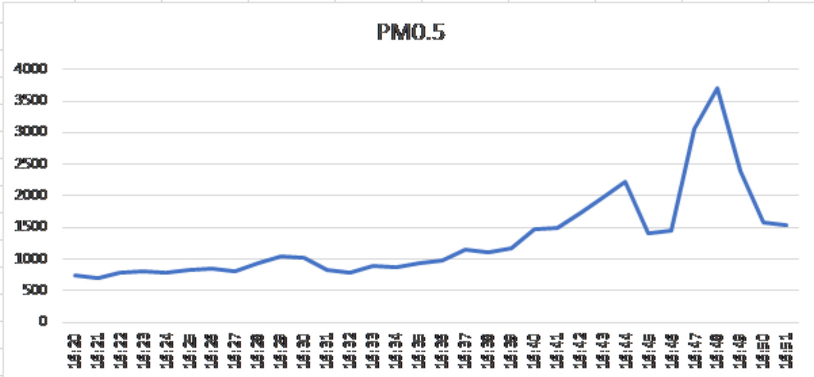


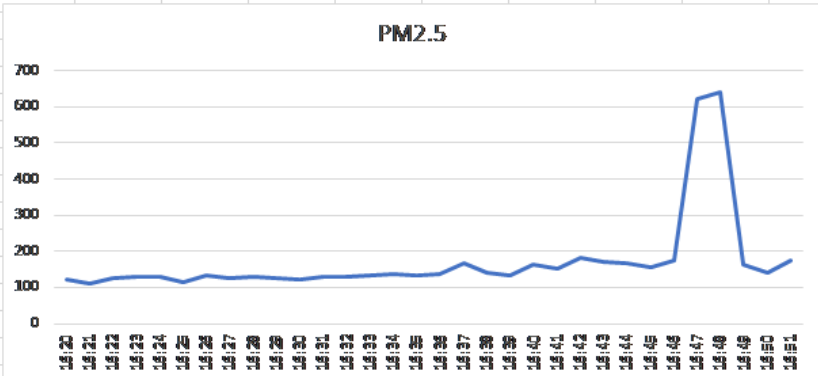


Evening			
1st	Time:	PM0.5	PM2.5
	15:41	1152	146
	15:42	1071	122
	15:43	981	119
	15:44	944	120
	15:45	1182	121
	15:46	1024	110
	15:47	991	96
	15:48	1127	111
	15:49	1060	107
	15:50	752	101
	15:51	768	101
	15:52	683	84
	15:53	718	87
	15:54	703	99
	15:55	647	93
	15:56	719	117
	15:57	809	113
	15:58	837	121
	15:59	692	107
	16:00	799	116
	16:01	1092	287
	16:02	702	112
	16:03	689	107
	16:04	780	124
	16:05	727	108
	16:06	731	112
	16:07	848	131
	16:08	858	106
	16:09	765	107
	16:10	728	129
	16:11	1219	298
	16:12	747	132
	16:13	772	131
	Average:	858.0909	123.4848
2nd	16:20	742	122
	16:21	708	112
	16:22	788	127
	16:23	809	128
	16:24	795	130
	16:25	824	116
	16:26	856	133
	16:27	803	125
	16:28	930	128
	16:29	1049	125
	16:30	1013	123
	16:31	832	130
	16:32	791	128
	16:33	899	132
	16:34	879	137
	16:35	940	135
	16:36	980	136
	16:37	1143	166
	16:38	1106	141
	16:39	1169	135
	16:40	1471	164
	16:41	1489	151
	16:42	1740	183
	16:43	1971	172
	16:44	2231	167
	16:45	1416	157
	16:46	1449	176
	16:47	3069	620
	16:48	3695	639
	16:49	2398	164
	16:50	1580	141
	16:51	1539	175
	Average:	1315.75	172.4375





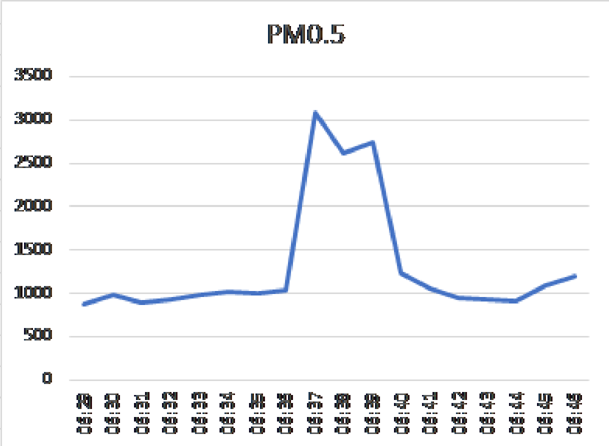


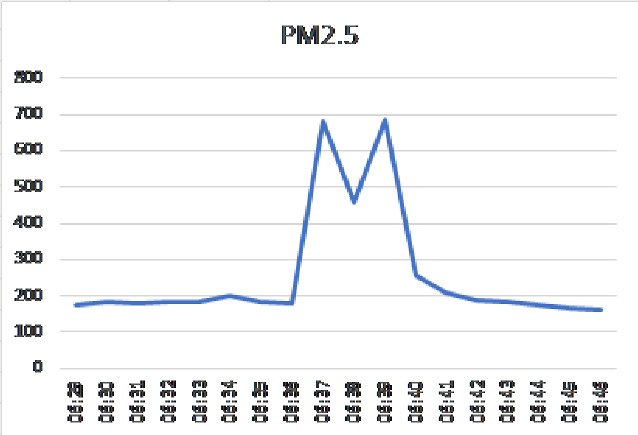


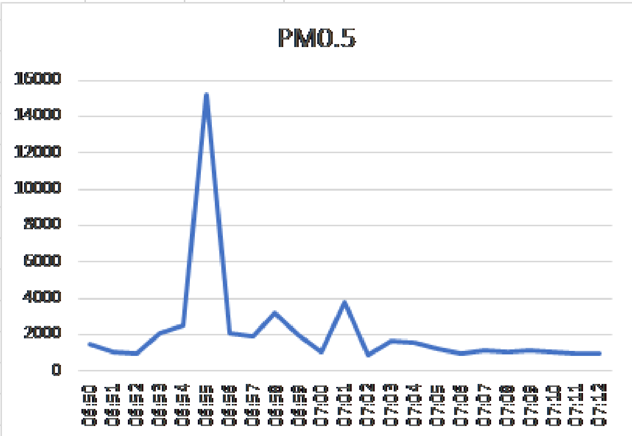
Date:26/06/19

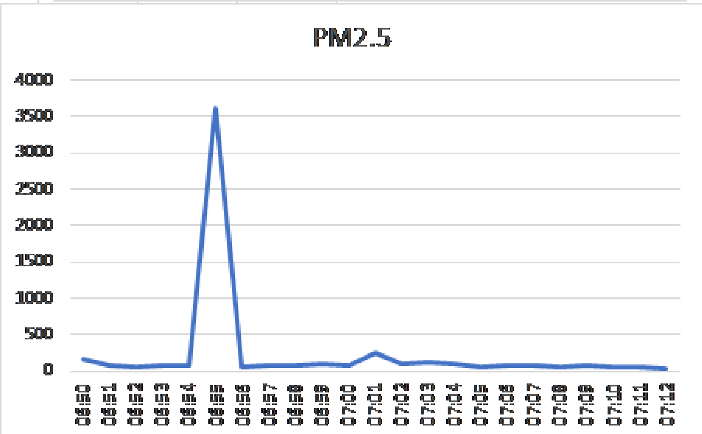
Morning

	Time:	PM0.5	PM2.5
	06:29	868	177
	06:30	982	185
	06:31	892	180
	06:32	933	183
	06:33	987	183
	06:34	1012	201
	06:35	995	185
	06:36	1036	180
	06:37	3083	682
	06:38	2612	458
	06:39	2750	686
	06:40	1240	257
	06:41	1053	210
	06:42	950	187
	06:43	929	184
	06:44	907	174
	06:45	1094	167
	06:46	1206	163
	Average:	**1307.167**	**257.8889**
2nd	06:50	1430	161
	06:51	1057	83
	06:52	966	60
	06:53	2104	76
	06:54	2534	74
	06:55	15221	3624
	06:56	2072	64
	06:57	1900	75
	06:58	3172	76
	06:59	1968	90
	07:00	1039	78
	07:01	3765	245
	07:02	891	109
	07:03	1657	120
	07:04	1548	89
	07:05	1189	65
	07:06	934	75
	07:07	1137	69
	07:08	1003	63
	07:09	1155	81
	07:10	1004	46
	07:11	959	49
	07:12	919	42
	Average:	**2157.565**	**239.7391**

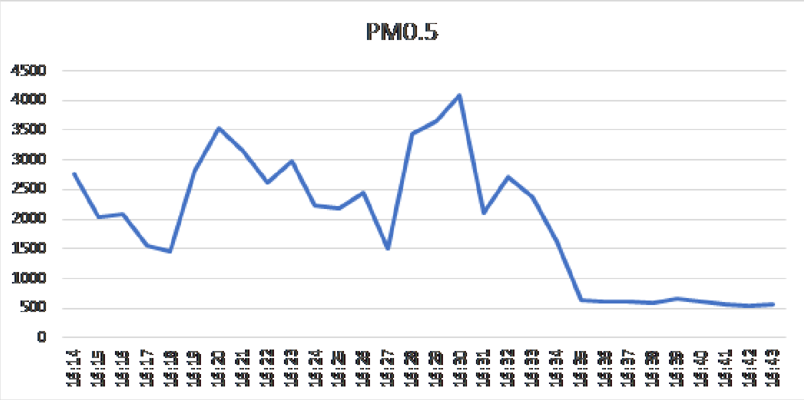


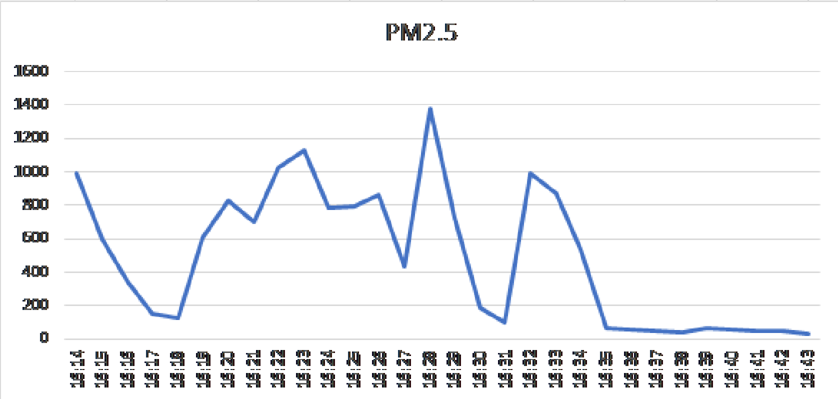


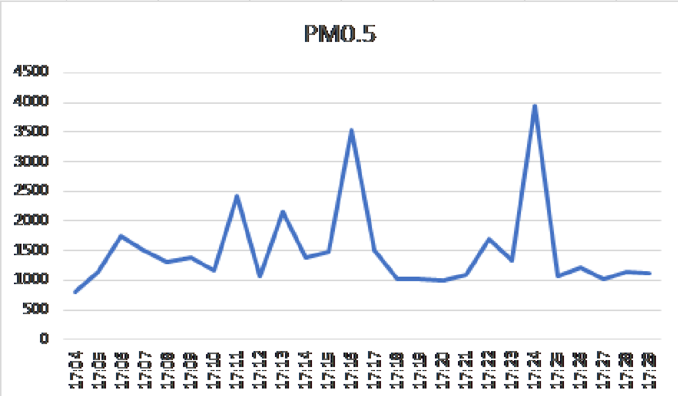


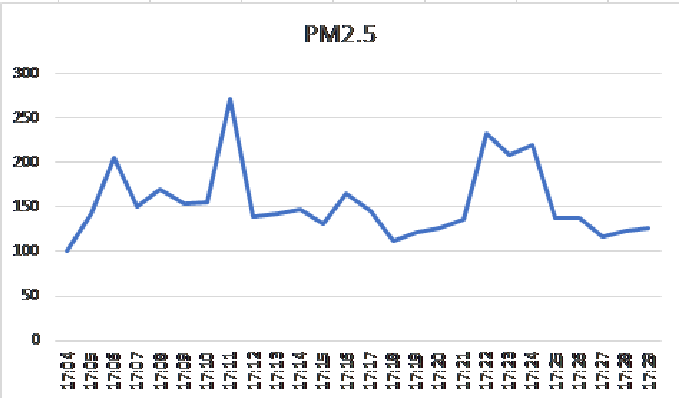


Evening			
1st	Time:	PM0.5	PM2.5
	16:14	2765	993
	16:15	2030	598
	16:16	2084	338
	16:17	1562	148
	16:18	1459	125
	16:19	2802	606
	16:20	3545	826
	16:21	3156	702
	16:22	2622	1023
	16:23	2976	1128
	16:24	2222	788
	16:25	2180	793
	16:26	2444	862
	16:27	1500	436
	16:28	3439	1378
	16:29	3656	725
	16:30	4084	187
	16:31	2109	98
	16:32	2713	994
	16:33	2373	875
	16:34	1640	540
	16:35	642	61
	16:36	621	54
	16:37	607	45
	16:38	584	40
	16:39	670	66
	16:40	623	57
	16:41	570	49
	16:42	542	45
	16:43	557	33
	Average:	1959.233	487.1
2nd	17:04	798	100
	17:05	1131	143
	17:06	1741	205
	17:07	1510	151
	17:08	1299	170
	17:09	1373	154
	17:10	1173	156
	17:11	2418	272
	17:12	1066	140
	17:13	2153	143
	17:14	1393	148
	17:15	1481	132
	17:16	3542	165
	17:17	1492	145
	17:18	1012	112
	17:19	1012	121
	17:20	987	126
	17:21	1104	136
	17:22	1696	233
	17:23	1337	208
	17:24	3939	220
	17:25	1074	138
	17:26	1209	138
	17:27	1011	116
	17:28	1143	123
	17:29	1115	127
	Average:	1508.038	154.6923

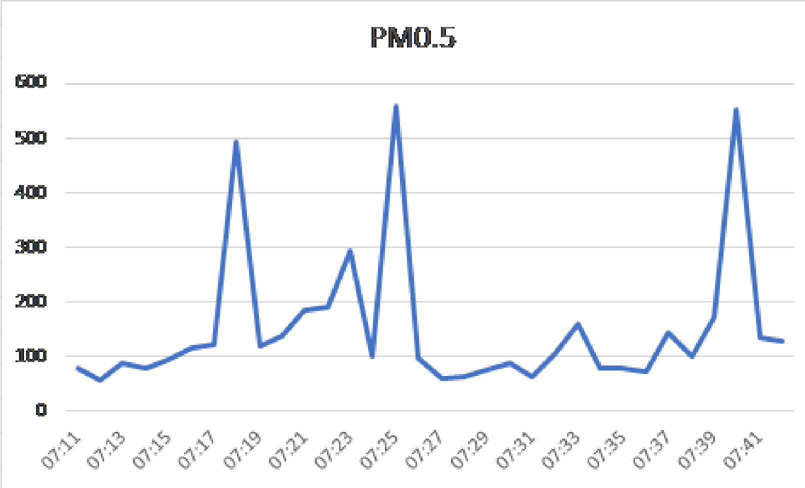


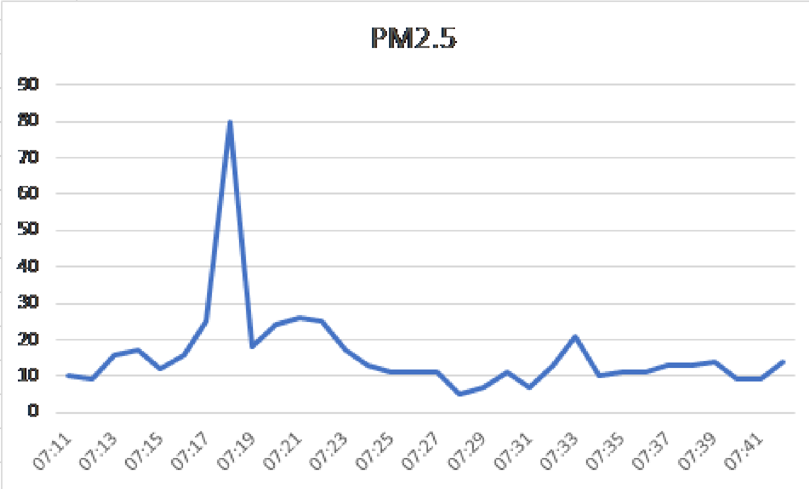




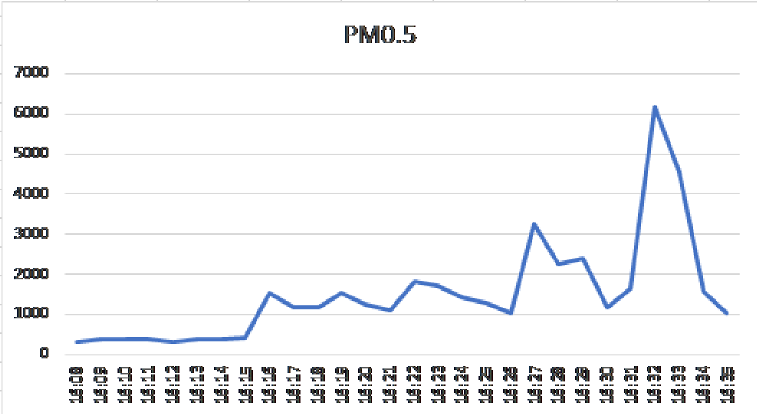


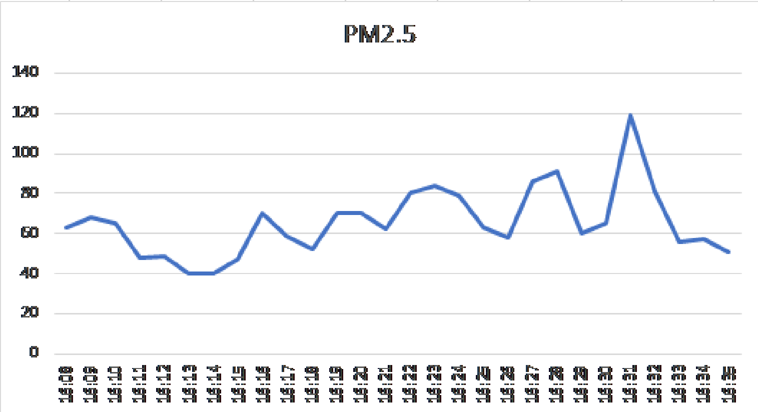
	Date:01/07/19	Temp:	
	Morning		
1st	Time:	PM0.5	PM2.5
	07:11	79	10
	07:12	56	9
	07:13	87	16
	07:14	79	17
	07:15	96	12
	07:16	117	16
	07:17	124	25
	07:18	493	80
	07:19	121	18
	07:20	138	24
	07:21	184	26
	07:22	191	25
	07:23	294	17
	07:24	100	13
	07:25	560	11
	07:26	97	11
	07:27	61	11
	07:28	64	5
	07:29	75	7
	07:30	88	11
	07:31	65	7
	07:32	104	13
	07:33	161	21
	07:34	80	10
	07:35	79	11
	07:36	73	11
	07:37	145	13
	07:38	102	13
	07:39	172	14
	07:40	552	9
	07:41	136	9
	07:42	128	14
	Average:	153.1563	15.90625
2nd	no data		

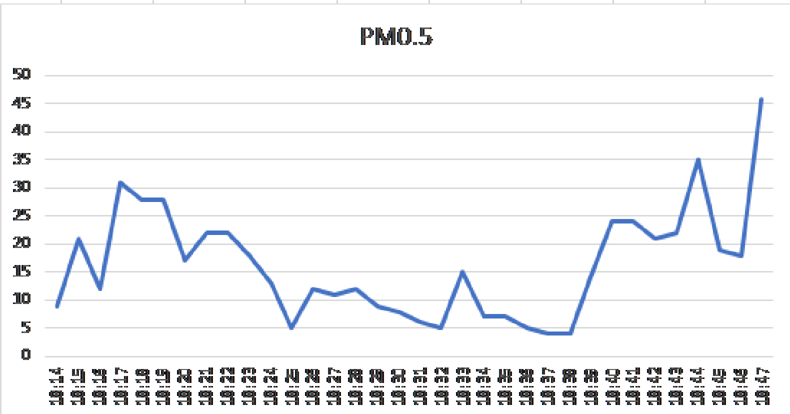


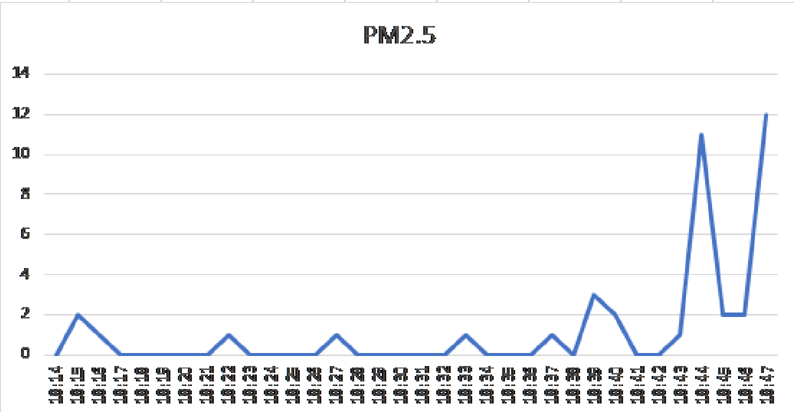


Evening			
1st	Time:	PM0.5	PM2.5
	16:08	315	63
	16:09	399	68
	16:10	389	65
	16:11	373	48
	16:12	330	49
	16:13	392	40
	16:14	398	40
	16:15	416	47
	16:16	1540	70
	16:17	1171	59
	16:18	1179	52
	16:19	1536	70
	16:20	1256	70
	16:21	1118	62
	16:22	1810	80
	16:23	1697	84
	16:24	1428	79
	16:25	1279	63
	16:26	1043	58
	16:27	3267	86
	16:28	2243	91
	16:29	2381	60
	16:30	1174	65
	16:31	1646	119
	16:32	6177	81
	16:33	4548	56
	16:34	1586	57
	16:35	1019	51
	Average:	1503.929	65.46429
	18:14	9	0
	18:15	21	2
	18:16	12	1
	18:17	31	0
	18:18	28	0
	18:19	28	0
	18:20	17	0
	18:21	22	0
	18:22	22	1
	18:23	18	0
	18:24	13	0
	18:25	5	0
	18:26	12	0
	18:27	11	1
	18:28	12	0
	18:29	9	0
	18:30	8	0
	18:31	6	0
	18:32	5	0
	18:33	15	1
	18:34	7	0
	18:35	7	0
	18:36	5	0
	18:37	4	1
	18:38	4	0
	18:39	14	3
	18:40	24	2
	18:41	24	0
	18:42	21	0
	18:43	22	1
	18:44	35	11
	18:45	19	2
	18:46	18	2
	18:47	46	12
	Average:	16.29412	1.176471



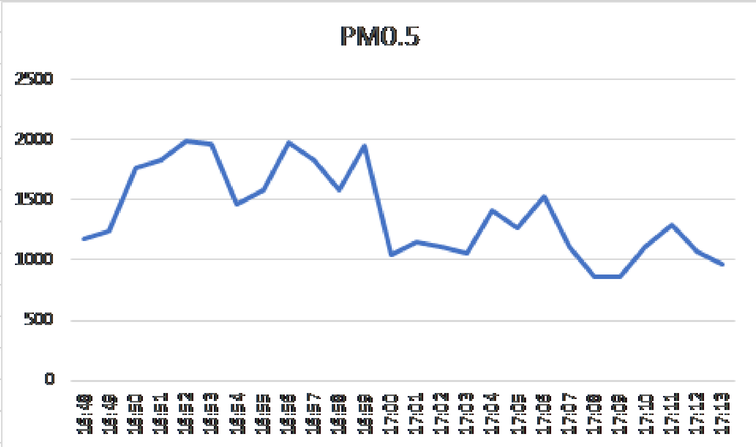


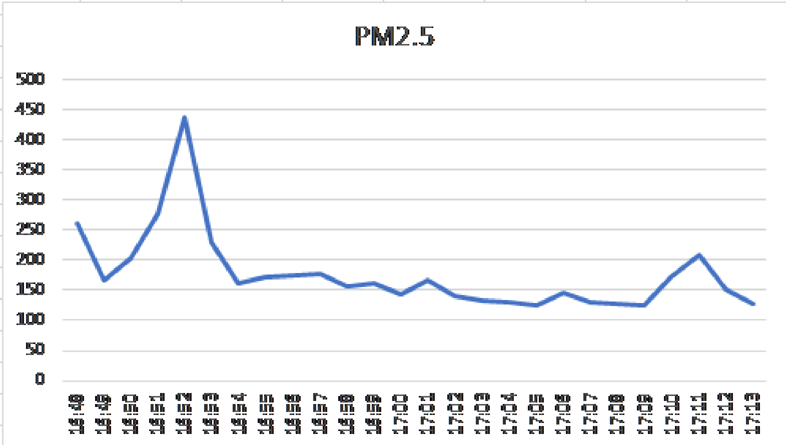


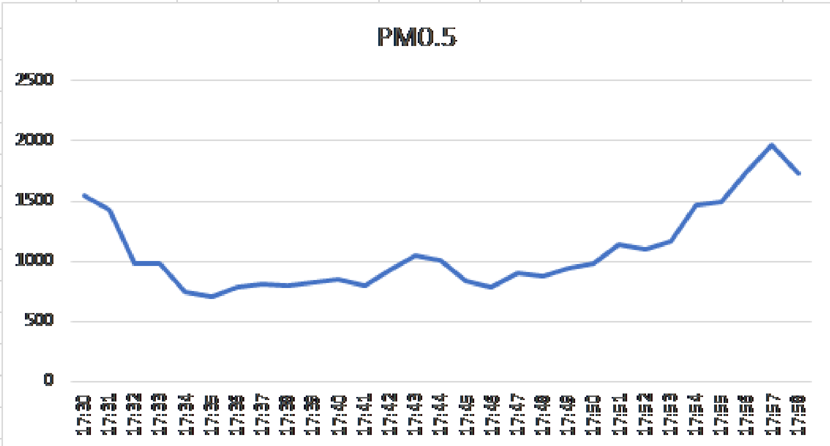


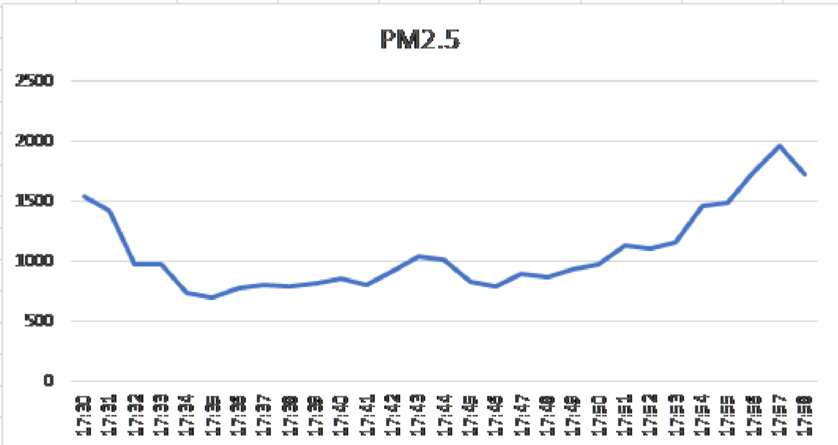
	Date:02/0	Temp:						
	Morning							
1st	Time:	PM0.5	PM2.5					
	NO DATA							

Evening			
1st	Time:	PM0.5	PM2.5
	16:48	1175	262
	16:49	1247	167
	16:50	1762	204
	16:51	1834	277
	16:52	1997	438
	16:53	1963	231
	16:54	1466	162
	16:55	1589	171
	16:56	1974	174
	16:57	1831	177
	16:58	1590	157
	16:59	1951	162
	17:00	1048	142
	17:01	1149	168
	17:02	1116	140
	17:03	1053	134
	17:04	1417	129
	17:05	1267	124
	17:06	1538	147
	17:07	1109	131
	17:08	864	127
	17:09	856	124
	17:10	1105	172
	17:11	1299	209
	17:12	1066	151
	17:13	966	128
	Average:	1393.538	177.2308
	17:30	1542	152
	17:31	1423	124
	17:32	983	124
	17:33	981	128
	17:34	742	122
	17:35	708	112
	17:36	788	127
	17:37	809	128
	17:38	795	130
	17:39	824	116
	17:40	856	133
	17:41	803	125
	17:42	930	128
	17:43	1049	125
	17:44	1013	123
	17:45	832	130
	17:46	791	128
	17:47	899	132
	17:48	879	137
	17:49	940	135
	17:50	980	136
	17:51	1143	166
	17:52	1106	141
	17:53	1169	135
	17:54	1471	164
	17:55	1489	151
	17:56	1740	183
	17:57	1971	172
	17:58	1734	141
	Average:	1082.414	136.1379

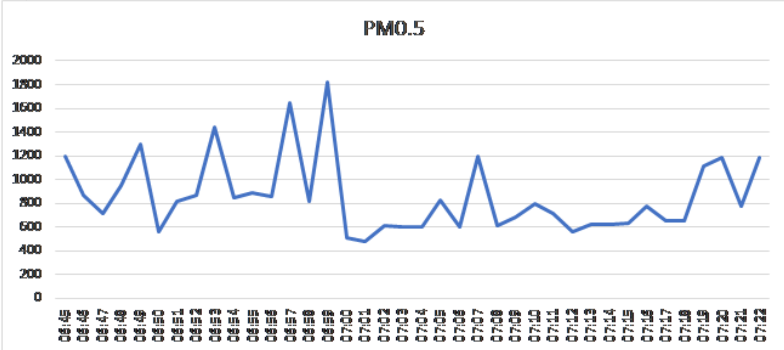


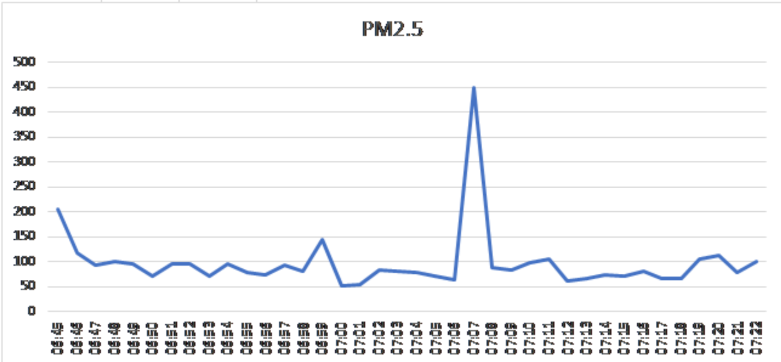


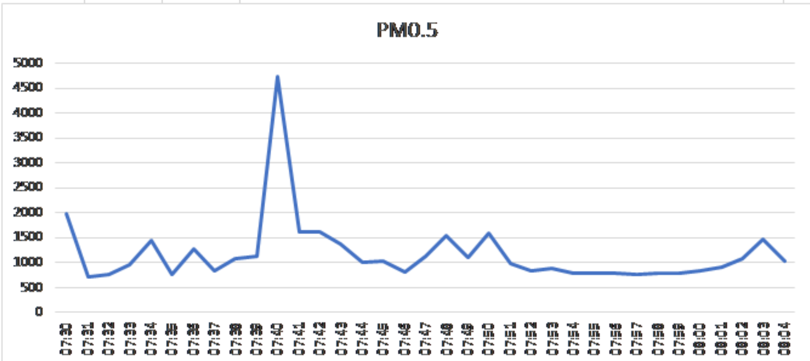


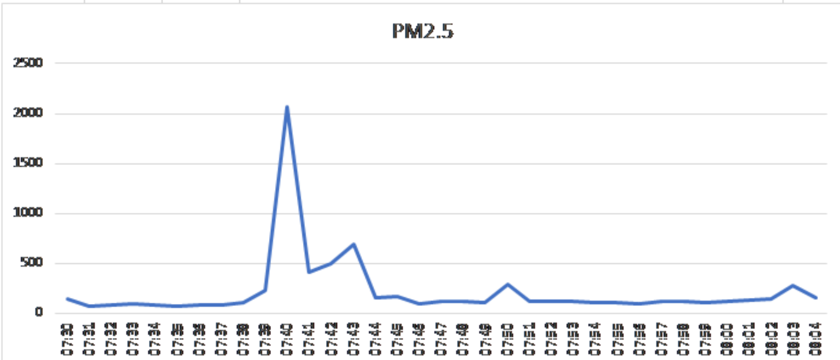


	Date:03/07/19			
	Morning			
1st	Time:	PM0.5	PM2.5	
	06:45	1200	205	
	06:46	870	118	
	06:47	712	94	
	06:48	949	102	
	06:49	1295	95	
	06:50	564	71	
	06:51	820	96	
	06:52	871	97	
	06:53	1445	71	
	06:54	852	96	
	06:55	890	80	
	06:56	861	75	
	06:57	1645	93	
	06:58	817	81	
	06:59	1823	144	
	07:00	509	52	
	07:01	481	54	
	07:02	618	84	
	07:03	606	81	
	07:04	605	79	
	07:05	823	72	
	07:06	600	65	
	07:07	1200	450	
	07:08	616	89	ped.
	07:09	689	83	
	07:10	793	98	
	07:11	711	105	
	07:12	562	63	
	07:13	620	68	
	07:14	625	74	
	07:15	632	71	
	07:16	777	81	
	07:17	654	67	
	07:18	650	67	
	07:19	1110	107	
	07:20	1182	114	
	07:21	777	78	
	07:22	1185	102	
	Average:	858.9211	97.94737	
2nd	07:30	1978	137	
	07:31	724	74	
	07:32	779	79	
	07:33	952	91	
	07:34	1455	77	
	07:35	774	73	
	07:36	1269	86	mixed
	07:37	843	85	
	07:38	1086	106	
	07:39	1143	231	
	07:40	4727	2064	
	07:41	1623	415	
	07:42	1623	497	
	07:43	1386	693	
	07:44	1003	151	
	07:45	1042	173	
	07:46	813	92	
	07:47	1129	117	
	07:48	1537	123	
	07:49	1105	106	
	07:50	1603	290	
	07:51	988	124	
	07:52	838	115	
	07:53	879	116	
	07:54	782	105	
	07:55	786	106	
	07:56	799	91	
	07:57	779	117	
	07:58	802	117	
	07:59	785	102	
	08:00	843	118	
	08:01	917	130	
	08:02	1084	139	
	08:03	1464	271	
	08:04	1035	150	
	Average:	1182.143	216.0286	

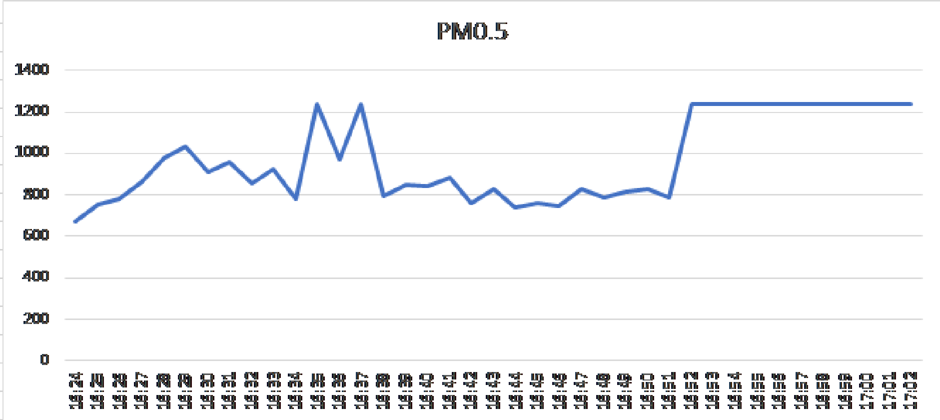


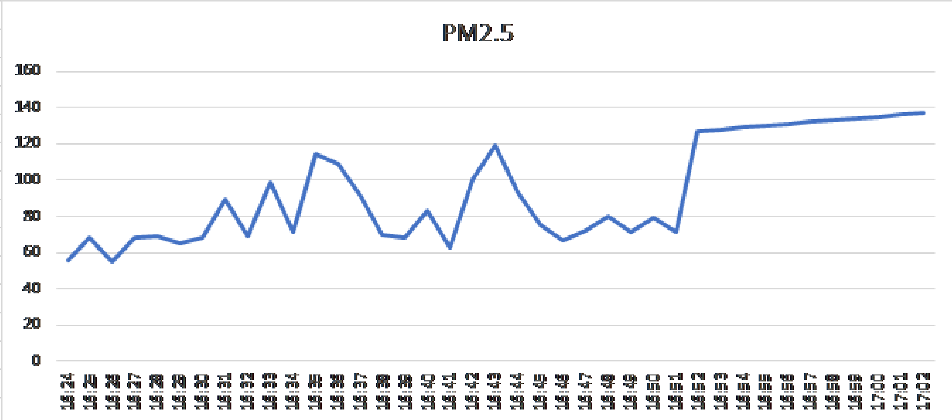




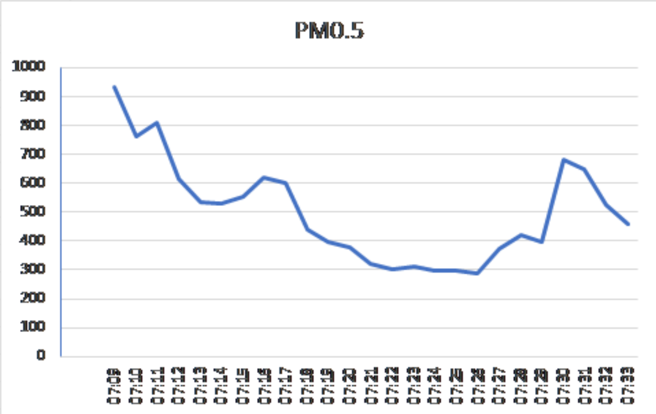


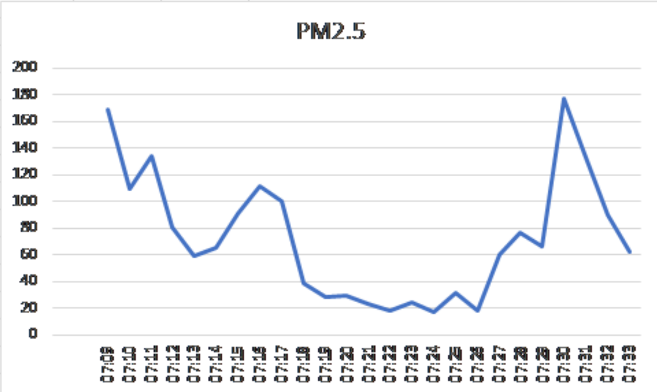
Evening				
1st	Time:	PM0.5	PM2.5	
	16:24	669	56	
	16:25	752	68	
	16:26	784	55	
	16:27	862	68	
	16:28	978	69	
	16:29	1036	65	
	16:30	913	68	
	16:31	959	89	
	16:32	859	69	
	16:33	922	99	
	16:34	784	71	
	16:35	1241	114	
	16:36	974	109	
	16:37	1235	91	
	16:38	797	70	
	16:39	852	68	
	16:40	839	83	
	16:41	882	63	
	16:42	761	100	
	16:43	826	119	
	16:44	742	93	
	16:45	760	75	
	16:46	746	67	
	16:47	829	72	
	16:48	788	80	
	16:49	815	71	
	16:50	829	79	
	16:51	786	71	
	16:52	1239	127	
	16:53	1239	128	
	16:54	1239	129	
	16:55	1239	130	
	16:56	1239	131	
	16:57	1239	132	
	16:58	1239	133	
	16:59	1239	134	
	17:00	1239	135	
	17:01	1239	136	
	17:02	1239	137	
	Average:	970.4872	93.69231	
	17:03	1239	138	
	17:04	1239	139	
	17:05	1239	140	
	17:06	1239	141	
	17:07	1239	142	
	17:08	1239	143	incomplete - walk cut short
	17:09	1239	144	
	17:10	1239	145	
	17:11	1239	146	
	Average:	1239	142	
	2nd	no data		

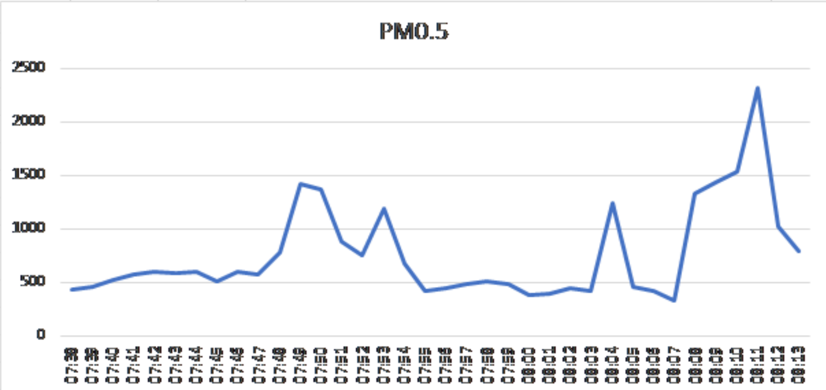


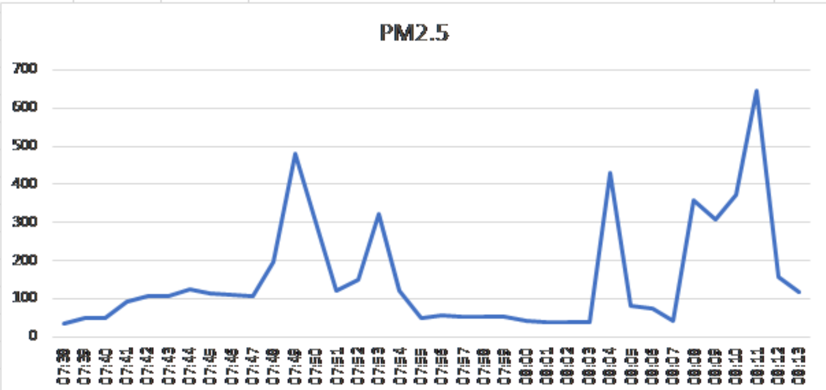


	Date:10/07/19		
	Morning		
1st	Time:	PM0.5	**PM2.5**
	07:09	931	**169**
	07:10	763	**110**
	07:11	808	**134**
	07:12	614	**81**
	07:13	533	**59**
	07:14	532	**65**
	07:15	556	**91**
	07:16	618	**112**
	07:17	603	**100**
	07:18	442	**39**
	07:19	396	**28**
	07:20	378	**29**
	07:21	322	**23**
	07:22	301	**18**
	07:23	310	**24**
	07:24	298	**17**
	07:25	299	**32**
	07:26	290	**18**
	07:27	374	**60**
	07:28	422	**77**
	07:29	397	**66**
	07:30	681	**177**
	07:31	649	**133**
	07:32	527	**90**
	07:33	460	**62**
	Average:	500.16	**72.56**
2nd	07:38	429	**34**
	07:39	455	**48**
	07:40	516	**49**
	07:41	574	**91**
	07:42	602	**107**
	07:43	586	**106**
	07:44	598	**123**
	07:45	515	**115**
	07:46	596	**110**
	07:47	573	**105**
	07:48	784	**198**
	07:49	1418	**480**
	07:50	1370	**302**
	07:51	879	**121**
	07:52	755	**149**
	07:53	1185	**324**
	07:54	672	**122**
	07:55	420	**48**
	07:56	446	**55**
	07:57	488	**51**
	07:58	504	**53**
	07:59	478	**53**
	08:00	386	**41**
	08:01	400	**38**
	08:02	441	**39**
	08:03	416	**40**
	08:04	1247	**432**
	08:05	459	**80**
	08:06	421	**73**
	08:07	324	**42**
	08:08	1329	**359**
	08:09	1439	**308**
	08:10	1537	**373**
	08:11	2322	**647**
	08:12	1027	**157**
	08:13	790	**119**
	Average:	760.5833	**155.3333**

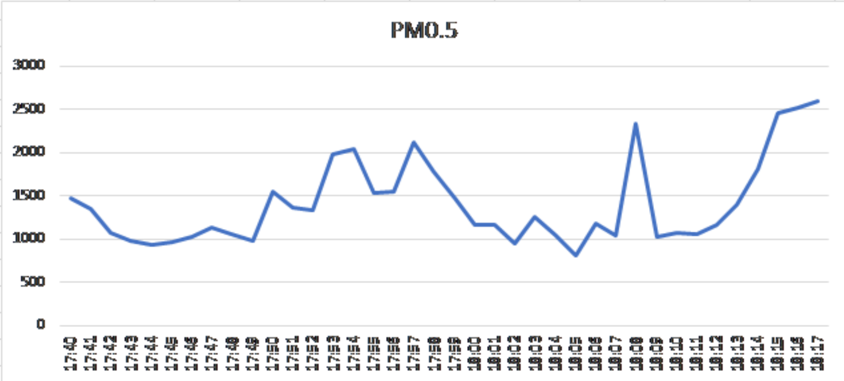


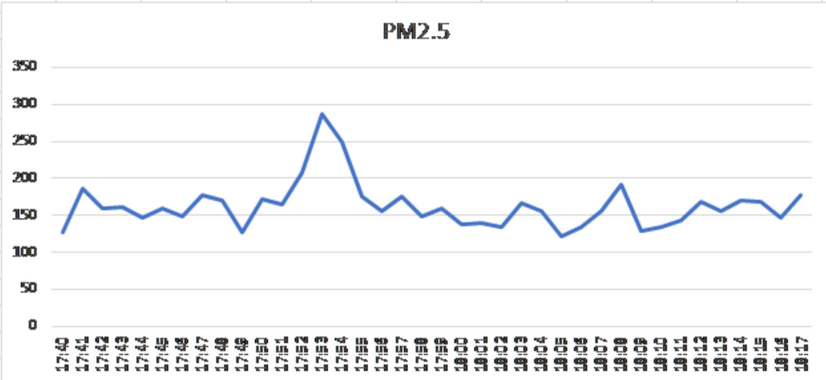


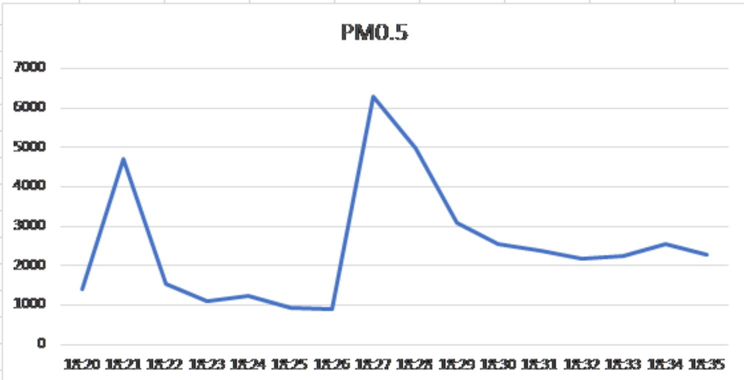


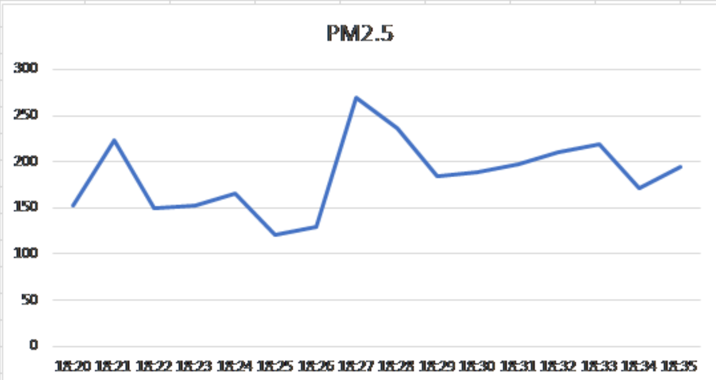


Evening			
1st	Time:	PM0.5	PM2.5
	17:40	1477	127
	17:41	1351	187
	17:42	1077	160
	17:43	976	161
	17:44	931	146
	17:45	967	159
	17:46	1030	148
	17:47	1135	177
	17:48	1052	170
	17:49	979	127
	17:50	1552	172
	17:51	1369	165
	17:52	1331	208
	17:53	1985	287
	17:54	2038	250
	17:55	1537	175
	17:56	1547	155
	17:57	2118	176
	17:58	1784	149
	17:59	1481	159
	18:00	1164	137
	18:01	1159	140
	18:02	950	134
	18:03	1260	166
	18:04	1041	155
	18:05	806	121
	18:06	1186	134
	18:07	1046	156
	18:08	2338	191
	18:09	1030	129
	18:10	1075	135
	18:11	1055	143
	18:12	1170	169
	18:13	1398	156
	18:14	1820	171
	18:15	2462	169
	18:16	2514	147
	18:17	2606	178
	Average:	1415.711	162.8684
	18:20	1412	152
	18:21	4698	224
	18:22	1544	149
	18:23	1110	152
	18:24	1247	165
	18:25	938	121
	18:26	896	129
	18:27	6283	269
	18:28	4984	237
	18:29	3082	185
	18:30	2560	188
	18:31	2363	197
	18:32	2161	210
	18:33	2250	219
	18:34	2556	172
	18:35	2267	195
	Average:	2521.938	185.25
	cut short		



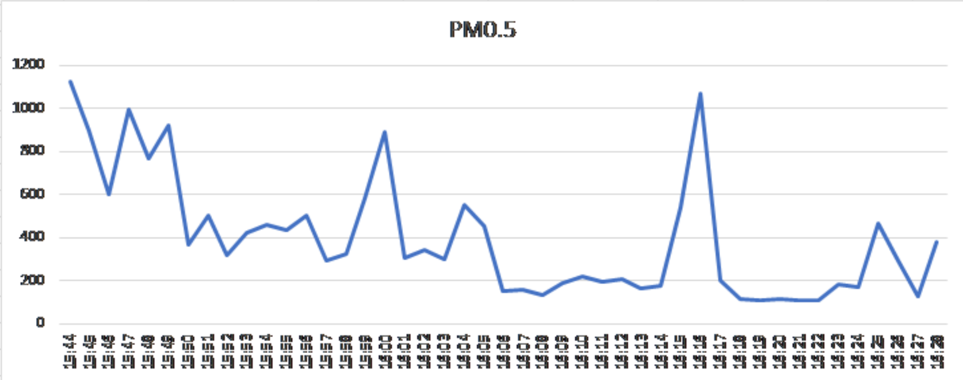


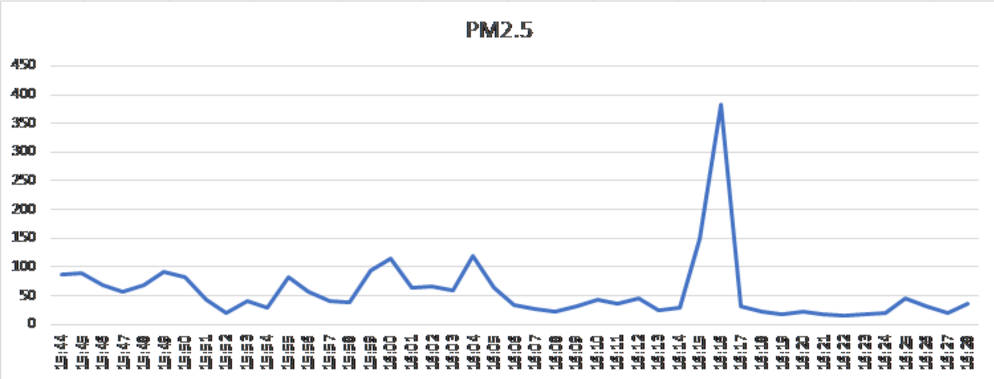


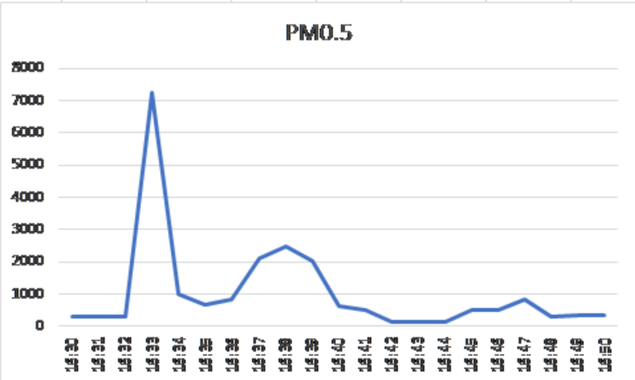


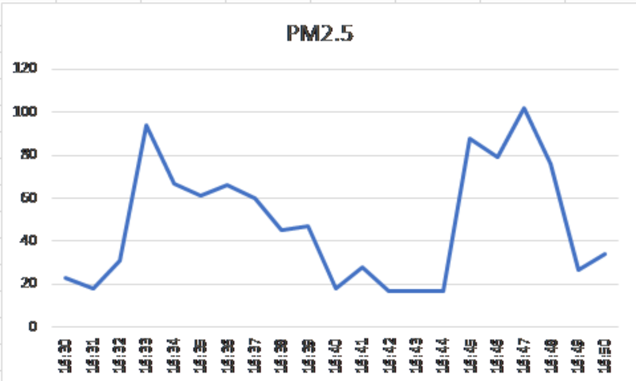
Date:11/07/19			
Morning			
Time:	PM0.5	**PM2.5**	
NO DATA			

Evening			
1st	Time:	PM0.5	PM2.5
	15:44	1127	87
	15:45	899	89
	15:46	600	68
	15:47	999	58
	15:48	771	69
	15:49	920	92
	15:50	370	83
	15:51	502	43
	15:52	321	20
	15:53	425	41
	15:54	459	29
	15:55	433	83
	15:56	504	56
	15:57	295	42
	15:58	327	39
	15:59	582	93
	16:00	894	114
	16:01	305	63
	16:02	346	66
	16:03	297	59
	16:04	551	120
	16:05	453	64
	16:06	154	35
	16:07	160	27
	16:08	134	22
	16:09	187	32
	16:10	217	44
	16:11	195	37
	16:12	210	46
	16:13	164	25
	16:14	177	30
	16:15	541	150
	16:16	1068	383
	16:17	204	31
	16:18	118	22
	16:19	111	18
	16:20	116	23
	16:21	111	17
	16:22	108	16
	16:23	184	17
	16:24	173	21
	16:25	466	45
	16:26	292	32
	16:27	126	19
	16:28	378	37
	Average:	399.4222	57.93333
	16:30	294	23
	16:31	312	18
	16:32	298	31
	16:33	7257	94
	16:34	992	67
	16:35	690	61
	16:36	821	66
	16:37	2104	60
	16:38	2489	45
	16:39	2020	47
	16:40	633	18
	16:41	513	28
	16:42	131	17
	16:43	129	17
	16:44	128	17
	16:45	523	88
	16:46	514	79
	16:47	826	102
	16:48	283	76
	16:49	341	27
	16:50	352	34
	Average:	1030.952	48.33333





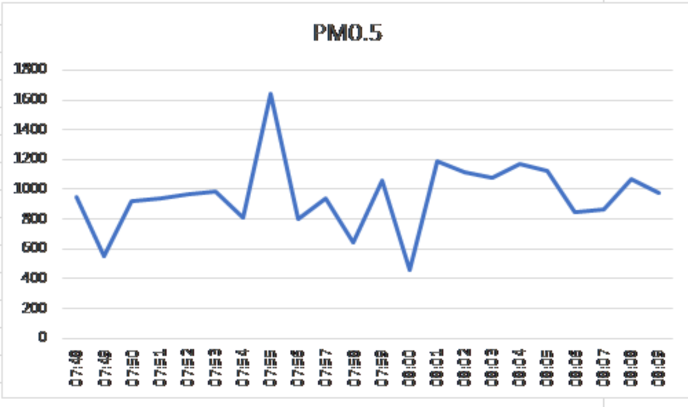


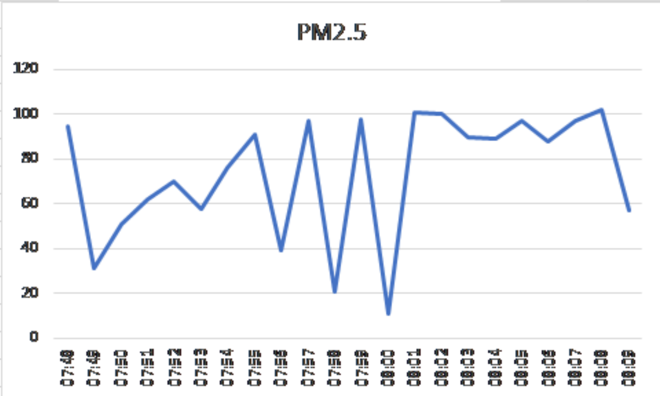


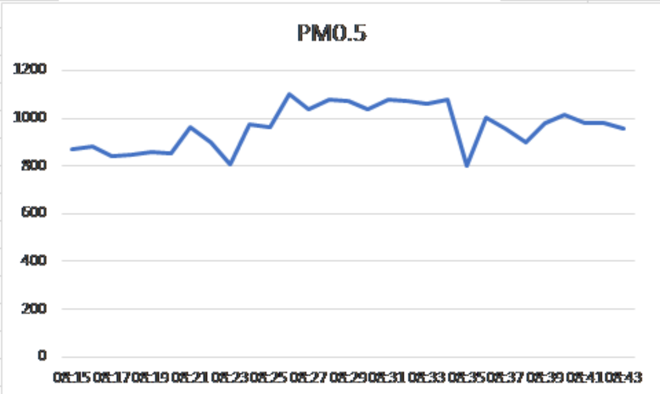
Date:11/08/19

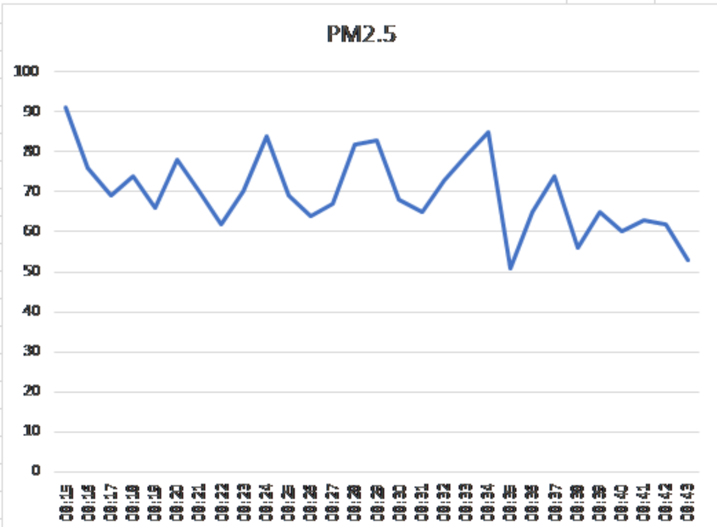
Morning

	Time:	PM0.5	PM2.5
1st	07:48	948	95
	07:49	553	31
	07:50	917	51
	07:51	940	62
	07:52	965	70
	07:53	988	58
	07:54	810	76
	07:55	1647	91
	07:56	805	39
	07:57	941	97
	07:58	643	21
	07:59	1060	98
	08:00	455	11
	08:01	1191	101
	08:02	1115	100
	08:03	1076	90
	08:04	1167	89
	08:05	1127	97
	08:06	850	88
	08:07	866	97
	08:08	1071	102
	08:09	973	57
	Average:	**959.4545**	**73.68182**
2nd	08:15	870	**91**
	08:16	880	**76**
	08:17	841	**69**
	08:18	846	**74**
	08:19	860	**66**
	08:20	855	**78**
	08:21	961	**70**
	08:22	902	**62**
	08:23	807	**70**
	08:24	974	**84**
	08:25	960	**69**
	08:26	1101	**64**
	08:27	1040	**67**
	08:28	1076	**82**
	08:29	1075	**83**
	08:30	1039	**68**
	08:31	1078	**65**
	08:32	1073	**73**
	08:33	1060	**79**
	08:34	1080	**85**
	08:35	799	**51**
	08:36	1006	**65**
	08:37	955	**74**
	08:38	901	**56**
	08:39	978	**65**
	08:40	1014	**60**
	08:41	982	**63**
	08:42	980	**62**
	08:43	958	**53**
	Average:	**963.8276**	**69.7931**

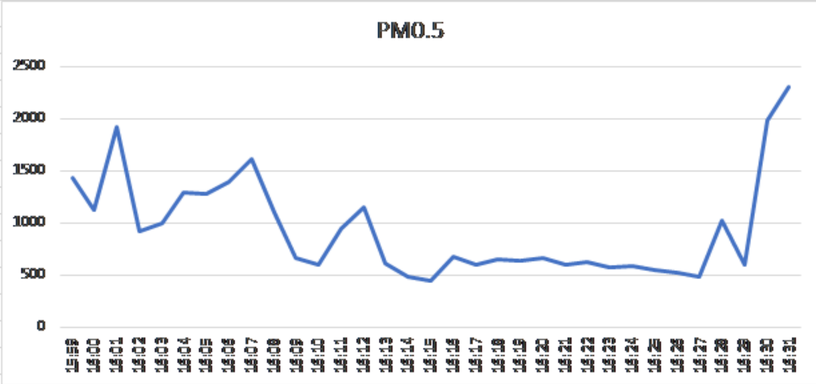


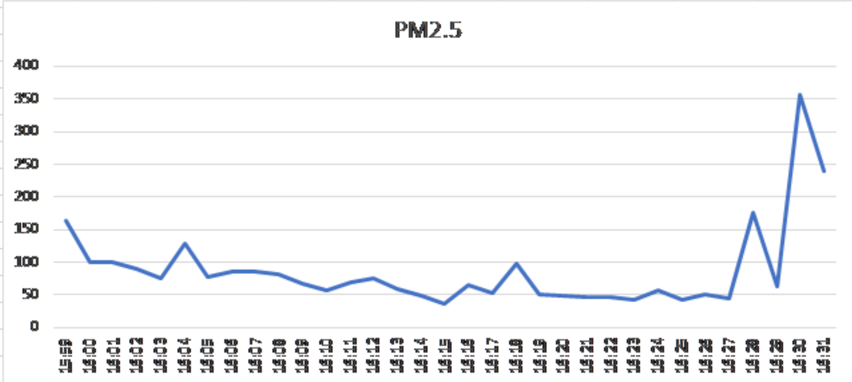


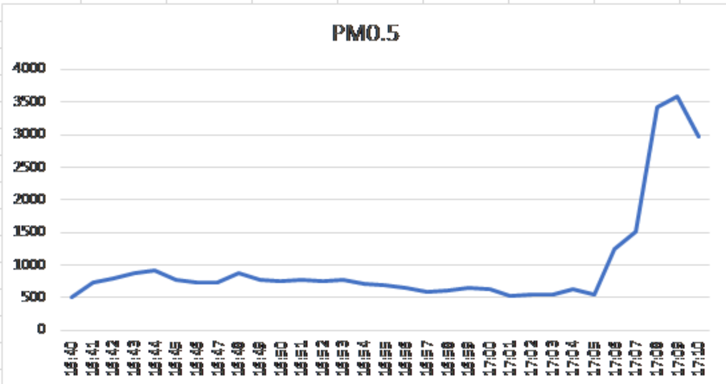


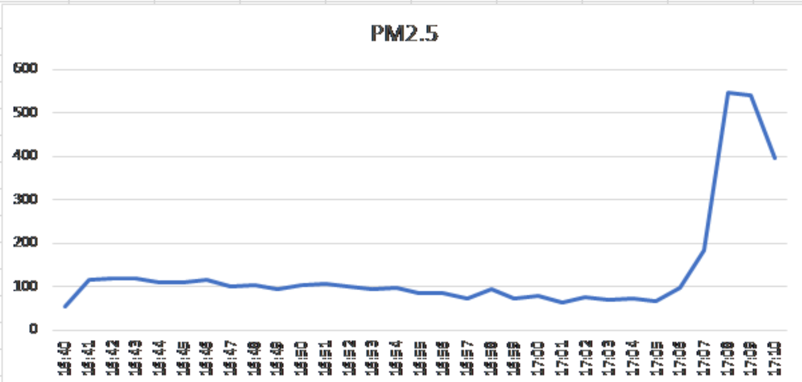


Evening			
1st	Time:	PM0.5	PM2.5
	15:59	1429	163
	16:00	1132	99
	16:01	1921	101
	16:02	916	89
	16:03	999	76
	16:04	1297	129
	16:05	1281	77
	16:06	1394	85
	16:07	1612	85
	16:08	1095	81
	16:09	660	68
	16:10	602	57
	16:11	948	70
	16:12	1146	76
	16:13	609	59
	16:14	483	49
	16:15	444	37
	16:16	682	66
	16:17	605	52
	16:18	645	98
	16:19	644	50
	16:20	661	49
	16:21	595	47
	16:22	622	46
	16:23	580	42
	16:24	582	56
	16:25	542	43
	16:26	526	51
	16:27	488	45
	16:28	1026	175
	16:29	598	63
	16:30	1991	357
	16:31	2306	240
	Average:	941.2424	87.30303
	16:40	513	56
	16:41	731	115
	16:42	796	118
	16:43	885	119
	16:44	928	111
	16:45	771	111
	16:46	732	115
	16:47	723	100
	16:48	867	103
	16:49	769	95
	16:50	754	103
	16:51	778	107
	16:52	759	102
	16:53	779	93
	16:54	713	97
	16:55	699	85
	16:56	659	86
	16:57	588	74
	16:58	600	94
	16:59	648	74
	17:00	640	79
	17:01	535	64
	17:02	540	75
	17:03	554	71
	17:04	639	72
	17:05	554	67
	17:06	1239	98
	17:07	1519	183
	17:08	3432	548
	17:09	3581	542
	17:10	2966	396
	Average:	996.4839	133.9677





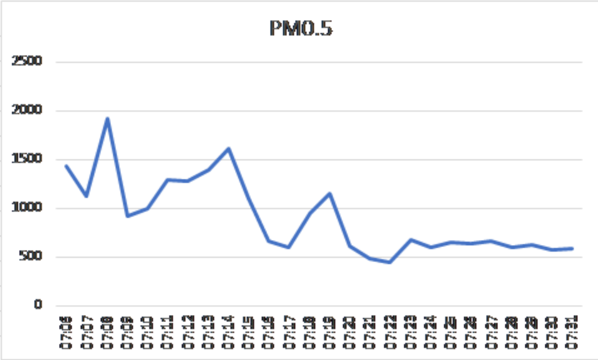


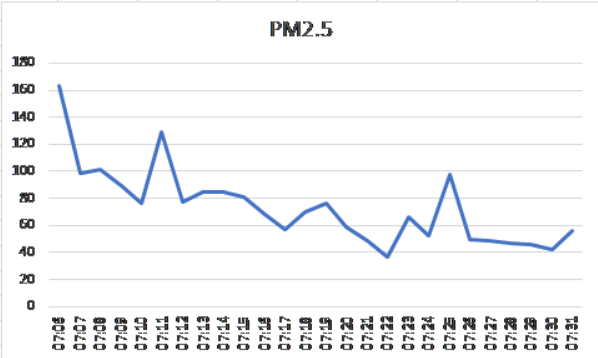


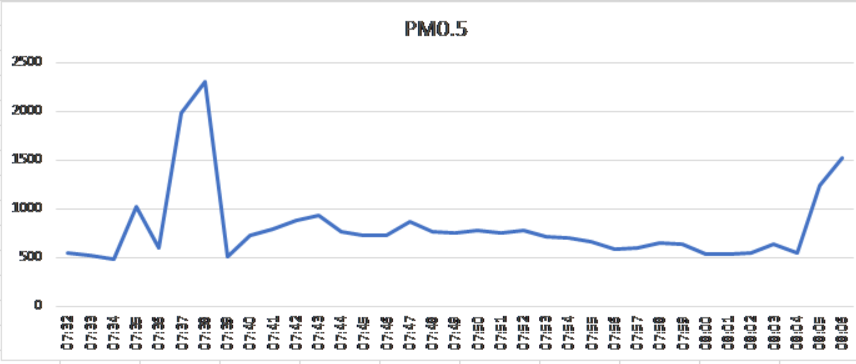
Date:11/08/19

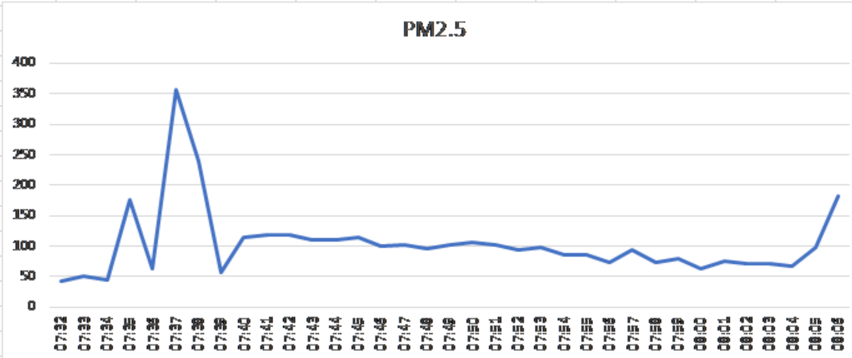
Morning

	Time:	PM0.5	PM2.5
1st			
	07:06	1429	163
	07:07	1132	99
	07:08	1921	101
	07:09	916	89
	07:10	999	76
	07:11	1297	129
	07:12	1281	77
	07:13	1394	85
	07:14	1612	85
	07:15	1095	81
	07:16	660	68
	07:17	602	57
	07:18	948	70
	07:19	1146	76
	07:20	609	59
	07:21	483	49
	07:22	444	37
	07:23	682	66
	07:24	605	52
	07:25	645	98
	07:26	644	50
	07:27	661	49
	07:28	595	47
	07:29	622	46
	07:30	580	42
	07:31	582	56
	Average:	**907.0769**	**73.34615**
	07:32	542	43
	07:33	526	51
	07:34	488	45
	07:35	1026	175
	07:36	598	63
2nd	07:37	1991	357
	07:38	2306	240
	07:39	513	56
	07:40	731	115
	07:41	796	118
	07:42	885	119
	07:43	928	111
	07:44	771	111
	07:45	732	115
	07:46	723	100
	07:47	867	103
	07:48	769	95
	07:49	754	103
	07:50	778	107
	07:51	759	102
	07:52	779	93
	07:53	713	97
	07:54	699	85
	07:55	659	86
	07:56	588	74
	07:57	600	94
	07:58	648	74
	07:59	640	79
	08:00	535	64
	08:01	540	75
	08:02	554	71
	08:03	639	72
	08:04	554	67
	08:05	1239	98
	08:06	1519	183
	Average:	**811.1143**	**104.0286**

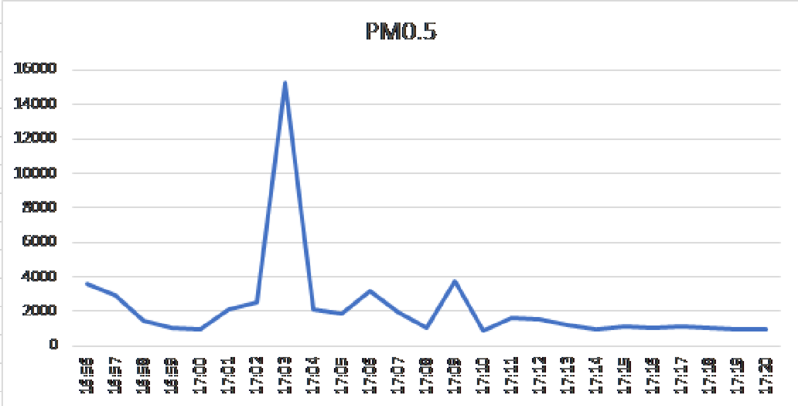


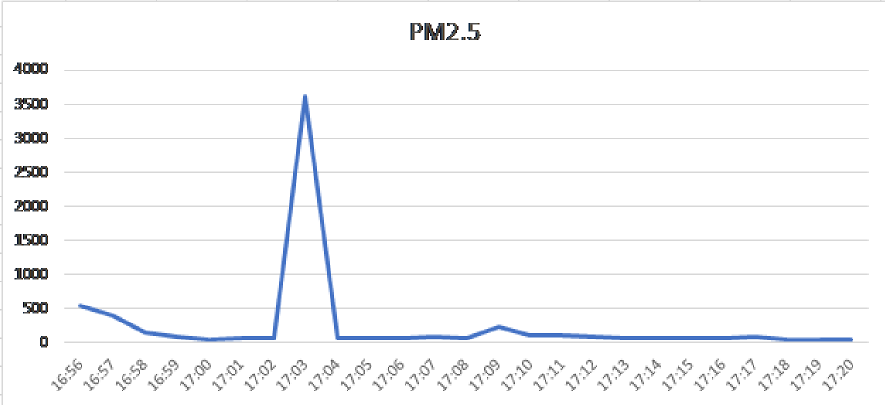






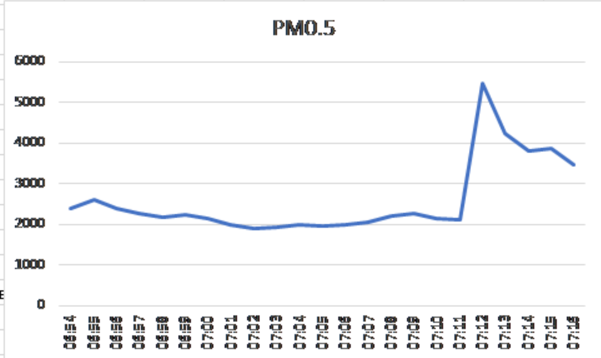
Evening			
1st	Time:	PM0.5	PM2.5
	16:56	3581	542
	16:57	2966	396
	16:58	1430	161
	16:59	1057	83
	17:00	966	60
	17:01	2104	76
	17:02	2534	74
	17:03	15221	3624
	17:04	2072	64
	17:05	1900	75
	17:06	3172	76
	17:07	1968	90
	17:08	1039	78
	17:09	3765	245
	17:10	891	109
	17:11	1657	120
	17:12	1548	89
	17:13	1189	65
	17:14	934	75
	17:15	1137	69
	17:16	1003	63
	17:17	1155	81
	17:18	1004	46
	17:19	959	49
	17:20	919	42
	Average:	2246.84	258.08
	no data for 2nd walk		

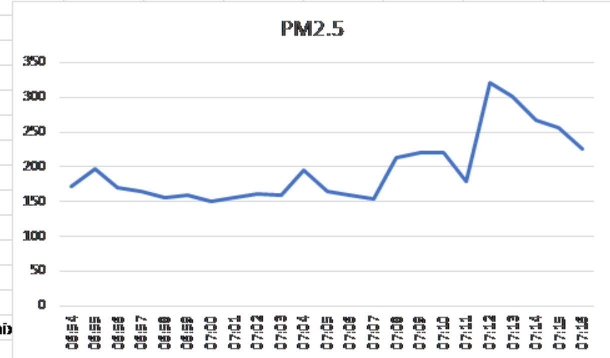


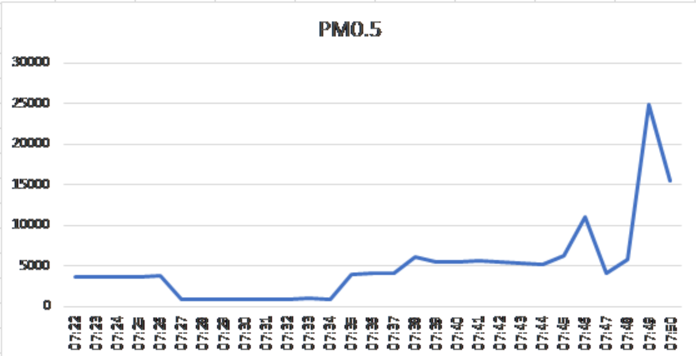


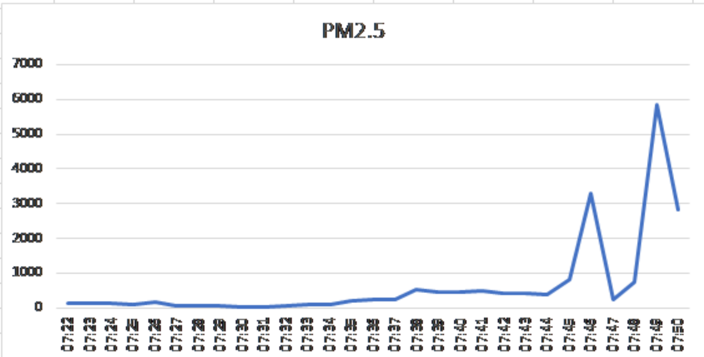
	Date:21/08/19			
	Morning			
1st	Time:	PM0.5	PM2.5	
	06:54	2385	172	
	06:55	2600	198	
	06:56	2407	170	
	06:57	2284	164	
	06:58	2190	156	
	06:59	2236	159	
	07:00	2156	150	
	07:01	1988	155	
	07:02	1914	161	
	07:03	1941	159	
	07:04	2004	196	
	07:05	1958	165	pe
	07:06	1980	159	
	07:07	2046	154	
	07:08	2199	213	
	07:09	2266	221	
	07:10	2146	221	
	07:11	2116	180	
	07:12	5464	321	
	07:13	4256	302	
	07:14	3806	268	
	07:15	3859	257	
	07:16	3462	226	
	Average:	2594.043	196.8261	
	07:22	3664	123	
	07:23	3669	128	
	07:24	3633	122	
	07:25	3646	109	mi
	07:26	3778	164	
	07:27	948	67	
	07:28	936	62	
	07:29	855	52	
	07:30	829	37	
	07:31	849	34	
	07:32	833	51	
	07:33	958	89	
	07:34	906	101	
	07:35	3911	217	
	07:36	4054	239	
	07:37	4073	227	
	07:38	6090	527	
	07:39	5549	439	
	07:40	5572	444	
	07:41	5639	476	
	07:42	5560	436	
	07:43	5349	415	
	07:44	5177	390	
	07:45	6330	810	
	07:46	11015	3290	
	07:47	4052	225	
	07:48	5846	744	
	07:49	24907	5847	
	07:50	15452	2820	
	Average:	4968.276	644.3103	

	Evening
1st	no data
2nd	no data

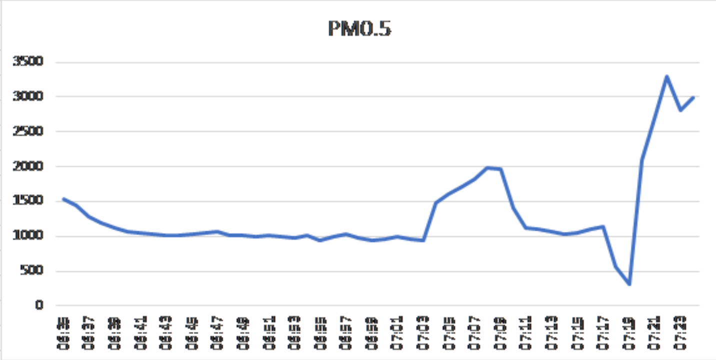


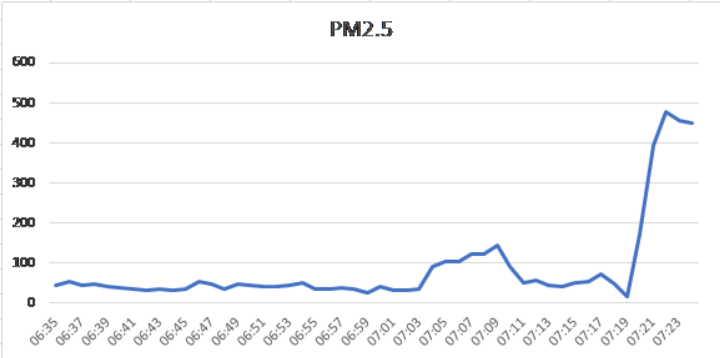






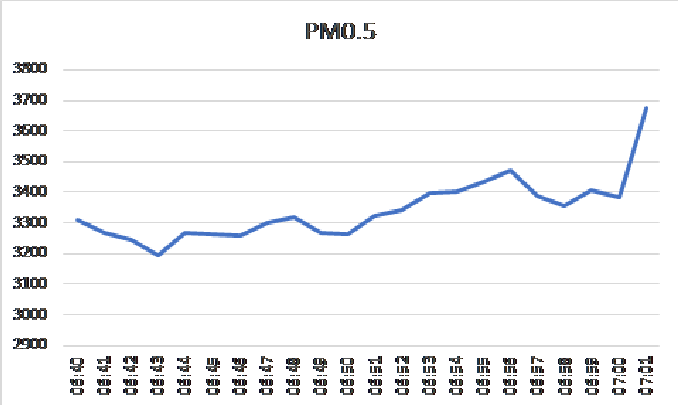
	Date: 24/08/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	06:35	1540	46
	06:36	1437	53
	06:37	1274	45
	06:38	1193	49
	06:39	1126	42
	06:40	1067	39
	06:41	1057	35
	06:42	1037	31
	06:43	1011	36
	06:44	1011	33
	06:45	1026	37
	06:46	1051	53
	06:47	1074	49
	06:48	1005	37
	06:49	1017	48
	06:50	994	45
	06:51	1014	42
	06:52	986	42
	06:53	970	44
	06:54	1014	50
	06:55	938	37
	06:56	996	35
	06:57	1026	39
	06:58	968	37
	06:59	936	26
	07:00	961	41
	07:01	989	33
	07:02	956	32
	07:03	934	36
	07:04	1474	93
	07:05	1605	103
	07:06	1707	103
	07:07	1822	123
	07:08	1978	122
	07:09	1961	145
	07:10	1404	92
	07:11	1115	51
	07:12	1094	57
	07:13	1071	46
	07:14	1038	43
	07:15	1047	51
	07:16	1099	54
	07:17	1142	72
	07:18	557	47
	07:19	307	17
	07:20	2094	174
	07:21	2685	393
	07:22	3302	478
	07:23	2814	457
	07:24	2987	451
	Average:	1298.22	86.88
2nd	no data		

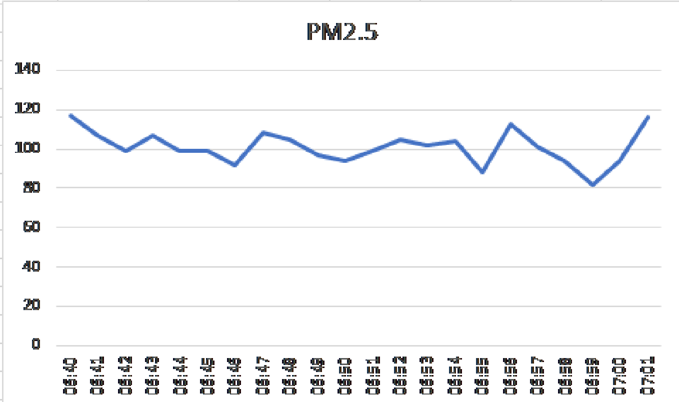


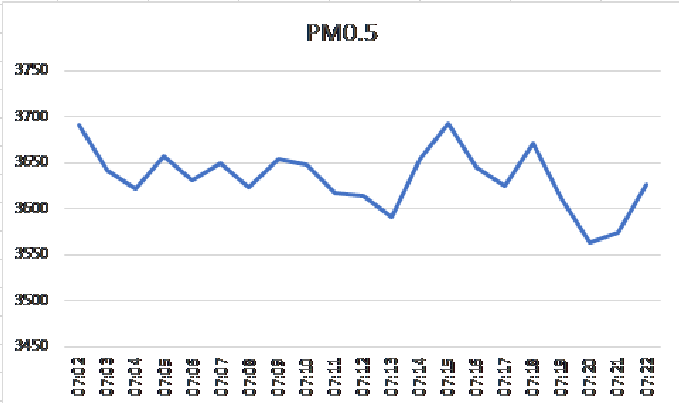


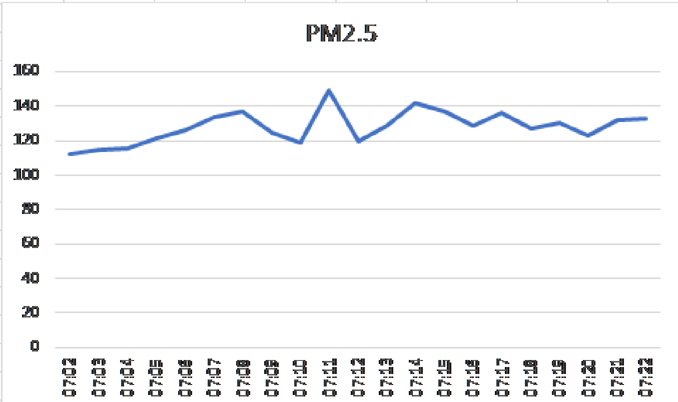
Evening	
1st	no data
2nd	no data

Date: 25/08/19		Morning	
1st	Time:	PM0.5	PM2.5
	06:40	3310	117
	06:41	3267	107
	06:42	3246	99
	06:43	3196	107
	06:44	3267	99
	06:45	3262	99
	06:46	3257	92
	06:47	3302	108
	06:48	3320	105
	06:49	3266	97
	06:50	3264	94
	06:51	3322	99
	06:52	3341	105
	06:53	3397	102
	06:54	3403	104
	06:55	3433	88
	06:56	3472	113
	06:57	3389	101
	06:58	3356	94
	06:59	3407	82
	07:00	3382	94
	07:01	3676	116
	Average:	3342.5	101
2nd	07:02	3692	112
	07:03	3642	115
	07:04	3622	116
	07:05	3657	121
	07:06	3631	126
	07:07	3650	134
	07:08	3624	137
	07:09	3655	125
	07:10	3648	119
	07:11	3618	149
	07:12	3614	120
	07:13	3591	129
	07:14	3655	142
	07:15	3693	137
	07:16	3645	129
	07:17	3625	136
	07:18	3672	127
	07:19	3612	130
	07:20	3563	123
	07:21	3574	132
	07:22	3626	133
	Average:	3633.762	128.1905





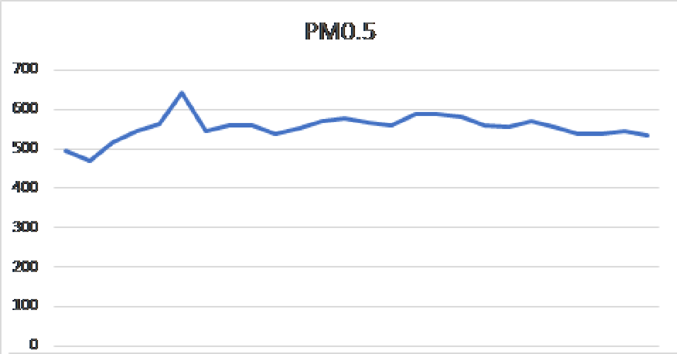


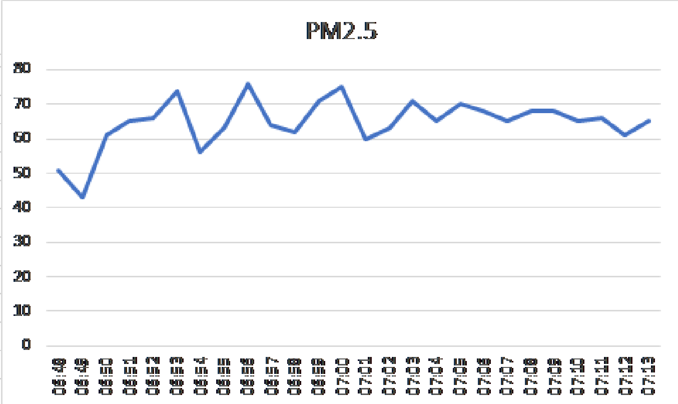


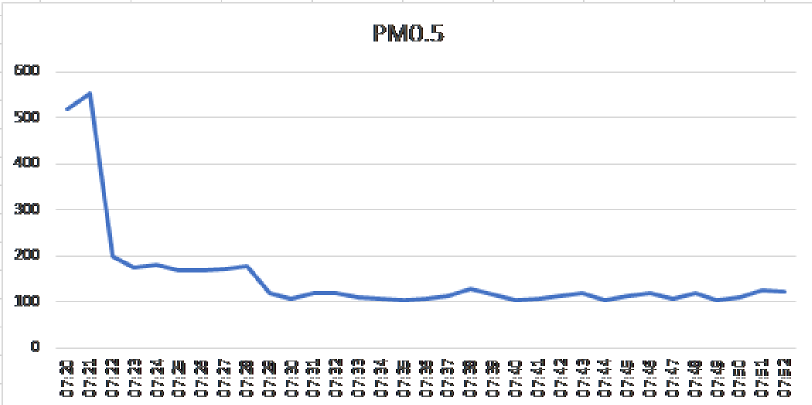
Evening	
1st	no data
2nd	no data

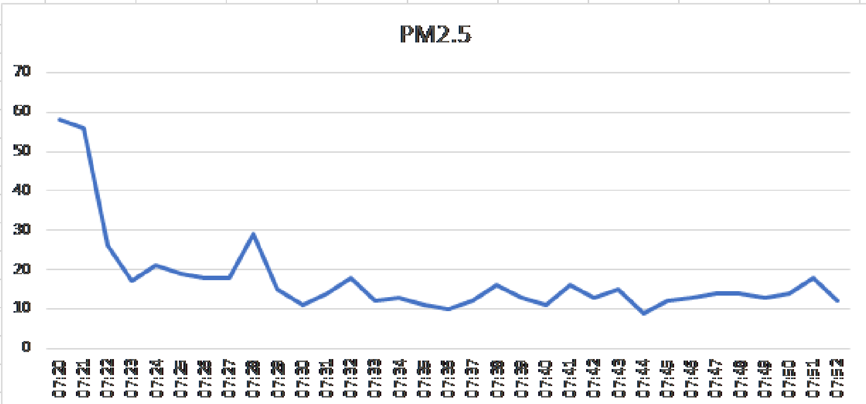
Date: 26/08/19		Morning	
1st	Time:	PM0.5	PM2.5
	06:48	495	51
	06:49	471	43
	06:50	515	61
	06:51	545	65
	06:52	562	66
	06:53	644	74
	06:54	547	56
	06:55	559	63
	06:56	561	76
	06:57	538	64
	06:58	551	62
	06:59	570	71
	07:00	576	75
	07:01	567	60
	07:02	561	63
	07:03	590	71
	07:04	590	65
	07:05	581	70
	07:06	559	68
	07:07	557	65
	07:08	572	68
	07:09	555	68
	07:10	537	65
	07:11	539	66
	07:12	546	61
	07:13	534	65
	Average:	554.6923	64.69231
2nd	07:20	521	58
	07:21	554	56
	07:22	199	26
	07:23	176	17
	07:24	182	21
	07:25	168	19
	07:26	168	18
	07:27	171	18
	07:28	177	29
	07:29	119	15
	07:30	108	11
	07:31	120	14
	07:32	119	18
	07:33	111	12
	07:34	106	13
	07:35	104	11
	07:36	108	10
	07:37	113	12
	07:38	127	16
	07:39	116	13
	07:40	104	11
	07:41	106	16
	07:42	113	13
	07:43	120	15
	07:44	105	9
	07:45	113	12
	07:46	120	13
	07:47	107	14
	07:48	120	14
	07:49	105	13
	07:50	110	14
	07:51	124	18
	07:52	121	12
	Average:	152.5758	17.60606

Evening	
1st	no data
2nd	no data

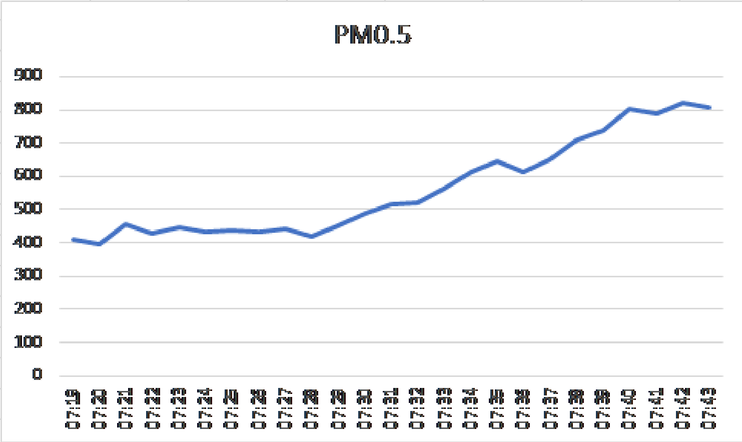


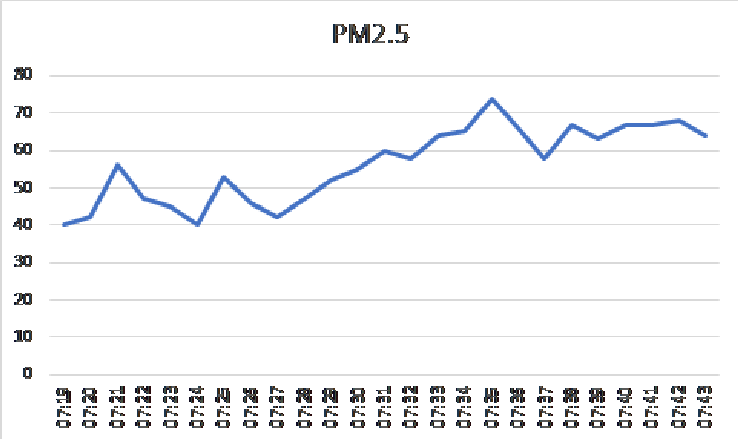


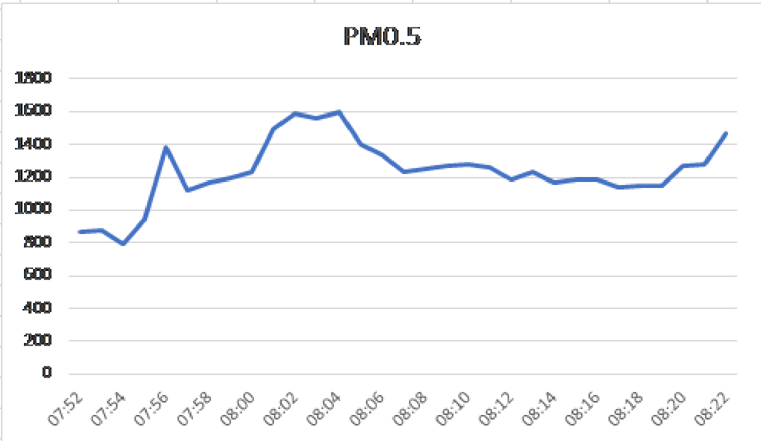


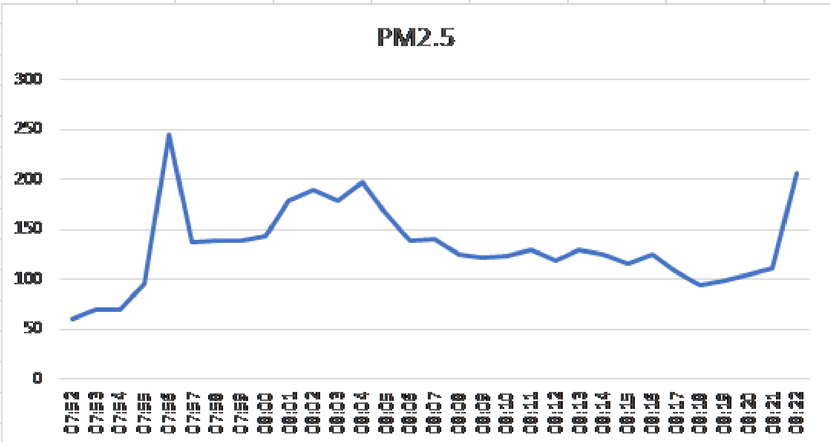


Date: 27/08/19			Morning	
1st	Time:	PM0.5	PM2.5	ped.
	07:19	408	40	
	07:20	397	42	
	07:21	458	56	
	07:22	427	47	
	07:23	445	45	
	07:24	435	40	
	07:25	438	53	
	07:26	435	46	
	07:27	440	42	
	07:28	421	47	
	07:29	453	52	
	07:30	488	55	
	07:31	514	60	
	07:32	520	58	
	07:33	563	64	
	07:34	611	65	
	07:35	647	74	
	07:36	613	66	
	07:37	652	58	
	07:38	708	67	
	07:39	738	63	
	07:40	804	67	
	07:41	787	67	
	07:42	822	68	
	07:43	806	64	
	Average:	561.2	56.24	
2nd	07:52	872	60	
	07:53	875	70	
mixed	07:54	792	69	
	07:55	940	96	
	07:56	1387	245	
	07:57	1119	137	
	07:58	1172	138	
	07:59	1196	139	
	08:00	1230	143	
	08:01	1495	179	
	08:02	1591	190	
	08:03	1556	178	
	08:04	1601	197	
	08:05	1405	167	
	08:06	1335	138	
	08:07	1230	140	
	08:08	1254	124	
	08:09	1271	122	
	08:10	1281	123	
	08:11	1264	129	
	08:12	1182	119	
	08:13	1236	130	
	08:14	1172	124	
	08:15	1185	115	
	08:16	1190	124	
	08:17	1139	108	
	08:18	1151	94	
	08:19	1147	99	
	08:20	1269	105	
	08:21	1277	111	
	08:22	1465	207	
	Average:	1234.806	132.9032	

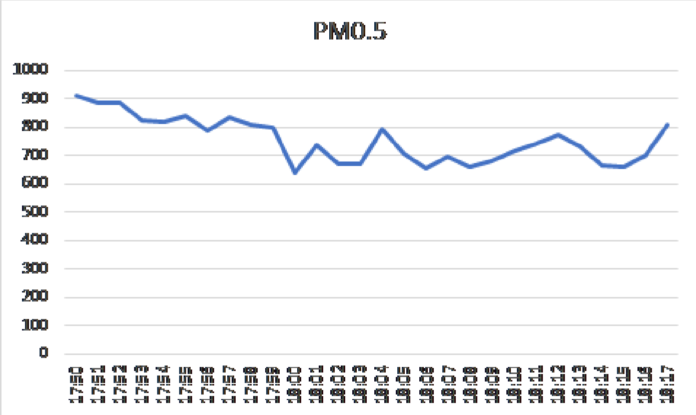


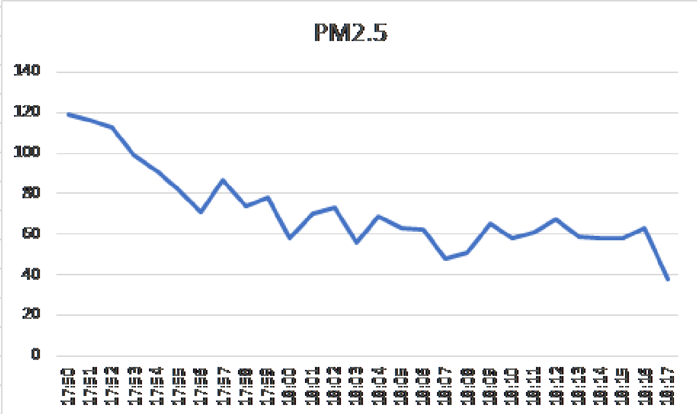


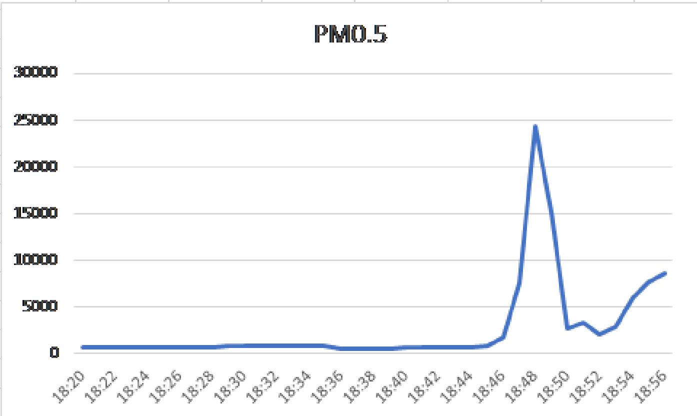


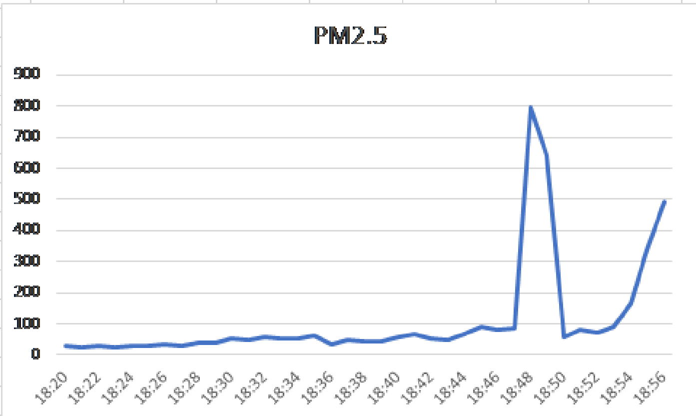


Evening			
1st	Time:	PM0.5	PM2.5
	17:50	910	119
	17:51	885	116
	17:52	889	113
	17:53	826	99
	17:54	819	91
	17:55	839	82
	17:56	787	71
	17:57	836	87
	17:58	809	74
	17:59	800	78
	18:00	638	58
	18:01	737	70
	18:02	672	73
	18:03	671	56
	18:04	792	69
	18:05	707	63
	18:06	658	62
	18:07	698	48
	18:08	662	51
	18:09	681	65
	18:10	718	58
	18:11	745	61
	18:12	772	67
	18:13	734	59
	18:14	667	58
	18:15	662	58
	18:16	704	63
	18:17	812	38
	Average:	754.6429	71.67857
	18:20	757	31
	18:21	761	26
	18:22	751	31
	18:23	729	24
	18:24	740	32
	18:25	734	31
	18:26	741	33
	18:27	750	29
	18:28	758	39
	18:29	783	38
	18:30	821	52
	18:31	798	49
	18:32	798	56
	18:33	791	52
	18:34	799	51
	18:35	838	62
	18:36	557	35
	18:37	580	48
	18:38	590	46
	18:39	571	46
	18:40	649	56
	18:41	686	65
	18:42	610	53
	18:43	623	50
	18:44	614	66
	18:45	764	91
	18:46	1737	79
	18:47	7532	86
	18:48	24340	798
	18:49	15219	643
	18:50	2642	57
	18:51	3410	82
	18:52	2043	71
	18:53	2879	91
	18:54	6017	167
	18:55	7737	337
	18:56	8615	492
	Average:	2723.351	110.6757

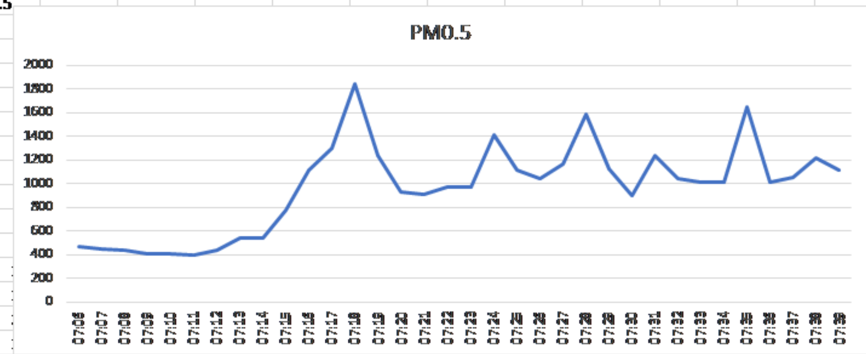


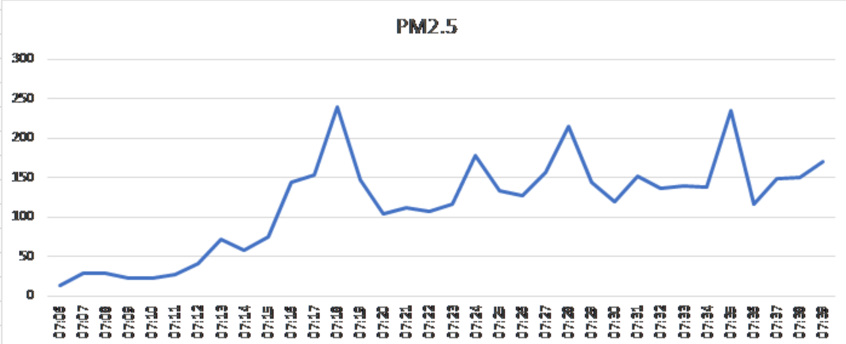


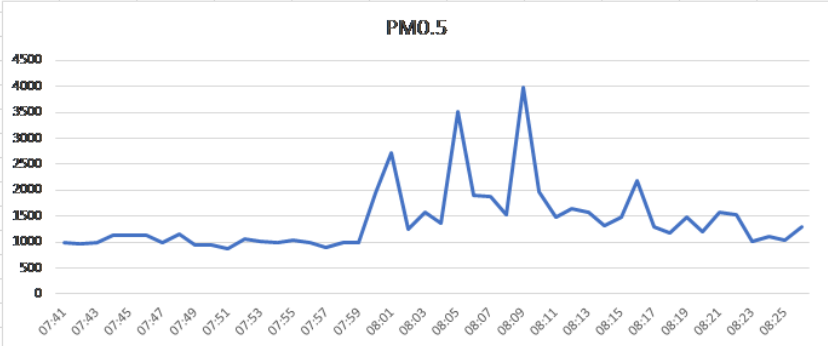


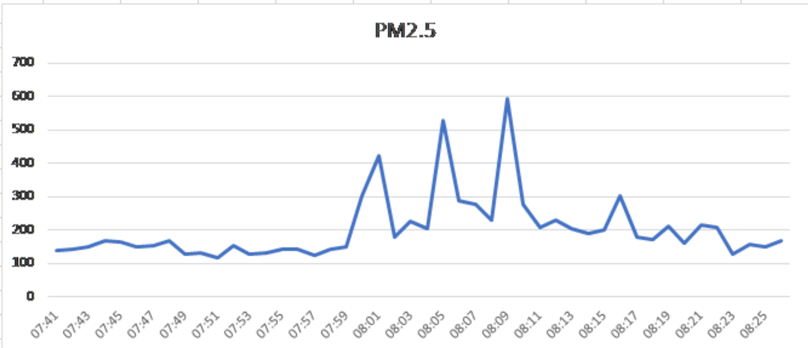


Date: 28/08/19			Morning
	Time:	PM0.5	PM2.5
1st	07:06	469	[illegible]
	07:07	449	[illegible]
	07:08	434	[illegible]
	07:09	409	[illegible]
	07:10	412	[illegible]
	07:11	395	[illegible]
	07:12	438	[illegible]
	07:13	546	[illegible]
	07:14	539	[illegible]
	07:15	775	[illegible]
	07:16	1112	[illegible]
	07:17	1298	[illegible]
	07:18	1844	[illegible]
	07:19	1238	[illegible]
	07:20	929	105
	07:21	908	112
	07:22	968	107
	07:23	968	116
	07:24	1415	178
	07:25	1112	134
	07:26	1041	127
	07:27	1163	156
	07:28	1592	215
	07:29	1124	144
	07:30	902	120
	07:31	1236	152
	07:32	1045	137
	07:33	1014	140
	07:34	1013	138
	07:35	1654	235
	07:36	1013	116
	07:37	1055	149
	07:38	1221	150
	07:39	1120	171
	Average:	966.2059	116.9706
	07:41	997	140
	07:42	970	143
	07:43	986	151
2nd	07:44	1129	169
	07:45	1131	166
	07:46	1121	152
	07:47	987	153
	07:48	1165	169
	07:49	939	130
	07:50	944	131
	07:51	875	118
	07:52	1051	156
	07:53	1008	129
	07:54	992	132
	07:55	1028	143
	07:56	984	142
	07:57	891	126
	07:58	1002	142
	07:59	993	151
	08:00	1952	303
	08:01	2715	425
	08:02	1254	179
	08:03	1565	227
	08:04	1354	206
	08:05	3517	528
	08:06	1912	288
	08:07	1876	279
	08:08	1540	231
	08:09	3994	593
	08:10	1971	278
	08:11	1494	208
	08:12	1646	232
	08:13	1587	206
	08:14	1326	189
	08:15	1481	203
	08:16	2175	303
	08:17	1290	180
	08:18	1181	173
	08:19	1487	211
	08:20	1207	161
	08:21	1581	217
	08:22	1521	208
	08:23	1005	129
	08:24	1102	158
	08:25	1027	149
	08:26	1289	170
	Average:	1418.304	203.8478

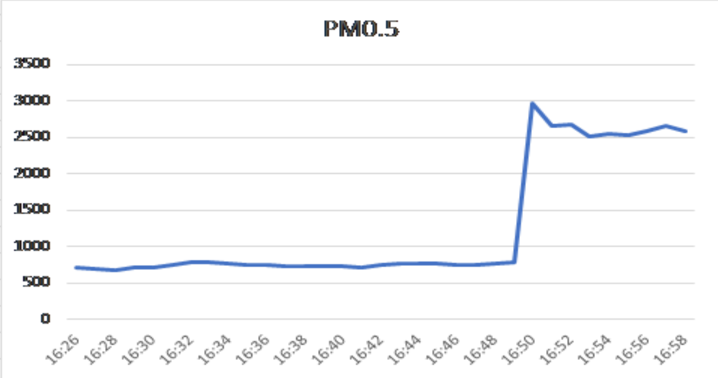


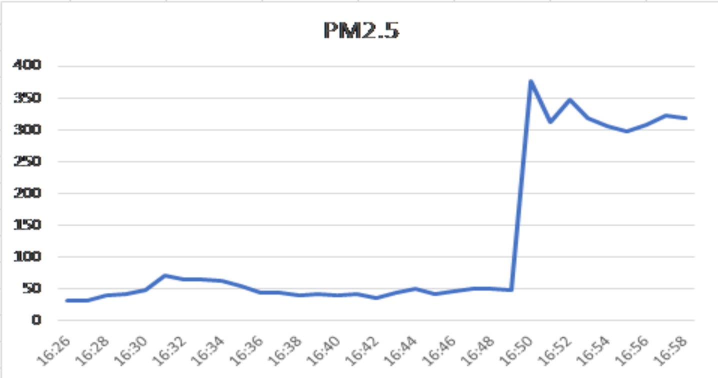


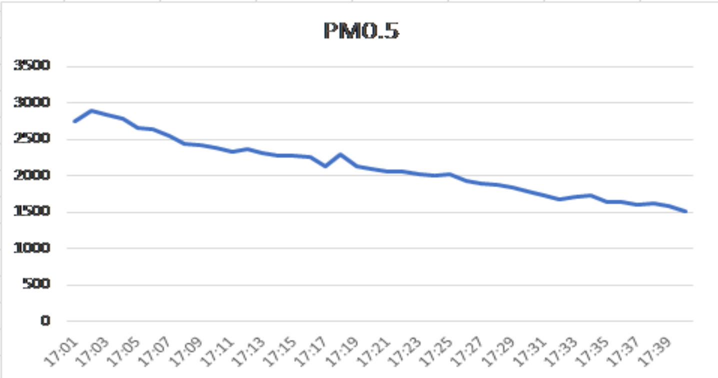


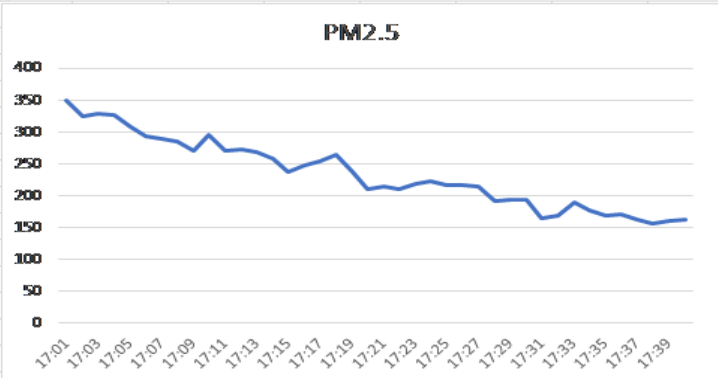


Evening		
Time:	PM0.5	PM2.5
16:26	723	33
16:27	698	31
16:28	682	40
16:29	720	43
16:30	709	49
16:31	750	72
16:32	785	65
16:33	784	66
16:34	763	64
16:35	750	54
16:36	746	45
16:37	736	44
16:38	729	40
16:39	736	42
16:40	732	41
16:41	714	43
16:42	748	36
16:43	768	45
16:44	771	50
16:45	778	42
16:46	748	46
16:47	752	51
16:48	779	51
16:49	794	49
16:50	2976	378
16:51	2668	313
16:52	2673	347
16:53	2526	319
16:54	2556	306
16:55	2531	298
16:56	2591	308
16:57	2656	324
16:58	2593	319
Average:	1262.576	122.8485
17:01	2751	350
17:02	2901	325
17:03	2852	330
17:04	2793	328
17:05	2658	308
17:06	2639	293
17:07	2555	289
17:08	2437	285
17:09	2434	271
17:10	2394	297
17:11	2327	270
17:12	2377	273
17:13	2314	268
17:14	2284	259
17:15	2275	237
17:16	2254	248
17:17	2135	254
17:18	2290	264
17:19	2132	238
17:20	2090	210
17:21	2058	215
17:22	2063	210
17:23	2029	219
17:24	2014	223
17:25	2032	218
17:26	1943	217
17:27	1905	214
17:28	1877	192
17:29	1846	194
17:30	1787	194
17:31	1732	165
17:32	1680	169
17:33	1724	190
17:34	1729	178
17:35	1636	170
17:36	1647	172
17:37	1607	162
17:38	1627	156
17:39	1585	160
17:40	1523	162
Average:	2123.4	234.425



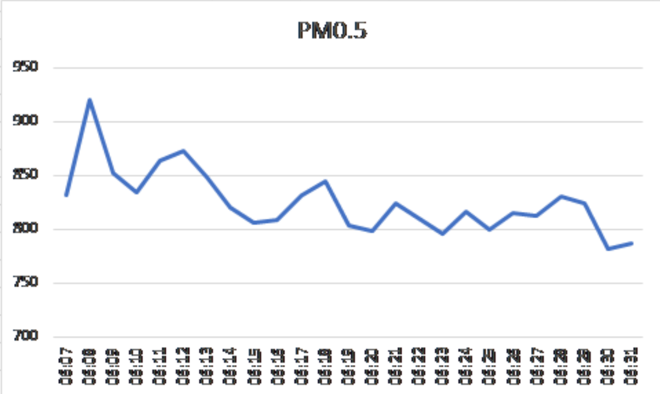


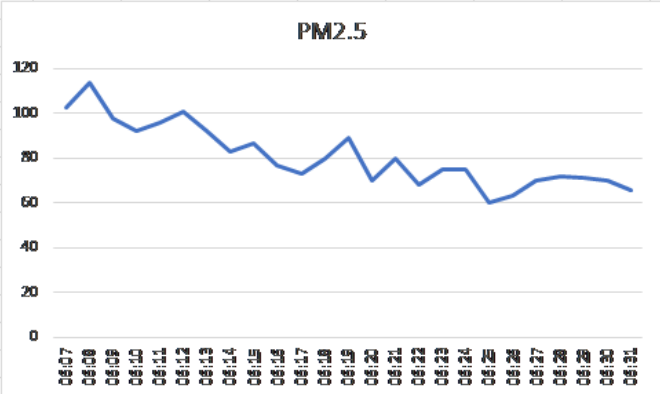


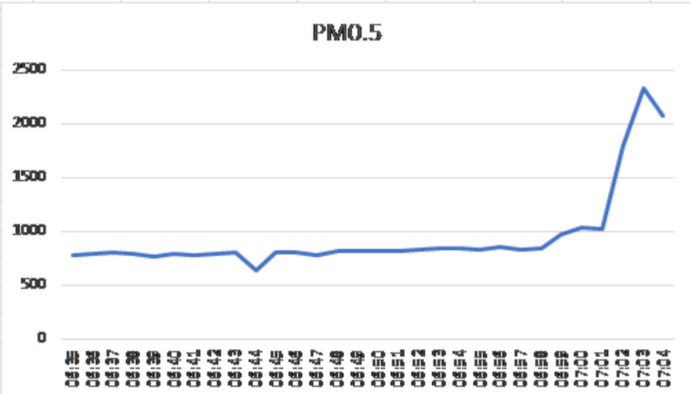


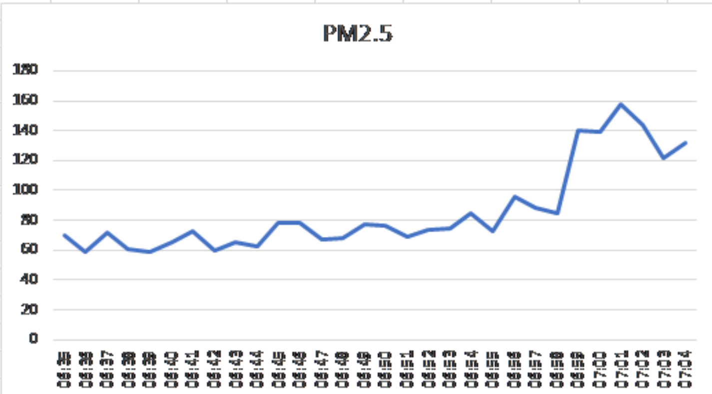
	Date:02/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	06:07	832	103
	06:08	921	114
	06:09	852	98
	06:10	834	92
	06:11	864	96
	06:12	873	101
	06:13	848	92
	06:14	820	83
	06:15	806	87
	06:16	809	77
	06:17	832	73
	06:18	845	80
	06:19	803	89
	06:20	798	70
	06:21	824	80
	06:22	810	68
	06:23	796	75
	06:24	817	75
	06:25	800	60
	06:26	815	63
	06:27	813	70
	06:28	831	72
	06:29	824	71
	06:30	782	70
	06:31	787	66
	Average:	825.44	81
2nd	06:35	781	70
	06:36	793	59
	06:37	806	72
	06:38	793	61
	06:39	771	59
	06:40	798	65
	06:41	781	73
	06:42	787	60
	06:43	806	65
	06:44	640	63
	06:45	799	78
	06:46	801	78
	06:47	782	67
	06:48	821	68
	06:49	819	77
	06:50	814	76
	06:51	818	69
	06:52	825	74
	06:53	845	75
	06:54	838	85
	06:55	825	73
	06:56	859	96
	06:57	835	88
	06:58	844	85
	06:59	973	140
	07:00	1030	139
	07:01	1026	158
	07:02	1787	144
	07:03	2334	122
	07:04	2074	132
	Average:	950.1667	85.7

Evening	
1st	no data
2nd	no data





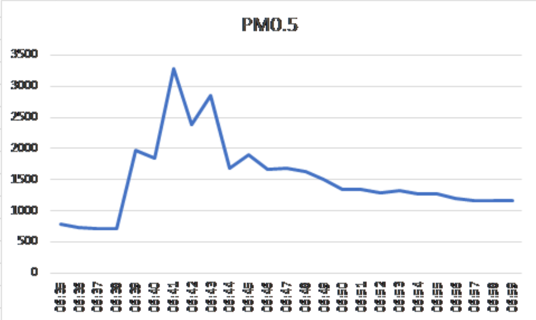


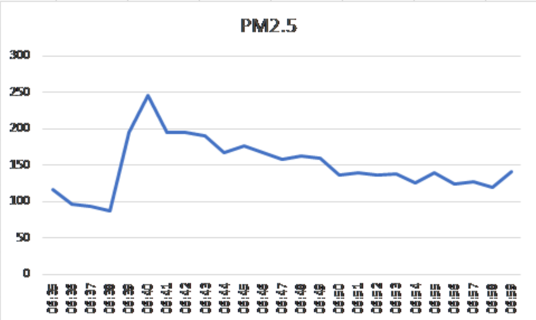


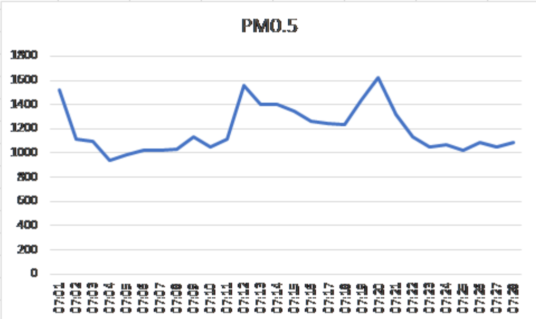
Date:03/09/19

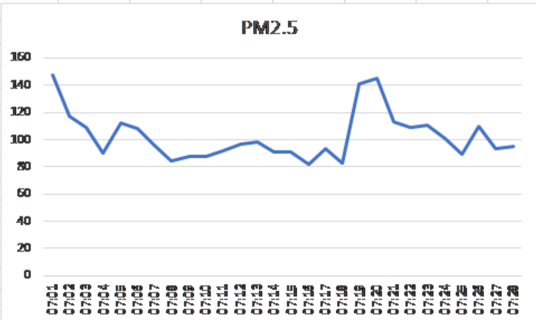
Morning

	Time:	PM0.5	PM2.5
1st	06:35	782	116
	06:36	738	97
	06:37	718	94
	06:38	721	88
	06:39	1973	195
	06:40	1853	246
	06:41	3292	195
	06:42	2388	195
	06:43	2848	191
	06:44	1690	168
	06:45	1905	176
	06:46	1673	167
	06:47	1675	158
	06:48	1630	163
	06:49	1513	160
	06:50	1346	136
	06:51	1346	139
	06:52	1292	136
	06:53	1320	138
	06:54	1265	126
	06:55	1263	140
	06:56	1190	124
	06:57	1163	127
	06:58	1164	120
	06:59	1156	142
	Average:	1516.16	149.48
2nd	07:01	1526	148
	07:02	1111	117
	07:03	1093	109
	07:04	943	90
	07:05	985	112
	07:06	1023	108
	07:07	1024	96
	07:08	1034	84
	07:09	1135	88
	07:10	1051	88
	07:11	1113	92
	07:12	1560	97
	07:13	1404	98
	07:14	1402	91
	07:15	1350	91
	07:16	1259	82
	07:17	1244	93
	07:18	1240	83
	07:19	1435	141
	07:20	1620	145
	07:21	1316	113
	07:22	1134	109
	07:23	1052	111
	07:24	1070	101
	07:25	1022	89
	07:26	1084	110
	07:27	1048	93
	07:28	1085	95
	Average:	1191.536	102.6429





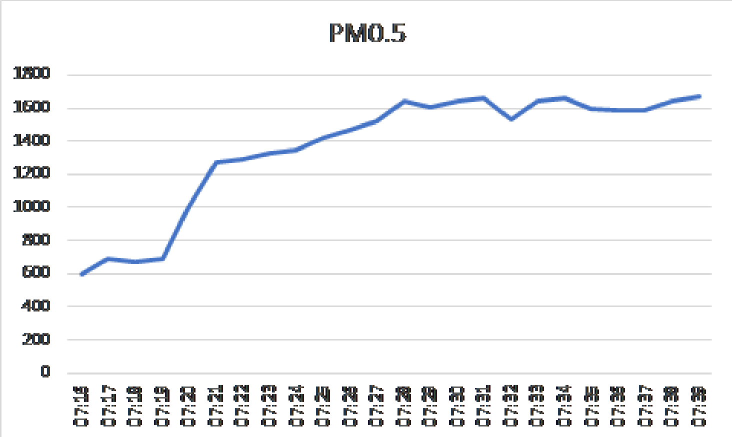


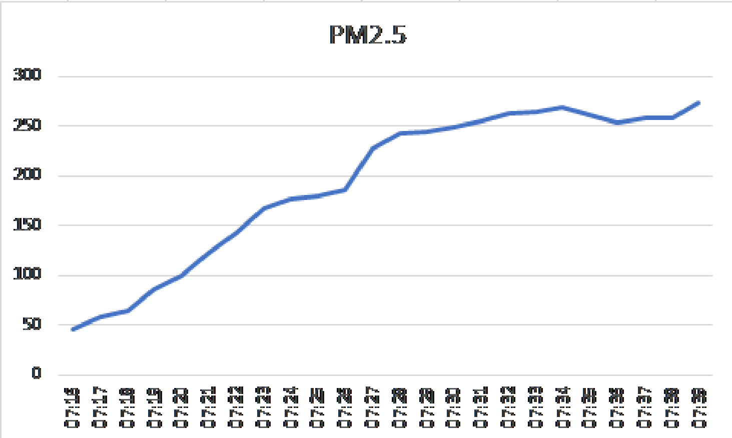


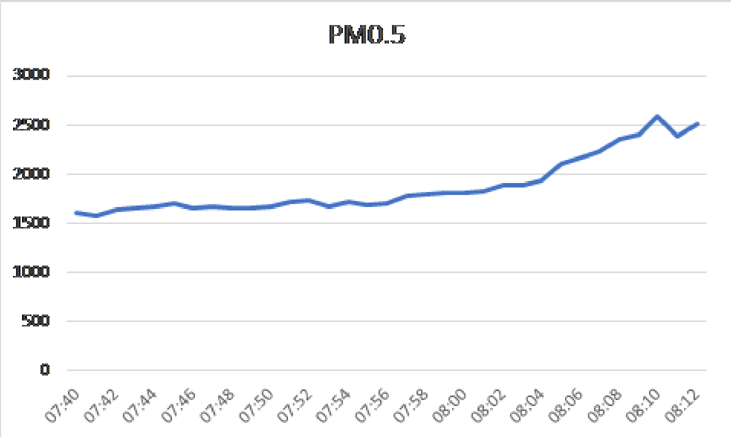
Evening

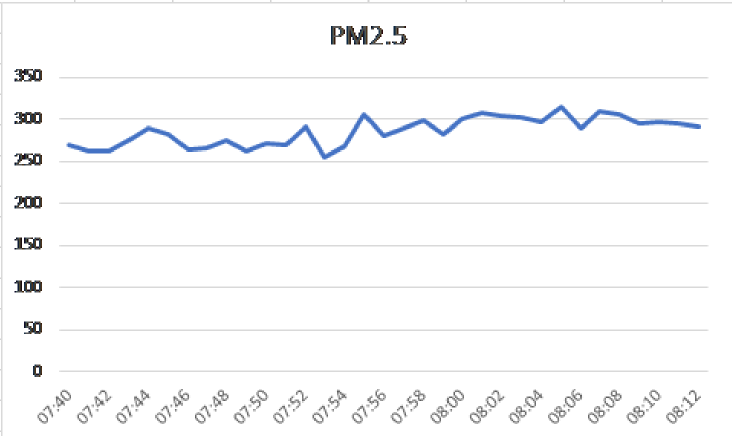
	Time:	PM0.5	PM2.5
1st			
no data			
2nd			
no data			

	Date:10/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:16	594	45
	07:17	694	58
	07:18	668	64
	07:19	689	86
	07:20	1007	100
	07:21	1272	122
	07:22	1289	143
	07:23	1328	168
	07:24	1351	176
	07:25	1420	180
	07:26	1470	186
	07:27	1525	228
	07:28	1646	243
	07:29	1608	245
	07:30	1643	249
	07:31	1661	256
	07:32	1534	263
	07:33	1639	264
	07:34	1662	269
	07:35	1592	261
	07:36	1591	253
	07:37	1586	258
	07:38	1643	259
	07:39	1669	273
	Average:	1365.875	193.7083
2nd	07:40	1612	269
	07:41	1575	263
	07:42	1638	262
	07:43	1663	276
	07:44	1679	289
	07:45	1701	282
	07:46	1665	264
	07:47	1677	267
	07:48	1660	275
	07:49	1657	262
	07:50	1679	271
	07:51	1718	269
	07:52	1743	291
	07:53	1668	256
	07:54	1715	268
	07:55	1686	307
	07:56	1710	281
	07:57	1780	289
	07:58	1792	299
	07:59	1811	283
	08:00	1814	301
	08:01	1833	308
	08:02	1898	305
	08:03	1891	303
	08:04	1941	297
	08:05	2105	316
	08:06	2179	290
	08:07	2230	309
	08:08	2357	306
	08:09	2410	296
	08:10	2588	297
	08:11	2385	296
	08:12	2522	292
	Average:	1878.242	286.0303

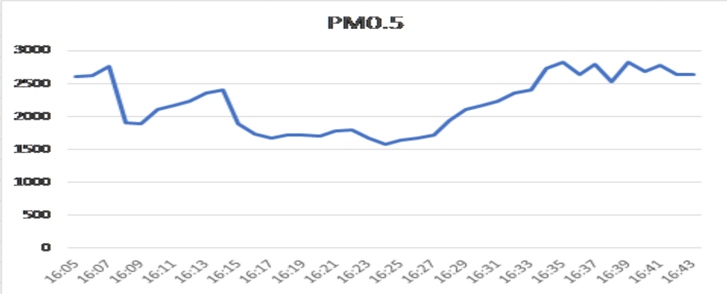


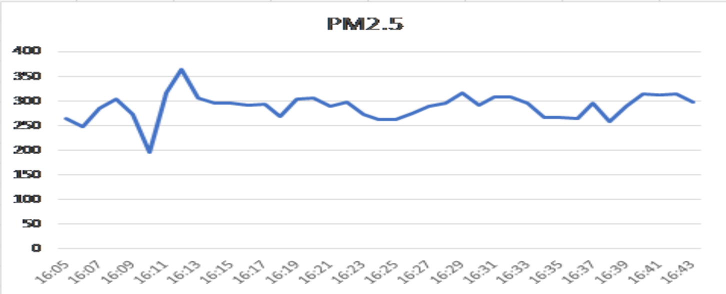




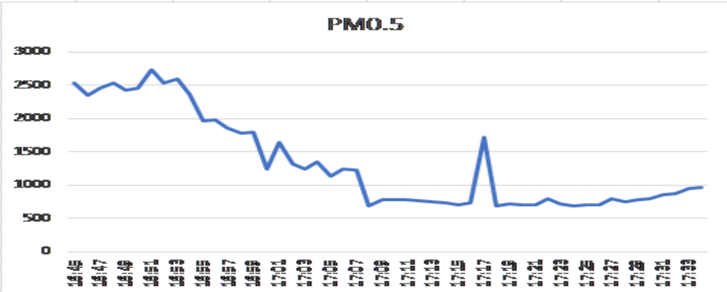


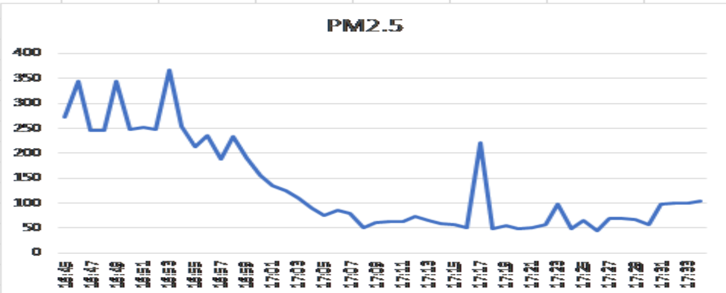
	Evening		
1st	Time:	PM0.5	PM2.5
	16:05	2605	264
	16:06	2619	248
	16:07	2765	286
	16:08	1901	304
	16:09	1892	274
	16:10	2105	197
	16:11	2179	316
	16:12	2230	365
	16:13	2357	306
	16:14	2410	296
	16:15	1892	296
	16:16	1743	291
	16:17	1668	294
	16:18	1715	268
	16:19	1728	304
	16:20	1710	307
	16:21	1780	289
	16:22	1792	299
	16:23	1669	273
	16:24	1573	263
	16:25	1639	262
	16:26	1679	276
	16:27	1724	289
	16:28	1942	297
	16:29	2105	316
	16:30	2179	291
	16:31	2238	309
	16:32	2357	308
	16:33	2410	296
	16:34	2742	266
	16:35	2830	266
	16:36	2637	265
	16:37	2798	297
	16:38	2536	258
	16:39	2834	290
	16:40	2693	314
	16:41	2782	312
	16:42	2634	314
	16:43	2643	298
	Average:	2198.333	288.8205



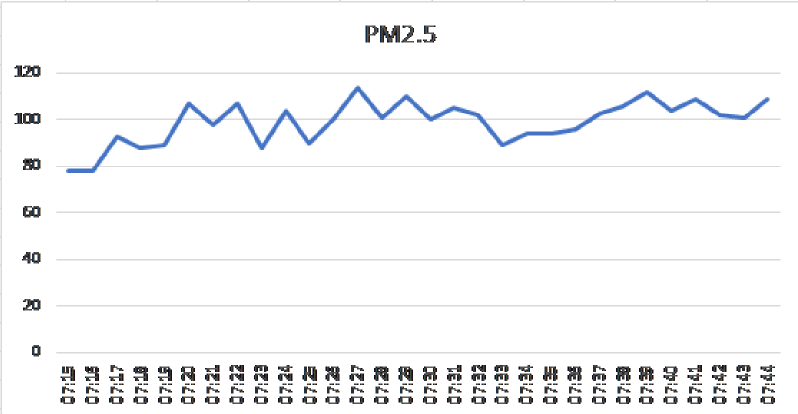


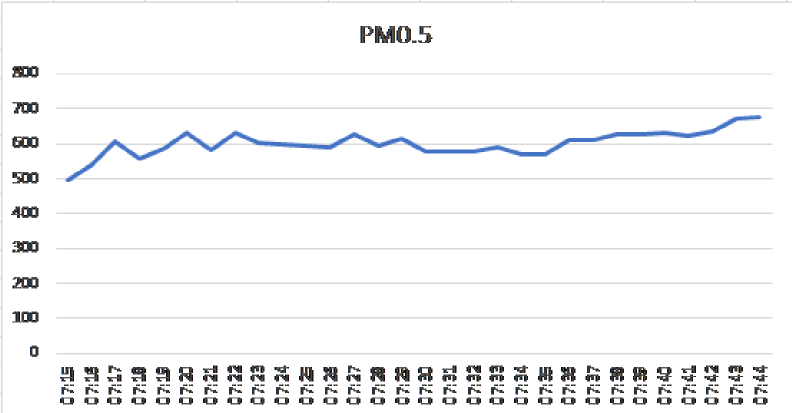
2nd	16:45	2536	273
	16:46	2356	345
	16:47	2464	245
	16:48	2536	246
	16:49	2435	345
	16:50	2456	247
	16:51	2733	253
	16:52	2535	248
	16:53	2597	367
	16:54	2363	255
	16:55	1965	214
	16:56	1975	235
	16:57	1854	189
	16:58	1785	234
	16:59	1796	190
	17:00	1245	156
	17:01	1637	134
	17:02	1324	124
	17:03	1243	110
	17:04	1345	89
	17:05	1135	76
	17:06	1243	85
	17:07	1234	80
	17:08	694	51
	17:09	781	61
	17:10	788	62
	17:11	781	64
	17:12	765	74
	17:13	744	66
	17:14	737	58
	17:15	711	57
	17:16	733	51
	17:17	1717	221
	17:18	686	48
	17:19	723	54
	17:20	699	48
	17:21	698	51
	17:22	794	56
	17:23	712	97
	17:24	695	49
	17:25	697	65
	17:26	698	45
	17:27	793	69
	17:28	756	69
	17:29	784	68
	17:30	789	56
	17:31	865	98
	17:32	869	99
	17:33	945	101
	17:34	965	104
	Average:	1328.22	133.64

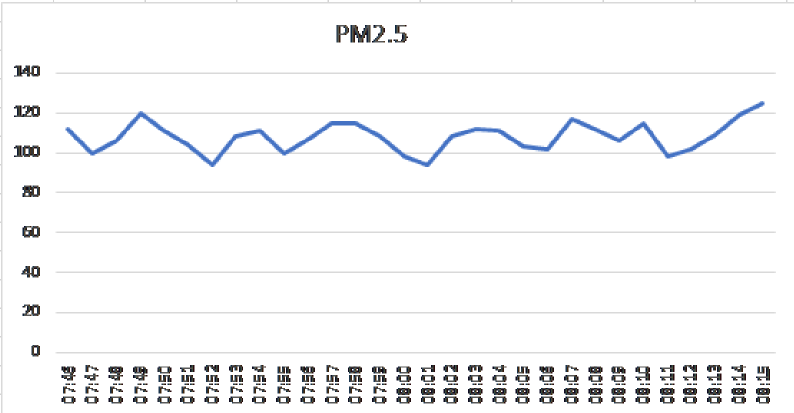


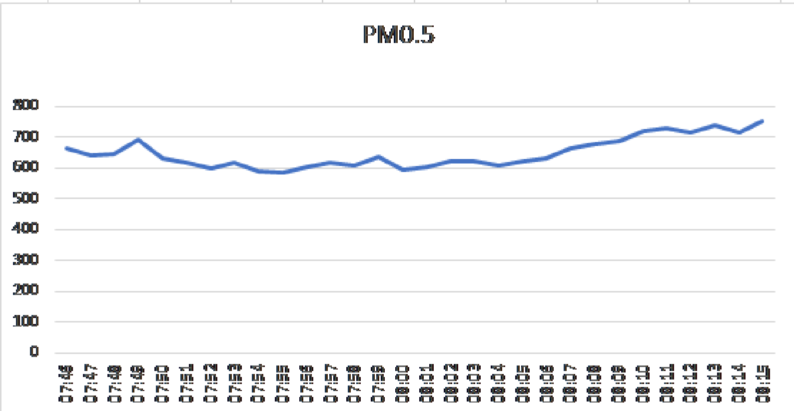


	Date:11/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:15	496	78
	07:16	542	78
	07:17	608	93
	07:18	558	88
	07:19	588	89
	07:20	632	107
	07:21	584	98
	07:22	631	107
	07:23	604	88
	07:24	599	104
	07:25	593	90
	07:26	591	100
	07:27	627	114
	07:28	593	101
	07:29	616	110
	07:30	577	100
	07:31	576	105
	07:32	576	102
	07:33	589	89
	07:34	569	94
	07:35	569	94
	07:36	609	96
	07:37	612	103
	07:38	629	106
	07:39	629	112
	07:40	631	104
	07:41	624	109
	07:42	635	102
	07:43	673	101
	07:44	678	109
	Average:	601.2667	99.03333
2nd	07:46	663	112
	07:47	642	100
	07:48	647	106
	07:49	692	120
	07:50	632	111
	07:51	619	104
	07:52	600	94
	07:53	618	108
	07:54	590	111
	07:55	585	100
	07:56	602	107
	07:57	616	115
	07:58	607	115
	07:59	634	108
	08:00	592	98
	08:01	605	94
	08:02	623	108
	08:03	620	112
	08:04	606	111
	08:05	623	103
	08:06	630	102
	08:07	663	117
	08:08	676	112
	08:09	685	106
	08:10	720	115
	08:11	729	98
	08:12	713	102
	08:13	737	109
	08:14	716	119
	08:15	751	125
	Average:	647.8667	108.0667

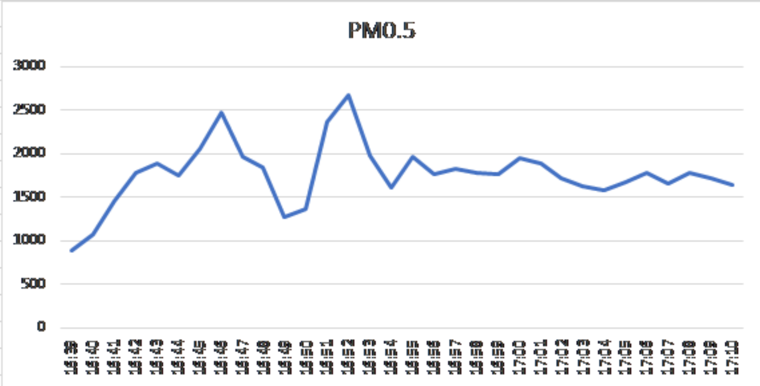


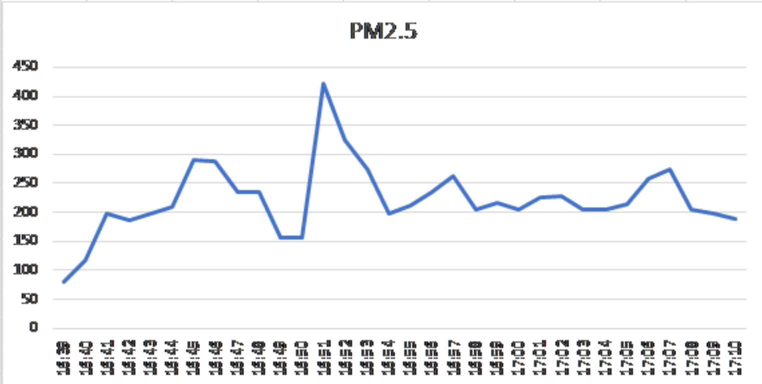


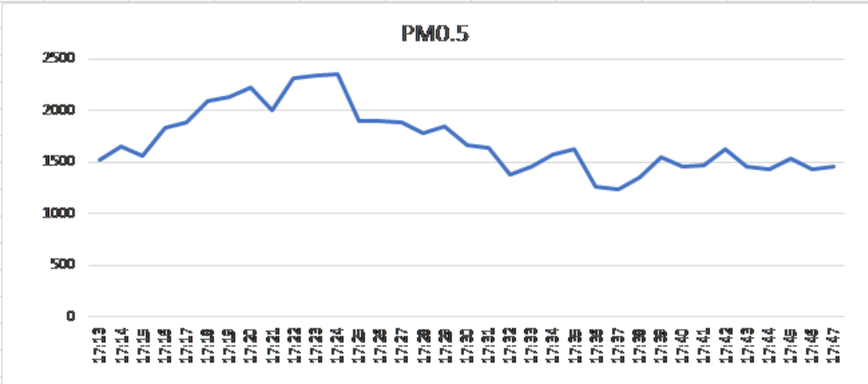


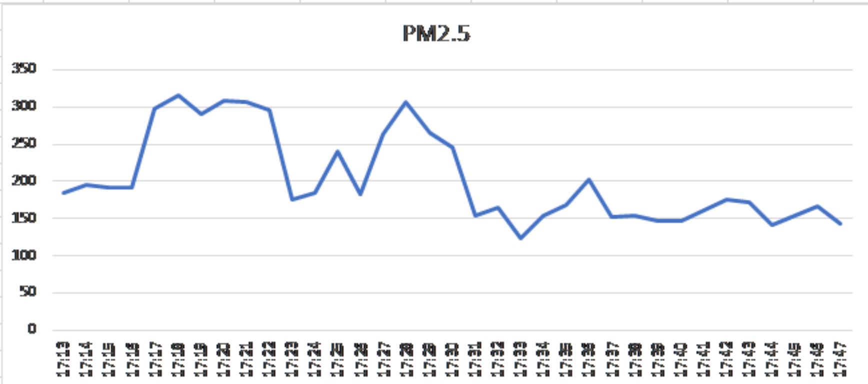


	Evening		
1st	Time:	PM0.5	PM2.5
	16:39	886	81
	16:40	1075	118
	16:41	1457	198
	16:42	1785	187
	16:43	1897	198
	16:44	1753	209
	16:45	2053	290
	16:46	2468	289
	16:47	1964	234
	16:48	1845	235
	16:49	1278	156
	16:50	1370	157
	16:51	2367	422
	16:52	2674	325
	16:53	1989	275
	16:54	1607	199
	16:55	1974	213
	16:56	1764	236
	16:57	1829	263
	16:58	1785	205
	16:59	1765	217
	17:00	1957	204
	17:01	1894	226
	17:02	1725	227
	17:03	1623	205
	17:04	1576	206
	17:05	1678	215
	17:06	1785	257
	17:07	1666	275
	17:08	1784	205
	17:09	1723	197
	17:10	1648	189
	Average:	1770.125	222.2813
2nd	17:13	1525	185
	17:14	1657	196
	17:15	1567	191
	17:16	1834	191
	17:17	1894	297
	17:18	2095	316
	17:19	2134	290
	17:20	2230	309
	17:21	2009	306
	17:22	2324	296
	17:23	2348	176
	17:24	2360	184
	17:25	1907	240
	17:26	1897	183
	17:27	1885	263
	17:28	1783	307
	17:29	1847	265
	17:30	1674	245
	17:31	1646	154
	17:32	1376	165
	17:33	1459	123
	17:34	1578	154
	17:35	1634	168
	17:36	1265	202
	17:37	1245	152
	17:38	1356	154
	17:39	1550	146
	17:40	1457	146
	17:41	1468	162
	17:42	1629	175
	17:43	1456	172
	17:44	1436	142
	17:45	1538	154
	17:46	1429	166
	17:47	1465	143
	Average:	1713.057	203.3714

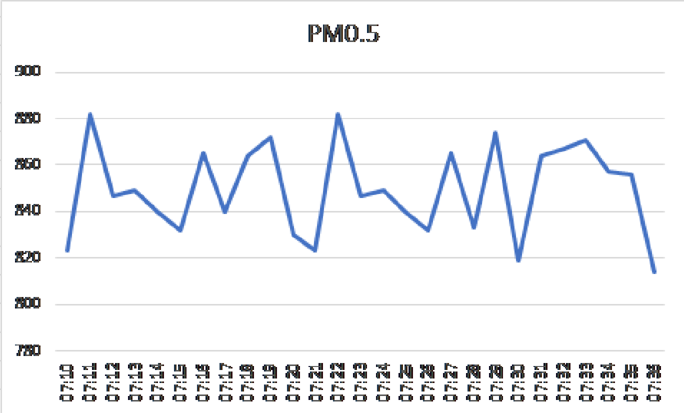


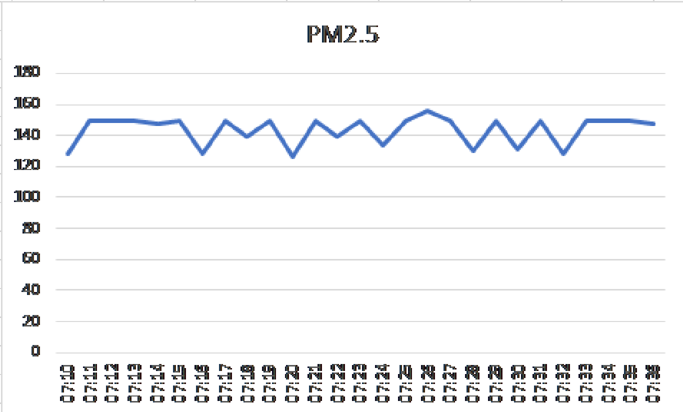


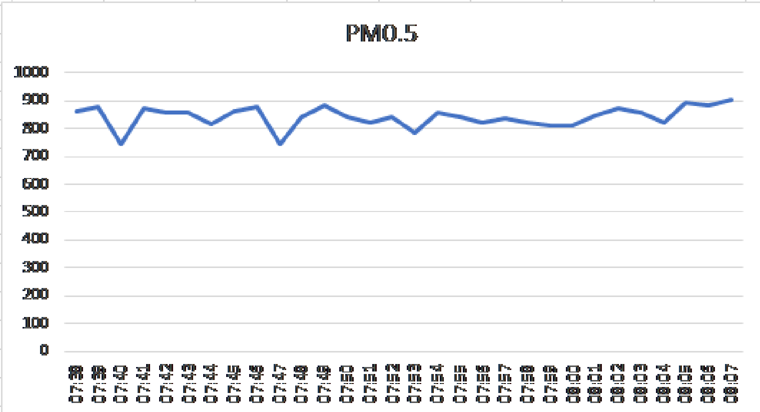


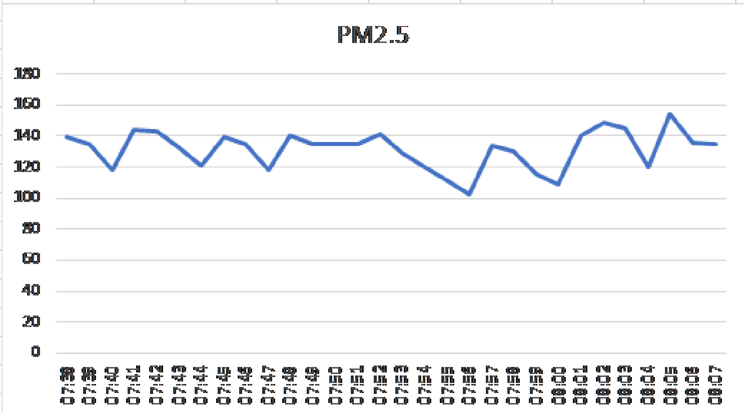


	Date:12/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:10	823	128
	07:11	882	149
	07:12	847	149
	07:13	849	149
	07:14	840	148
	07:15	832	149
	07:16	865	128
	07:17	840	149
	07:18	864	139
	07:19	872	149
	07:20	830	126
	07:21	823	149
	07:22	882	139
	07:23	847	149
	07:24	849	134
	07:25	840	149
	07:26	832	156
	07:27	865	149
	07:28	833	130
	07:29	874	149
	07:30	819	131
	07:31	864	149
	07:32	867	128
	07:33	871	149
	07:34	857	149
	07:35	856	149
	07:36	814	148
		849.5185	143.3333
2nd	07:38	862	139
	07:39	877	135
	07:40	744	118
	07:41	871	144
	07:42	857	143
	07:43	856	133
	07:44	815	121
	07:45	862	139
	07:46	877	135
	07:47	744	118
	07:48	842	140
	07:49	880	135
	07:50	843	135
	07:51	822	135
	07:52	842	141
	07:53	786	129
	07:54	856	120
	07:55	839	112
	07:56	820	102
	07:57	836	134
	07:58	822	130
	07:59	811	115
	08:00	808	109
	08:01	844	140
	08:02	874	149
	08:03	856	145
	08:04	823	120
	08:05	893	154
	08:06	881	136
	08:07	904	135
		841.5667	131.3667

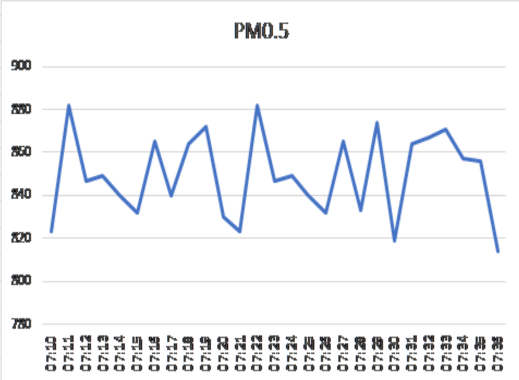


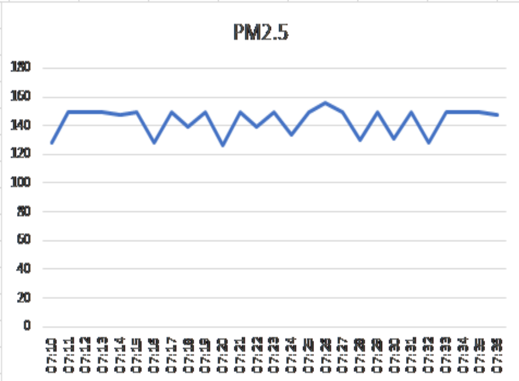


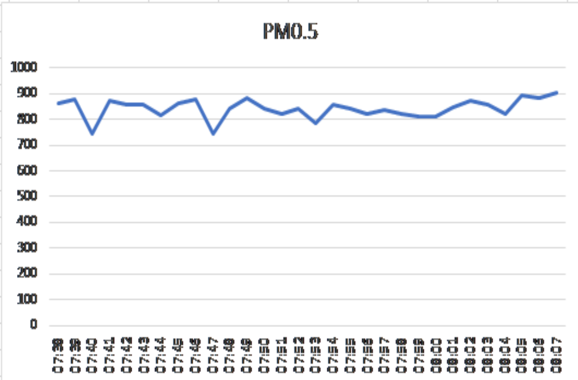


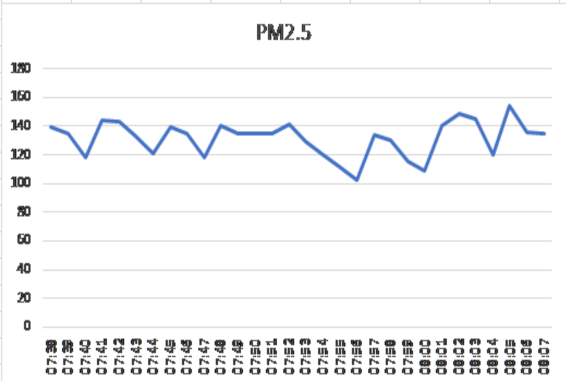


	Date:12/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:10	823	128
	07:11	882	149
	07:12	847	149
	07:13	849	149
	07:14	840	148
	07:15	832	149
	07:16	865	128
	07:17	840	149
	07:18	864	139
	07:19	872	149
	07:20	830	126
	07:21	823	149
	07:22	882	139
	07:23	847	149
	07:24	849	134
	07:25	840	149
	07:26	832	156
	07:27	865	149
	07:28	833	130
	07:29	874	149
	07:30	819	131
	07:31	864	149
	07:32	867	128
	07:33	871	149
	07:34	857	149
	07:35	856	149
	07:36	814	148
		849.5185	143.3333
2nd	07:38	862	139
	07:39	877	135
	07:40	744	118
	07:41	871	144
	07:42	857	143
	07:43	856	133
	07:44	815	121
	07:45	862	139
	07:46	877	135
	07:47	744	118
	07:48	842	140
	07:49	880	135
	07:50	843	135
	07:51	822	135
	07:52	842	141
	07:53	786	129
	07:54	856	120
	07:55	839	112
	07:56	820	102
	07:57	836	134
	07:58	822	130
	07:59	811	115
	08:00	808	109
	08:01	844	140
	08:02	874	149
	08:03	856	145
	08:04	823	120
	08:05	893	154
	08:06	881	136
	08:07	904	135
		841.5667	131.3667



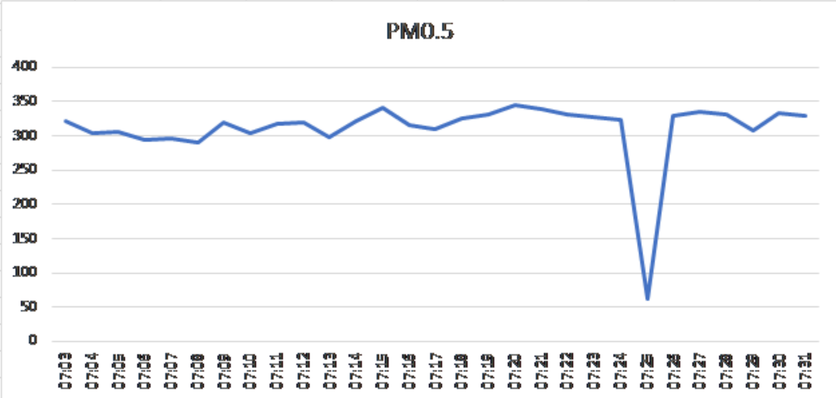


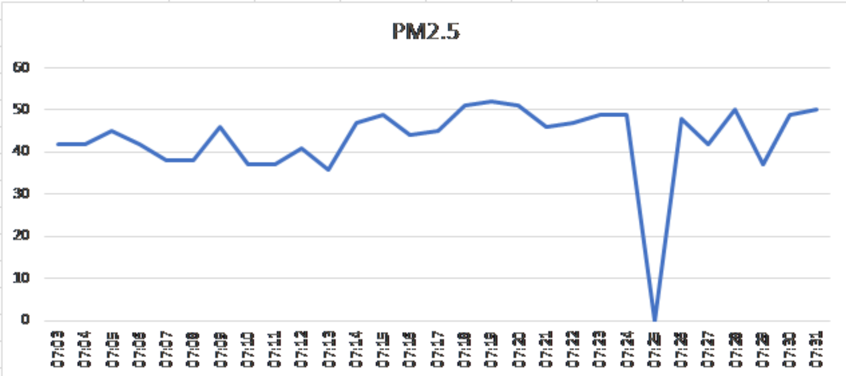


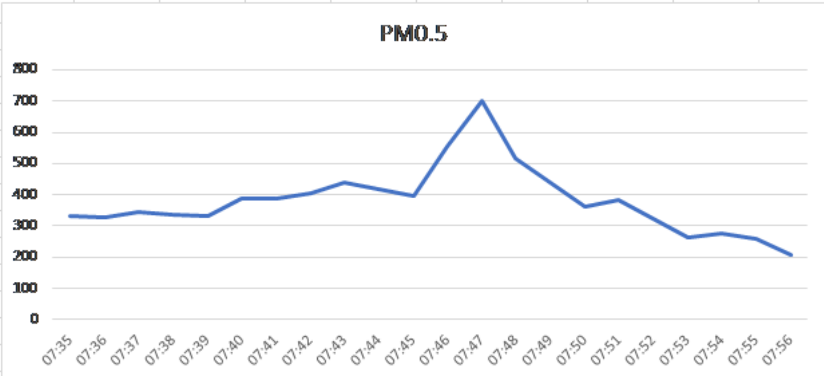


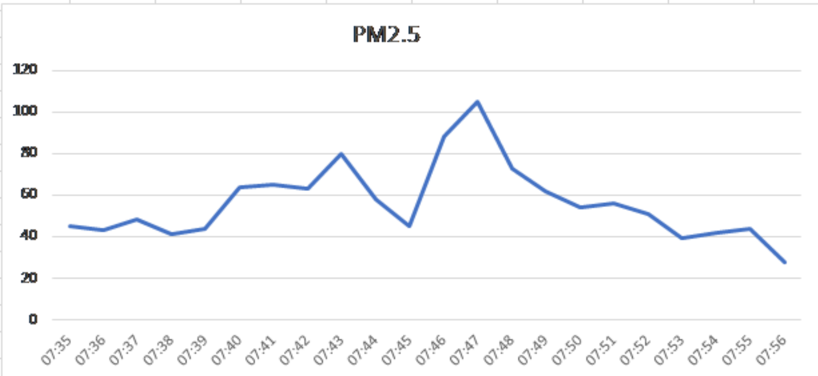
	Evening		
1st	Time:	PM0.5	PM2.5
no data			
2nd			
no data			

	Date:15/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:03	322	42
	07:04	304	42
	07:05	307	45
	07:06	295	42
	07:07	296	38
	07:08	290	38
	07:09	319	46
	07:10	305	37
	07:11	318	37
	07:12	320	41
	07:13	298	36
	07:14	322	47
	07:15	342	49
	07:16	315	44
	07:17	310	45
	07:18	325	51
	07:19	331	52
	07:20	345	51
	07:21	339	46
	07:22	332	47
	07:23	327	49
	07:24	323	49
	07:25	63	0
	07:26	330	48
	07:27	336	42
	07:28	331	50
	07:29	309	37
	07:30	333	49
	07:31	330	50
	Average:	310.931	43.10345
2nd	07:35	333	45
	07:36	326	43
	07:37	343	48
	07:38	336	41
	07:39	332	44
	07:40	388	64
	07:41	388	65
	07:42	403	63
	07:43	441	80
	07:44	416	58
	07:45	397	45
	07:46	554	88
	07:47	703	105
	07:48	518	73
	07:49	440	62
	07:50	364	54
	07:51	384	56
	07:52	324	51
	07:53	263	39
	07:54	275	42
	07:55	261	44
	07:56	206	28
	Average:	381.5909	56.27273

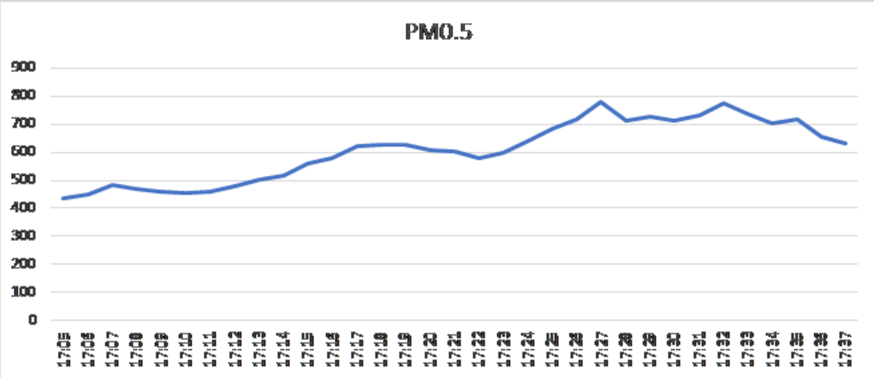


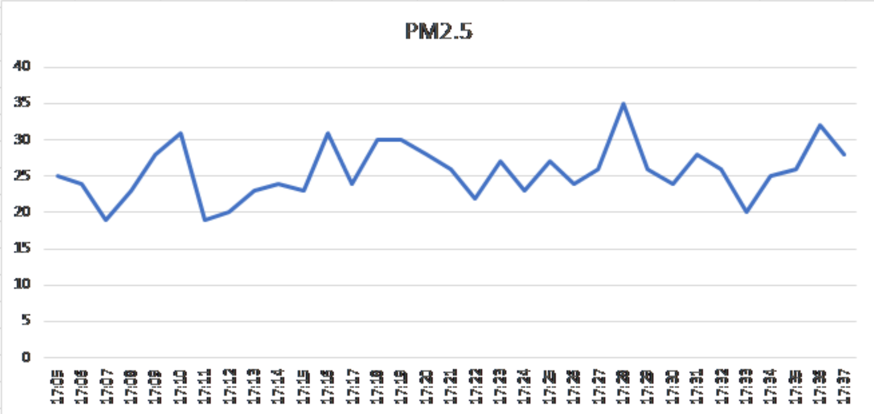


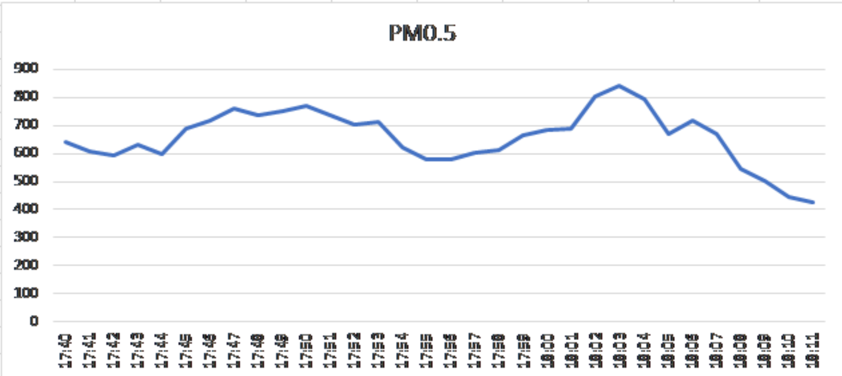


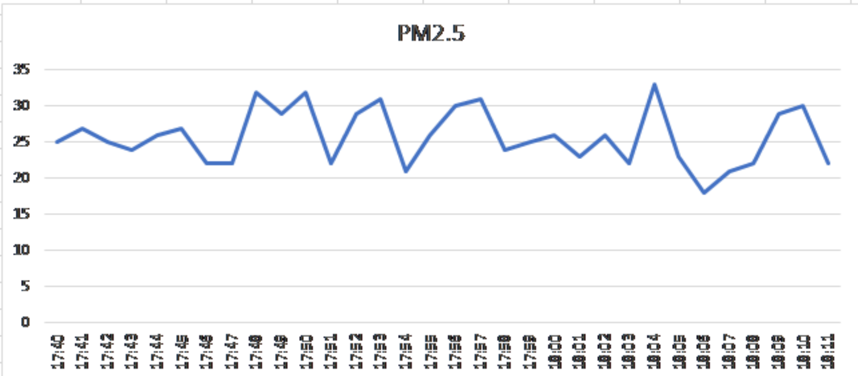


	Evening		
1st	Time:	PM0.5	PM2.5
	17:05	436	25
	17:06	449	24
	17:07	485	19
	17:08	469	23
	17:09	458	28
	17:10	456	31
	17:11	461	19
	17:12	480	20
	17:13	501	23
	17:14	519	24
	17:15	558	23
	17:16	577	31
	17:17	624	24
	17:18	625	30
	17:19	627	30
	17:20	606	28
	17:21	603	26
	17:22	579	22
	17:23	597	27
	17:24	641	23
	17:25	684	27
	17:26	718	24
	17:27	778	26
	17:28	713	35
	17:29	725	26
	17:30	714	24
	17:31	733	28
	17:32	772	26
	17:33	738	20
	17:34	701	25
	17:35	718	26
	17:36	655	32
	17:37	633	28
	Average:	607.0606	25.66667
2nd	17:40	639	25
	17:41	607	27
	17:42	592	25
	17:43	634	24
	17:44	597	26
	17:45	688	27
	17:46	717	22
	17:47	763	22
	17:48	738	32
	17:49	752	29
	17:50	768	32
	17:51	738	22
	17:52	701	29
	17:53	715	31
	17:54	621	21
	17:55	581	26
	17:56	580	30
	17:57	603	31
	17:58	614	24
	17:59	663	25
	18:00	682	26
	18:01	691	23
	18:02	802	26
	18:03	844	22
	18:04	794	33
	18:05	669	23
	18:06	716	18
	18:07	668	21
	18:08	545	22
	18:09	501	29
	18:10	447	30
	18:11	428	22
	Average:	659.3125	25.78125

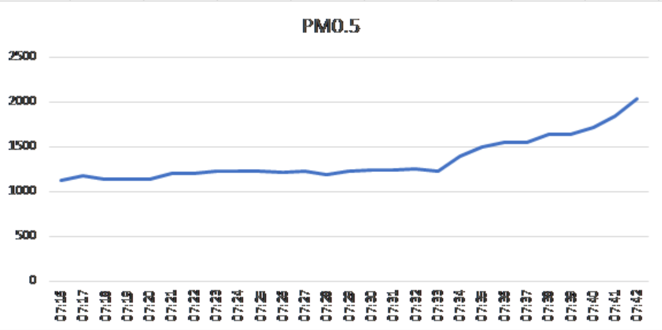


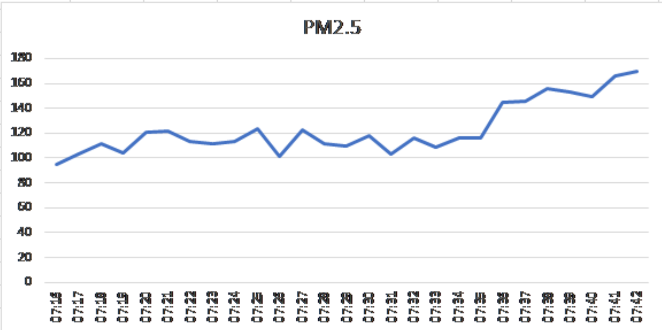


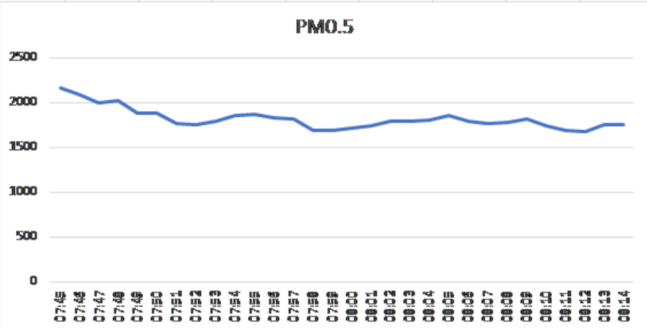


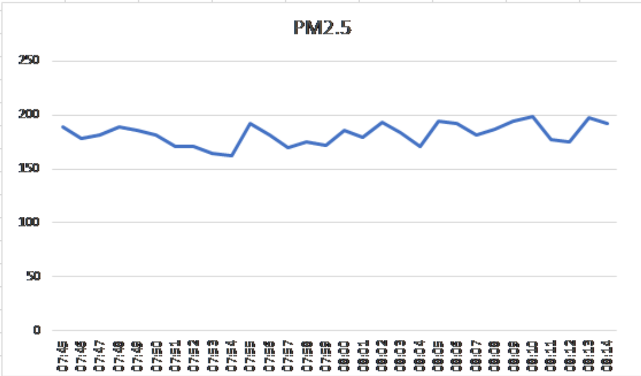


	Date:17/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:16	1121	95
	07:17	1176	103
	07:18	1133	112
	07:19	1134	104
	07:20	1144	121
	07:21	1209	122
	07:22	1202	113
	07:23	1229	112
	07:24	1225	113
	07:25	1228	124
	07:26	1218	101
	07:27	1234	123
	07:28	1195	112
	07:29	1229	110
	07:30	1246	118
	07:31	1235	103
	07:32	1260	116
	07:33	1227	109
	07:34	1400	116
	07:35	1500	116
	07:36	1547	145
	07:37	1546	146
	07:38	1637	156
	07:39	1637	153
	07:40	1715	149
	07:41	1848	166
	07:42	2031	170
	Average:	1352.074	123.2593
2nd	07:45	2168	189
	07:46	2088	178
	07:47	1999	182
	07:48	2023	189
	07:49	1886	186
	07:50	1884	181
	07:51	1762	171
	07:52	1759	171
	07:53	1799	164
	07:54	1857	162
	07:55	1874	192
	07:56	1836	182
	07:57	1824	170
	07:58	1696	175
	07:59	1691	172
	08:00	1712	186
	08:01	1739	179
	08:02	1795	193
	08:03	1789	184
	08:04	1802	171
	08:05	1854	194
	08:06	1794	192
	08:07	1768	182
	08:08	1781	187
	08:09	1824	194
	08:10	1747	199
	08:11	1697	177
	08:12	1682	175
	08:13	1751	197
	08:14	1757	192
	Average:	1821.267	182.2



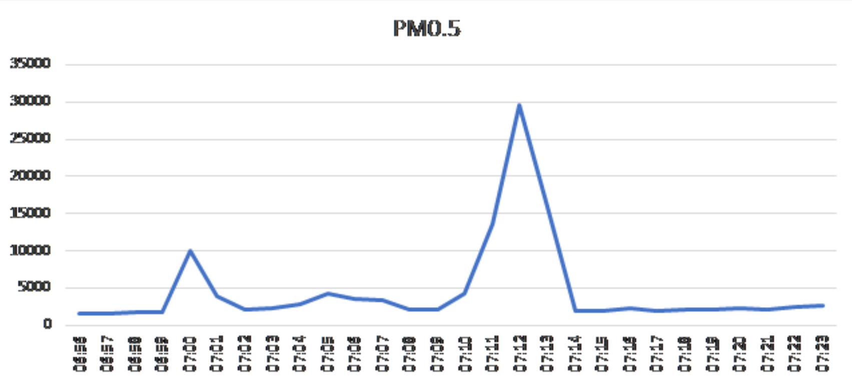


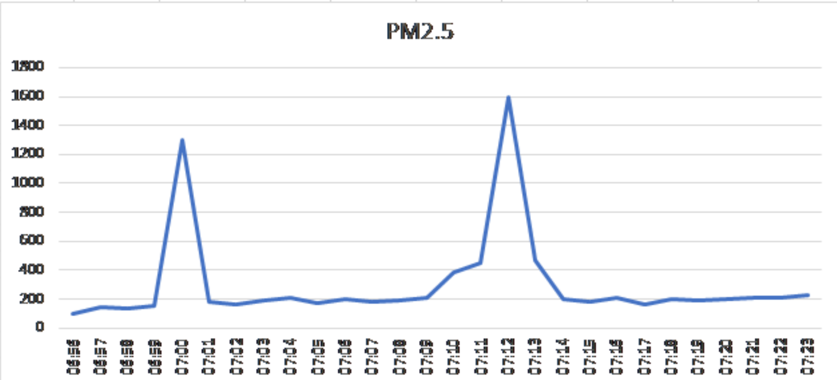


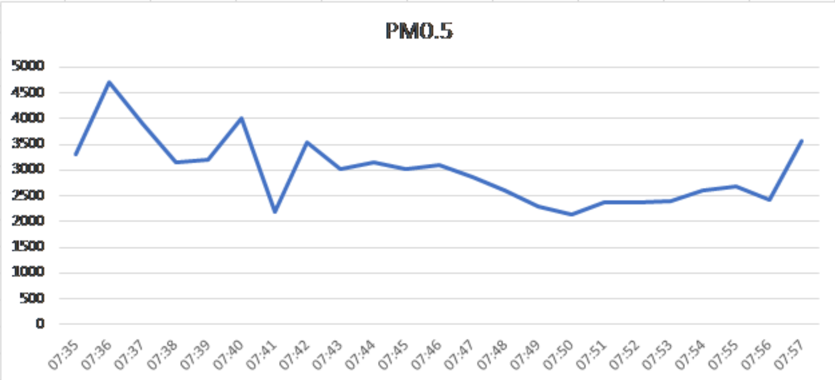


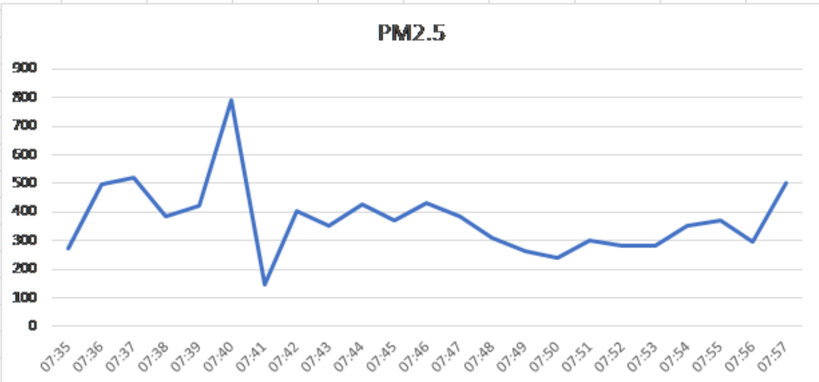
Evening		
Time:	PM0.5	PM2.5
NO DATA		

	Date:19/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	06:56	1558	96
	06:57	1642	148
	06:58	1734	140
	06:59	1750	151
	07:00	10015	1303
	07:01	3965	180
	07:02	2053	163
	07:03	2256	189
	07:04	2899	208
	07:05	4250	175
	07:06	3622	205
	07:07	3311	182
	07:08	2055	194
	07:09	2176	210
	07:10	4314	387
	07:11	13683	448
	07:12	29555	1593
	07:13	15932	471
	07:14	1951	200
	07:15	1982	181
	07:16	2296	210
	07:17	1936	168
	07:18	2136	204
	07:19	2110	191
	07:20	2279	201
	07:21	2078	211
	07:22	2462	211
	07:23	2592	226
	Average:	4592.571	301.6429
2nd	07:35	3311	272
	07:36	4702	497
	07:37	3900	521
	07:38	3152	387
	07:39	3204	421
	07:40	4019	794
	07:41	2189	149
	07:42	3531	403
	07:43	3017	351
	07:44	3149	428
	07:45	3019	372
	07:46	3114	434
	07:47	2876	386
	07:48	2602	311
	07:49	2294	264
	07:50	2129	242
	07:51	2381	299
	07:52	2380	282
	07:53	2395	281
	07:54	2599	351
	07:55	2683	372
	07:56	2423	297
	07:57	3560	502
	Average:	2983.87	374.6087

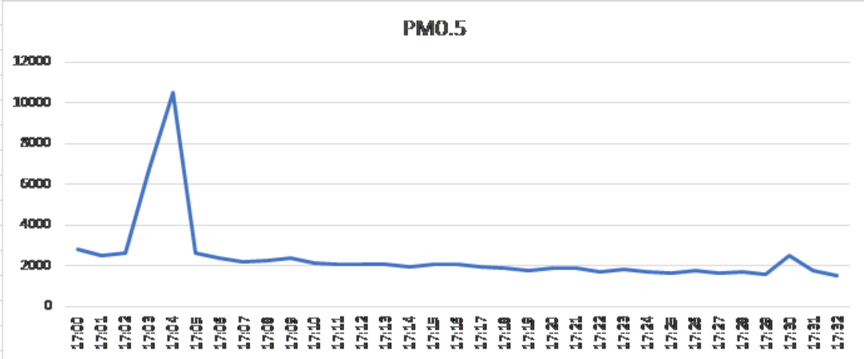


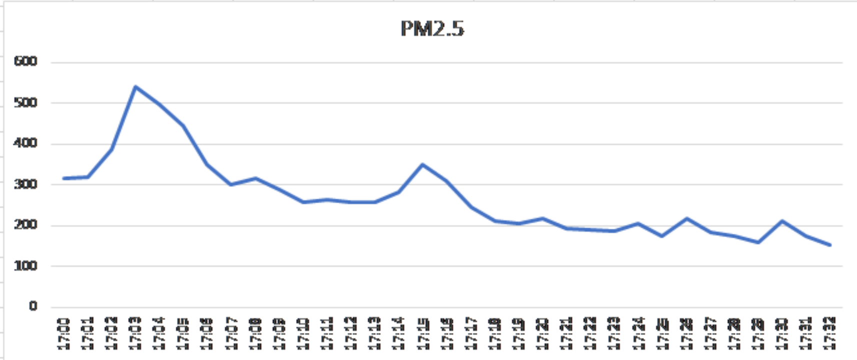


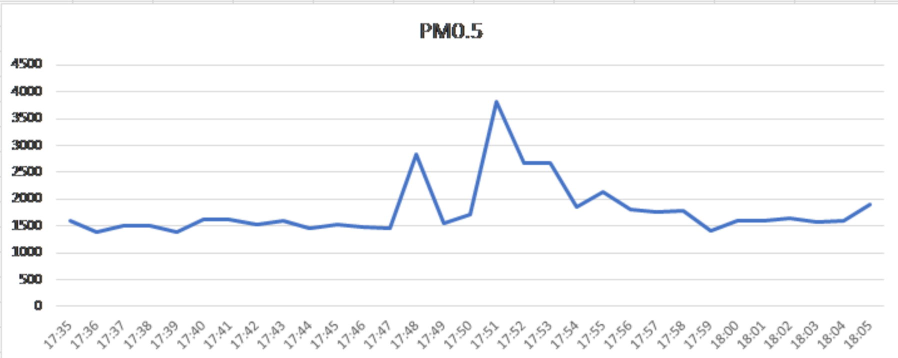


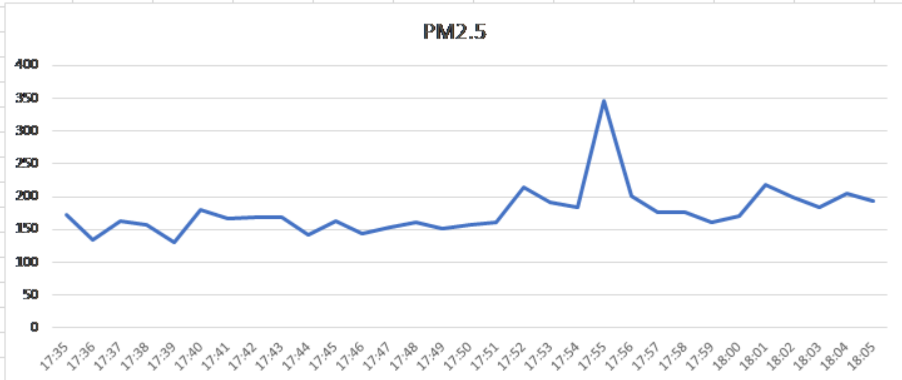


	Evening		
1st	Time:	PM0.5	PM2.5
	17:00	2811	316
	17:01	2479	318
	17:02	2615	387
	17:03	6762	541
	17:04	10500	499
	17:05	2637	446
	17:06	2355	349
	17:07	2220	300
	17:08	2258	316
	17:09	2387	290
	17:10	2157	259
	17:11	2097	263
	17:12	2059	259
	17:13	2081	259
	17:14	1980	283
	17:15	2097	351
	17:16	2058	310
	17:17	1942	245
	17:18	1880	212
	17:19	1792	206
	17:20	1902	217
	17:21	1875	193
	17:22	1701	191
	17:23	1815	188
	17:24	1715	207
	17:25	1614	174
	17:26	1772	218
	17:27	1646	184
	17:28	1691	176
	17:29	1563	159
	17:30	2529	212
	17:31	1757	174
	17:32	1537	154
	Average:	2432.848	268.3636
2nd	17:35	1590	172
	17:36	1399	134
	17:37	1517	163
	17:38	1511	158
	17:39	1378	130
	17:40	1627	181
	17:41	1619	167
	17:42	1534	168
	17:43	1592	169
	17:44	1467	143
	17:45	1533	164
	17:46	1492	144
	17:47	1467	154
	17:48	2842	161
	17:49	1547	151
	17:50	1705	158
	17:51	3816	161
	17:52	2674	214
	17:53	2665	191
	17:54	1849	184
	17:55	2135	346
	17:56	1803	201
	17:57	1765	176
	17:58	1791	176
	17:59	1402	162
	18:00	1607	171
	18:01	1605	218
	18:02	1651	200
	18:03	1576	184
	18:04	1588	206
	18:05	1910	193
	Average:	1795.387	177.4194





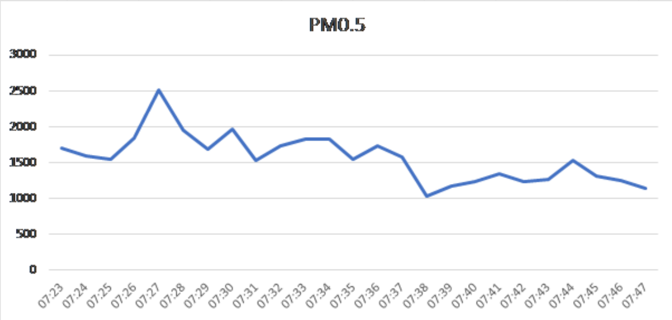


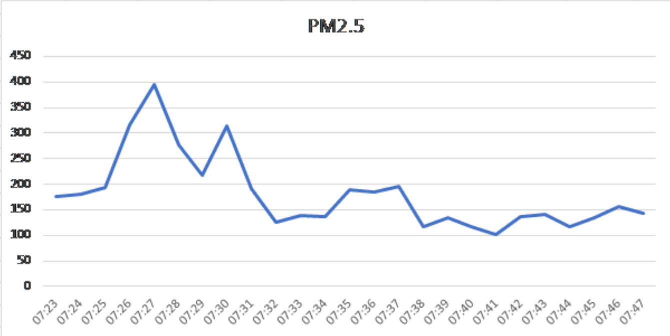


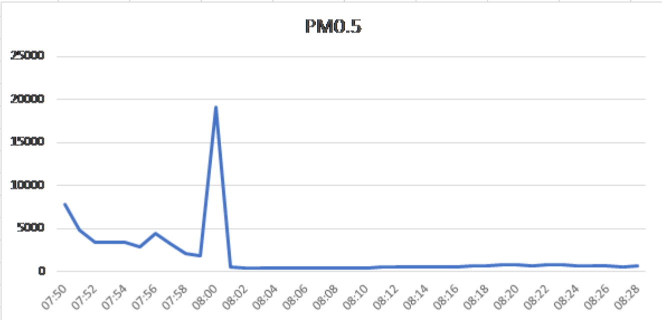
Date:20/09/19

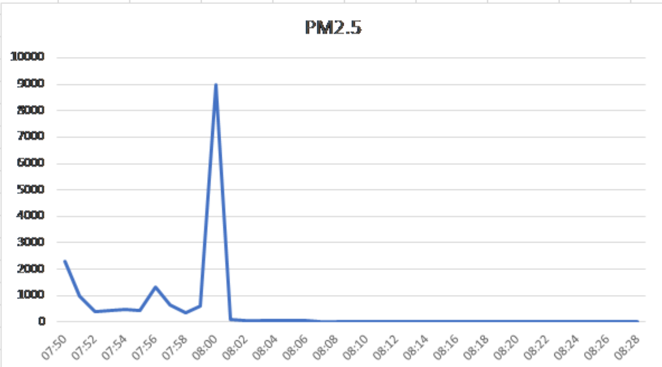
Morning

	Time:	PM0.5	PM2.5
1st	07:23	1707	177
	07:24	1598	180
	07:25	1543	193
	07:26	1838	317
	07:27	2518	395
	07:28	1960	277
	07:29	1685	218
	07:30	1970	314
	07:31	1537	192
	07:32	1739	126
	07:33	1832	139
	07:34	1825	136
	07:35	1548	189
	07:36	1739	185
	07:37	1573	196
	07:38	1037	118
	07:39	1183	135
	07:40	1231	116
	07:41	1352	101
	07:42	1231	137
	07:43	1264	141
	07:44	1532	117
	07:45	1323	134
	07:46	1250	156
	07:47	1137	143
	Average:	1566.08	181.28
2nd	07:50	7827	2295
	07:51	4896	989
	07:52	3477	382
	07:53	3424	437
	07:54	3457	491
	07:55	2863	424
	07:56	4502	1312
	07:57	3309	658
	07:58	2136	346
	07:59	1927	600
	08:00	19185	8990
	08:01	602	92
	08:02	504	43
	08:03	484	41
	08:04	453	41
	08:05	444	39
	08:06	442	40
	08:07	406	19
	08:08	428	23
	08:09	422	22
	08:10	429	19
	08:11	510	25
	08:12	577	23
	08:13	577	28
	08:14	595	28
	08:15	594	31
	08:16	632	36
	08:17	668	37
	08:18	723	28
	08:19	842	24
	08:20	772	22
	08:21	761	21
	08:22	823	23
	08:23	859	23
	08:24	722	26
	08:25	660	36
	08:26	664	27
	08:27	633	21
	08:28	665	32
	Average:	1894.718	456.2564





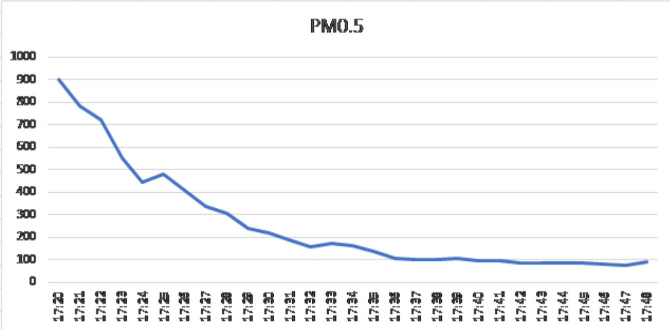


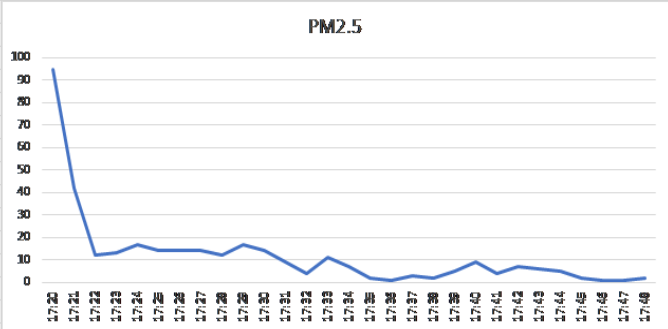


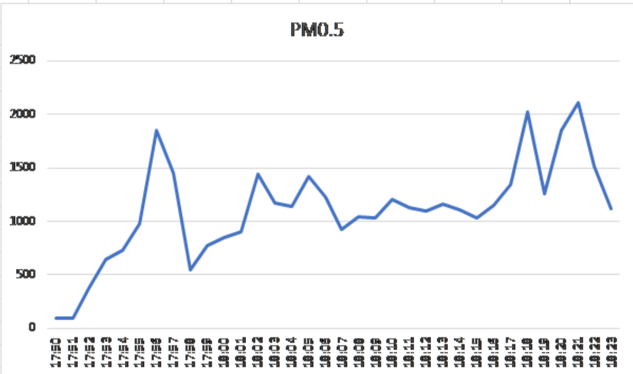
Evening

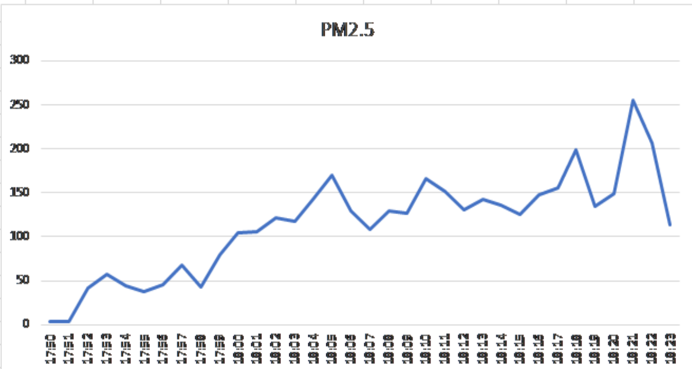
	Time:	PM0.5	PM2.5
1st			
NO DATA			

	Date:23/09/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	NO DATA		



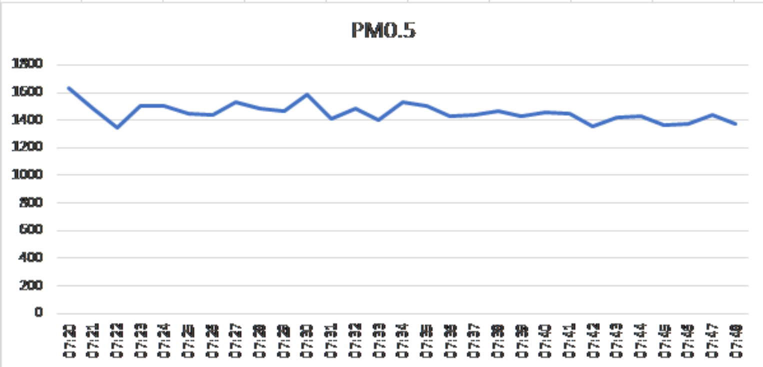


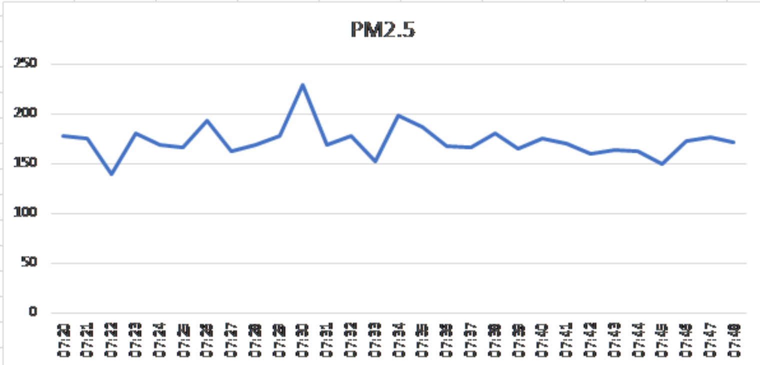


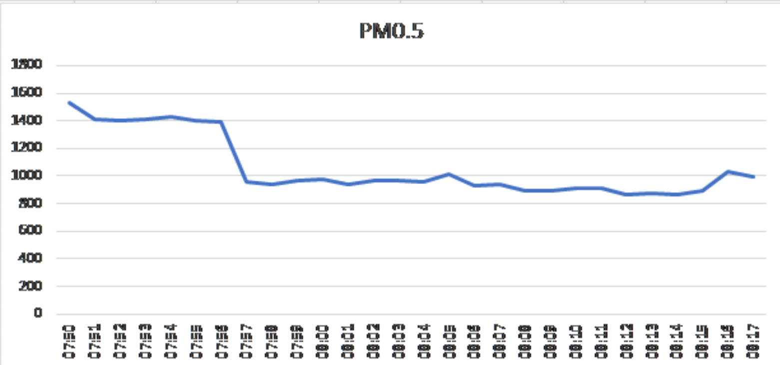


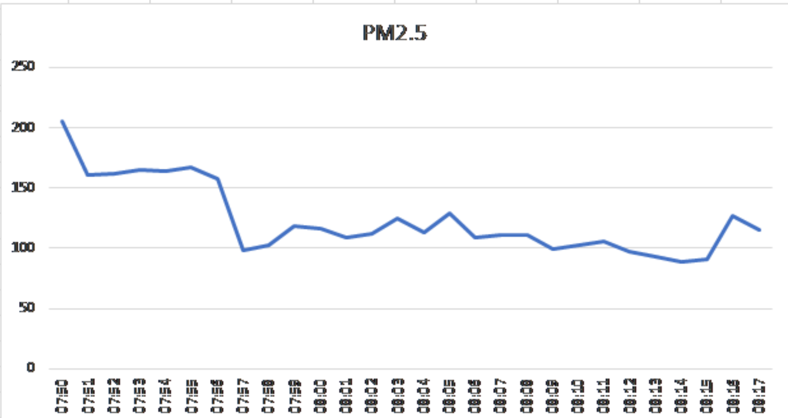
	Evening		
1st	Time:	PM0.5	PM2.5
	17:20	900	95
	17:21	782	42
	17:22	722	12
	17:23	553	13
	17:24	447	17
	17:25	482	14
	17:26	411	14
	17:27	339	14
	17:28	309	12
	17:29	240	17
	17:30	219	14
	17:31	189	9
	17:32	156	4
	17:33	173	11
	17:34	163	7
	17:35	135	2
	17:36	108	1
	17:37	102	3
	17:38	101	2
	17:39	108	5
	17:40	98	9
	17:41	94	4
	17:42	86	7
	17:43	85	6
	17:44	85	5
	17:45	86	2
	17:46	81	1
	17:47	74	1
	17:48	91	2
	Average:	255.8276	11.89655
2nd	17:50	91	4
	17:51	91	4
	17:52	377	42
	17:53	645	57
	17:54	730	44
	17:55	981	38
	17:56	1853	45
	17:57	1454	68
	17:58	544	43
	17:59	771	79
	18:00	854	104
	18:01	905	106
	18:02	1439	122
	18:03	1169	117
	18:04	1145	142
	18:05	1423	170
	18:06	1223	129
	18:07	928	109
	18:08	1043	129
	18:09	1027	127
	18:10	1202	166
	18:11	1134	152
	18:12	1092	131
	18:13	1157	143
	18:14	1104	136
	18:15	1030	125
	18:16	1147	148
	18:17	1345	156
	18:18	2029	199
	18:19	1258	135
	18:20	1849	149
	18:21	2109	256
	18:22	1517	207
	18:23	1117	114
	Average:	1111.265	114.5882

	Date:03/11/19			
	Morning			
1st		Time:	PM0.5	PM2.5
		07:20	1637	178
		07:21	1481	176
		07:22	1347	139
		07:23	1502	180
		07:24	1502	169
		07:25	1452	166
		07:26	1443	193
		07:27	1527	162
		07:28	1483	169
		07:29	1468	178
		07:30	1590	229
		07:31	1410	169
		07:32	1487	178
		07:33	1401	152
		07:34	1533	198
		07:35	1500	187
		07:36	1432	168
		07:37	1439	167
		07:38	1463	180
		07:39	1430	165
		07:40	1460	175
		07:41	1448	170
		07:42	1357	160
		07:43	1420	164
		07:44	1428	162
		07:45	1366	150
		07:46	1377	173
		07:47	1438	177
		07:48	1376	171
		Average:	1455.069	172.5862
	2nd	07:50	1532	205
		07:51	1412	161
		07:52	1404	162
		07:53	1411	165
		07:54	1429	164
		07:55	1399	167
		07:56	1391	158
		07:57	963	98
		07:58	940	103
		07:59	972	118
		08:00	980	116
		08:01	944	109
		08:02	967	112
		08:03	964	125
		08:04	961	113
		08:05	1014	129
		08:06	931	109
		08:07	940	111
		08:08	890	111
		08:09	894	99
		08:10	913	103
		08:11	913	106
		08:12	863	97
		08:13	878	93
		08:14	862	89
		08:15	891	91
		08:16	1030	127
		08:17	993	115
		Average:	1060.036	123.4286

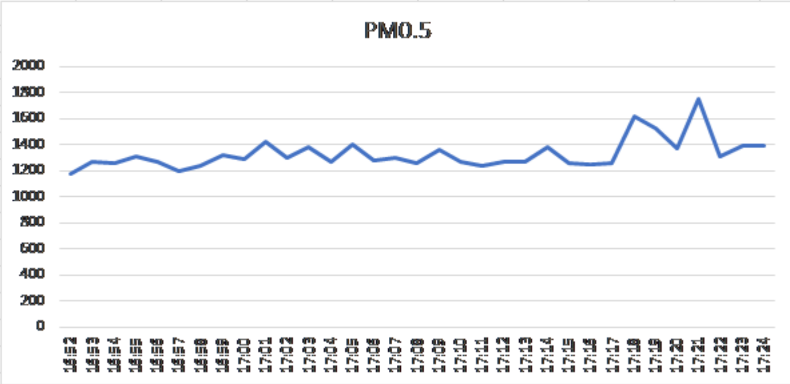


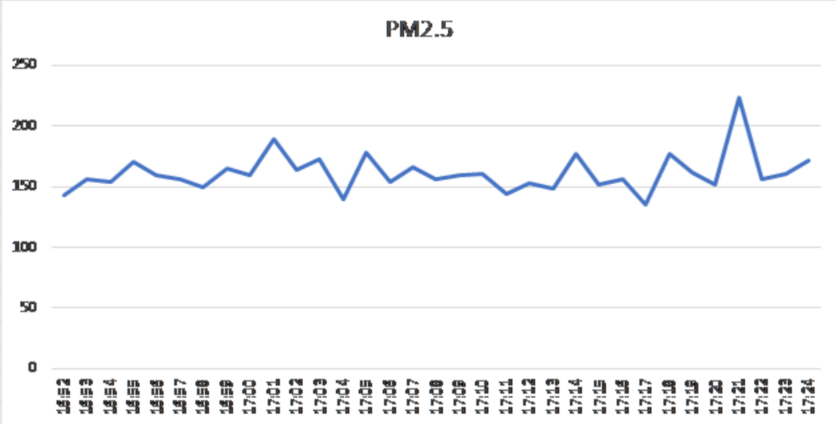


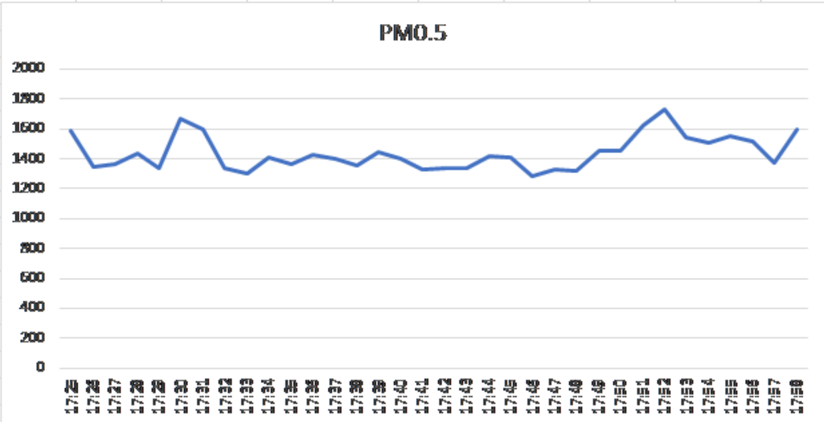


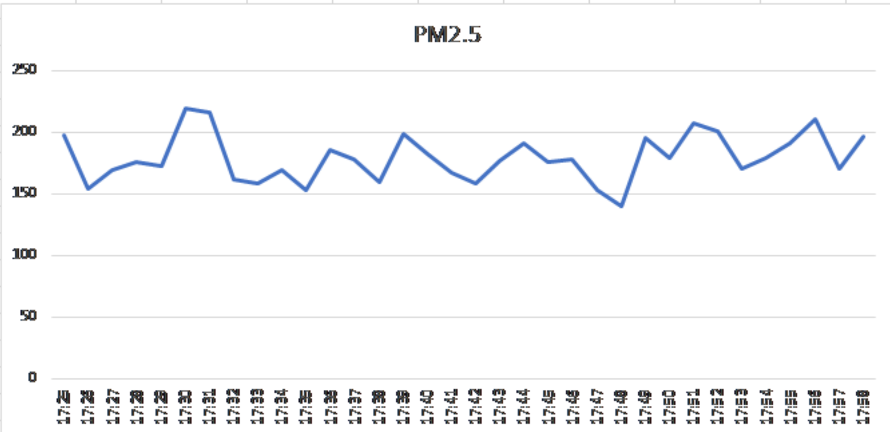


	Evening		
1st	Time:	PM0.5	PM2.5
	16:52	1174	143
	16:53	1274	156
	16:54	1259	154
	16:55	1307	171
	16:56	1272	159
	16:57	1198	156
	16:58	1240	150
	16:59	1324	165
	17:00	1288	159
	17:01	1424	189
	17:02	1300	164
	17:03	1382	173
	17:04	1272	140
	17:05	1407	178
	17:06	1283	154
	17:07	1304	166
	17:08	1262	156
	17:09	1360	159
	17:10	1272	161
	17:11	1235	144
	17:12	1271	153
	17:13	1272	148
	17:14	1384	177
	17:15	1264	152
	17:16	1254	156
	17:17	1263	135
	17:18	1623	177
	17:19	1531	162
	17:20	1374	152
	17:21	1758	224
	17:22	1312	156
	17:23	1393	161
	17:24	1397	172
	Average:	1331.303	161.2727
2nd	17:25	1589	198
	17:26	1348	154
	17:27	1368	169
	17:28	1440	176
	17:29	1340	173
	17:30	1666	219
	17:31	1598	216
	17:32	1336	162
	17:33	1302	159
	17:34	1409	169
	17:35	1361	153
	17:36	1425	186
	17:37	1397	178
	17:38	1358	160
	17:39	1443	199
	17:40	1405	183
	17:41	1330	167
	17:42	1339	159
	17:43	1339	177
	17:44	1415	191
	17:45	1411	176
	17:46	1288	178
	17:47	1333	153
	17:48	1324	140
	17:49	1456	195
	17:50	1450	179
	17:51	1621	207
	17:52	1732	201
	17:53	1543	170
	17:54	1510	179
	17:55	1554	191
	17:56	1514	211
	17:57	1372	171
	17:58	1599	197
	Average:	1438.676	179.2941

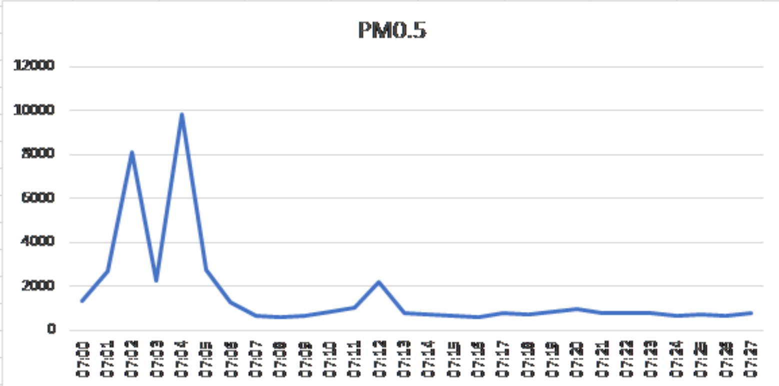


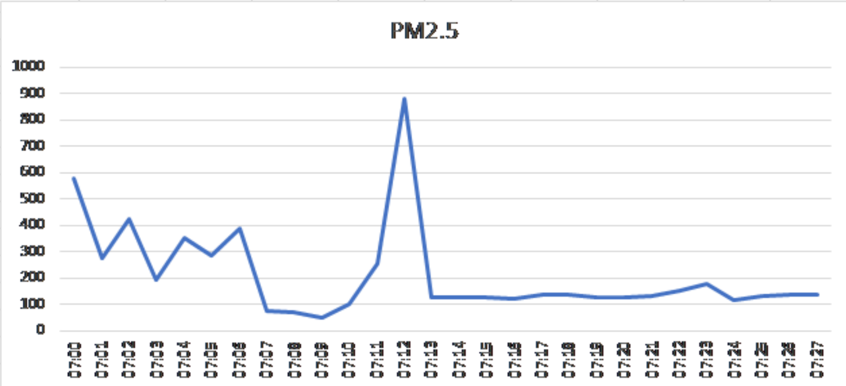


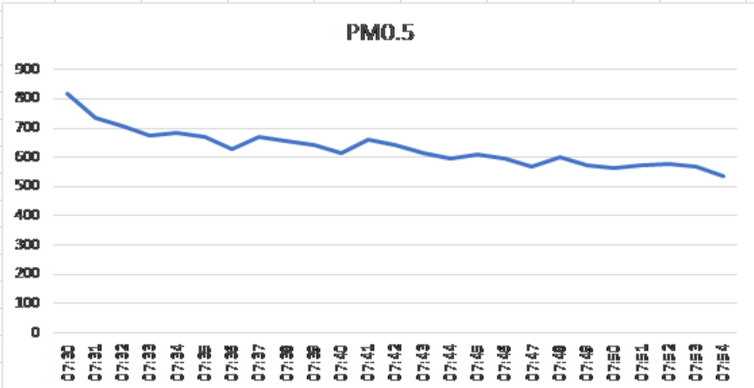


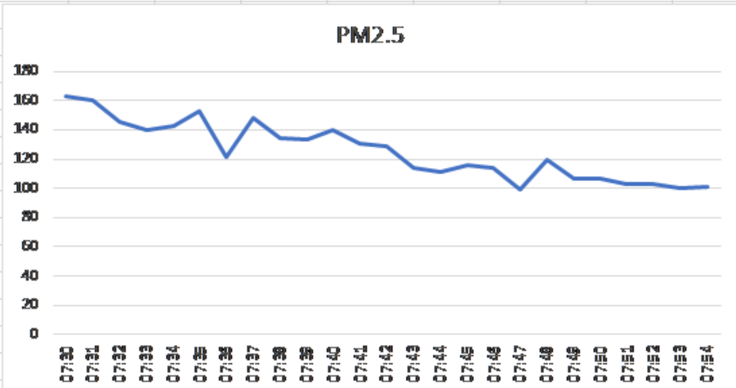


	Date:04/11/19			
	Morning			
1st		Time:	PM0.5	PM2.5
		07:00	1314	580
		07:01	2719	278
		07:02	8092	425
		07:03	2258	191
		07:04	9865	351
		07:05	2754	285
		07:06	1293	387
		07:07	641	74
		07:08	618	68
		07:09	630	49
		07:10	865	99
		07:11	1052	255
		07:12	2190	881
		07:13	757	125
		07:14	729	126
		07:15	681	125
		07:16	622	123
		07:17	781	137
		07:18	740	136
		07:19	821	125
		07:20	948	126
		07:21	766	132
		07:22	752	152
		07:23	787	180
		07:24	653	119
		07:25	698	131
		07:26	686	135
		07:27	756	135
		Average:	1623.857	211.7857
	2nd	07:30	816	163
		07:31	737	160
		07:32	708	145
		07:33	676	140
		07:34	682	143
		07:35	669	153
		07:36	627	121
		07:37	670	148
		07:38	655	134
		07:39	644	133
		07:40	616	140
		07:41	663	131
		07:42	642	129
		07:43	616	114
		07:44	597	111
		07:45	610	116
		07:46	595	114
		07:47	570	99
		07:48	603	120
		07:49	573	107
		07:50	563	107
		07:51	575	103
		07:52	577	103
		07:53	568	100
		07:54	535	101
		Average:	631.48	125.4

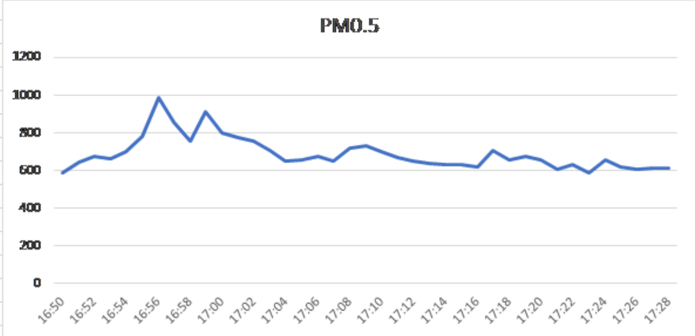


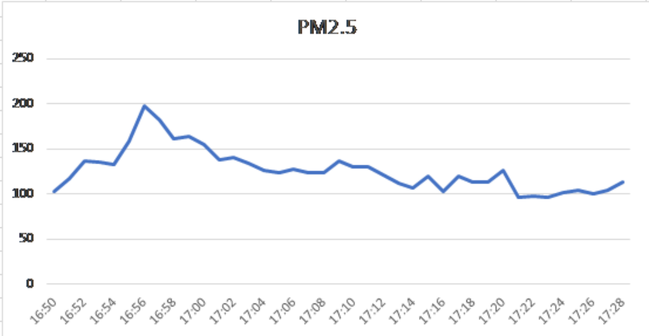


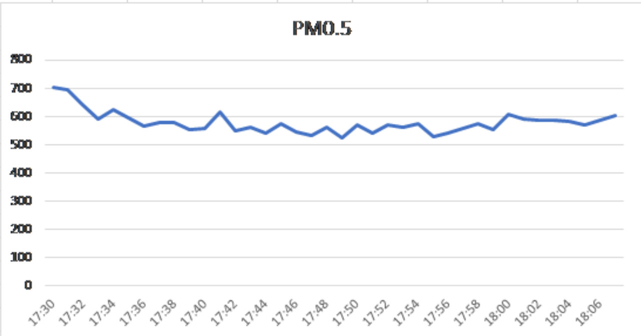


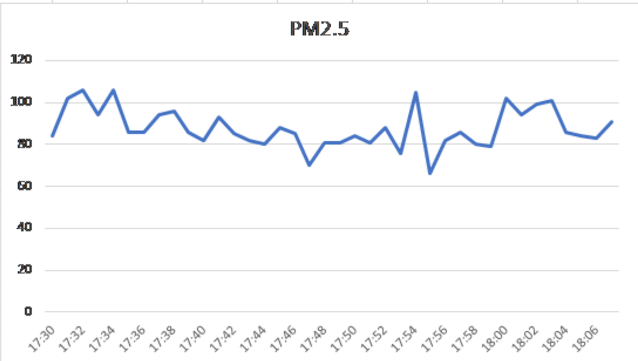


	Evening		
1st	Time:	PM0.5	PM2.5
	16:50	590	103
	16:51	645	118
	16:52	676	137
	16:53	661	135
	16:54	701	133
	16:55	780	159
	16:56	989	198
	16:57	854	183
	16:58	760	162
	16:59	912	164
	17:00	798	155
	17:01	776	138
	17:02	754	141
	17:03	710	134
	17:04	654	126
	17:05	660	124
	17:06	677	128
	17:07	652	124
	17:08	718	124
	17:09	732	137
	17:10	701	131
	17:11	667	130
	17:12	649	121
	17:13	638	112
	17:14	634	107
	17:15	634	120
	17:16	621	103
	17:17	709	120
	17:18	659	114
	17:19	673	114
	17:20	655	127
	17:21	608	97
	17:22	630	98
	17:23	589	96
	17:24	655	102
	17:25	617	104
	17:26	606	101
	17:27	614	104
	17:28	614	113
Average:		689.0256	126.5897
2nd	17:30	704	84
	17:31	695	102
	17:32	643	106
	17:33	593	94
	17:34	625	106
	17:35	598	86
	17:36	565	86
	17:37	581	94
	17:38	579	96
	17:39	553	86
	17:40	560	82
	17:41	617	93
	17:42	549	85
	17:43	561	82
	17:44	542	80
	17:45	577	88
	17:46	547	85
	17:47	532	70
	17:48	562	81
	17:49	526	81
	17:50	570	84
	17:51	541	81
	17:52	572	88
	17:53	561	76
	17:54	575	105
	17:55	531	66
	17:56	543	82
	17:57	560	86
	17:58	574	80
	17:59	553	79
	18:00	610	102
	18:01	592	94
	18:02	589	99
	18:03	586	101
	18:04	583	86
	18:05	573	84
	18:06	586	83
	18:07	603	91
Average:		579.2368	87.73684

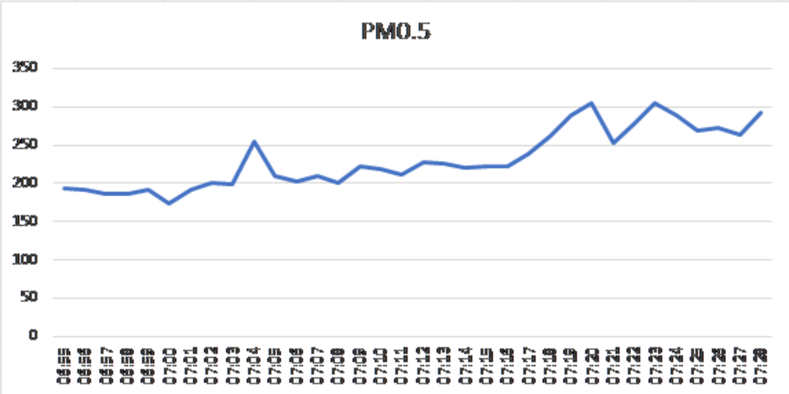


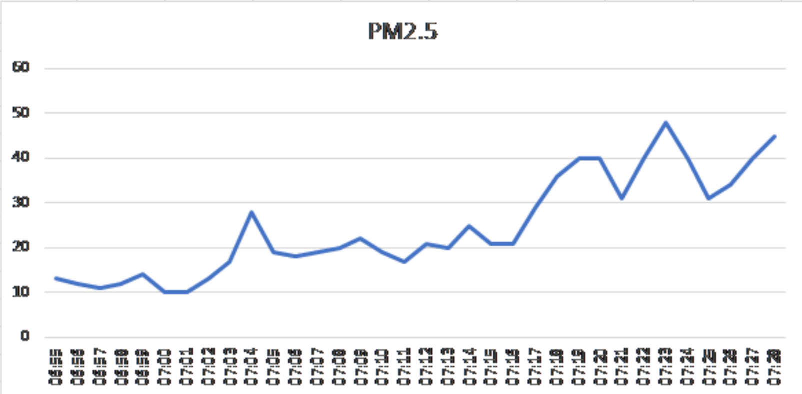


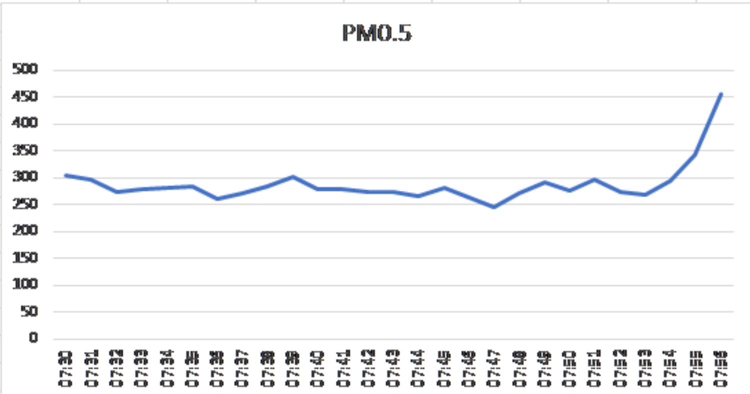


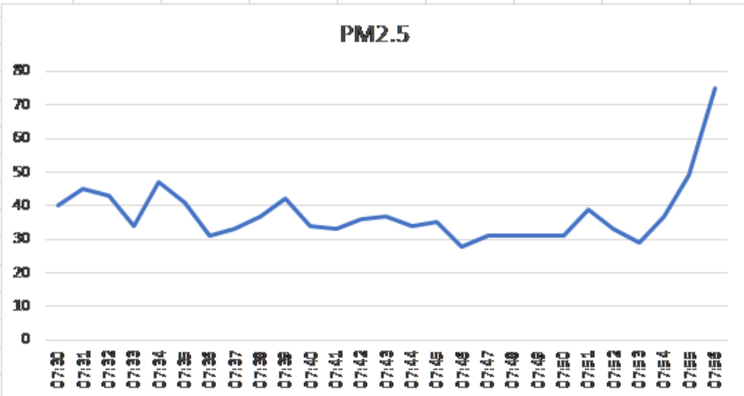


	Date: 05/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	06:55	193	13
	06:56	192	12
	06:57	186	11
	06:58	186	12
	06:59	191	14
	07:00	174	10
	07:01	192	10
	07:02	200	13
	07:03	199	17
	07:04	254	28
	07:05	210	19
	07:06	203	18
	07:07	210	19
	07:08	201	20
	07:09	223	22
	07:10	218	19
	07:11	212	17
	07:12	228	21
	07:13	225	20
	07:14	220	25
	07:15	222	21
	07:16	222	21
	07:17	238	29
	07:18	262	36
	07:19	289	40
	07:20	305	40
	07:21	252	31
	07:22	278	40
	07:23	305	48
	07:24	288	40
	07:25	269	31
	07:26	272	34
	07:27	264	40
	07:28	292	45
	Average:	231.6176	24.58824
2nd	07:30	305	40
	07:31	298	45
	07:32	273	43
	07:33	279	34
	07:34	282	47
	07:35	283	41
	07:36	261	31
	07:37	271	33
	07:38	283	37
	07:39	302	42
	07:40	279	34
	07:41	278	33
	07:42	275	36
	07:43	275	37
	07:44	265	34
	07:45	282	35
	07:46	264	28
	07:47	245	31
	07:48	271	31
	07:49	292	31
	07:50	276	31
	07:51	296	39
	07:52	273	33
	07:53	268	29
	07:54	294	37
	07:55	344	49
	07:56	456	75
	Average:	287.7778	37.62963

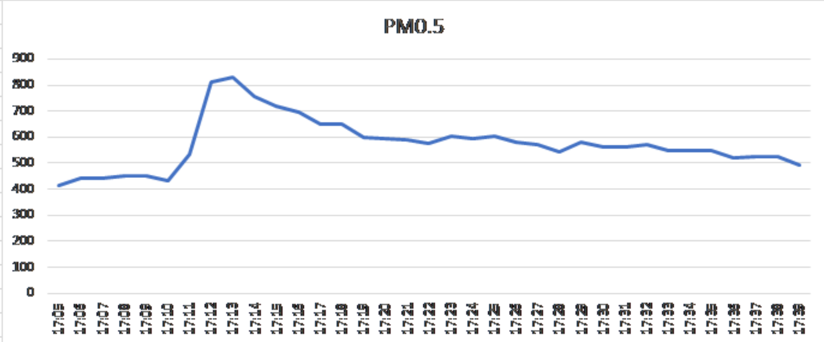


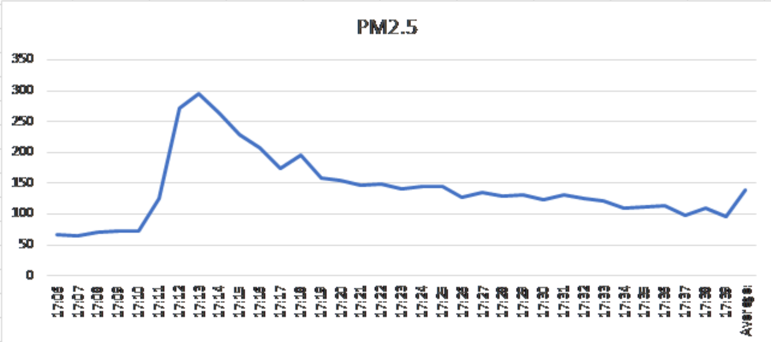


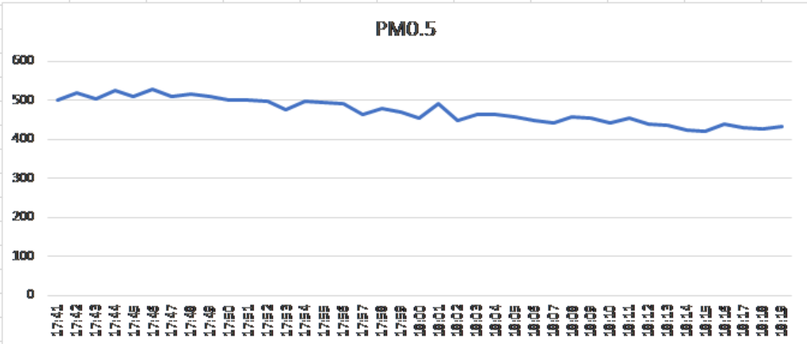


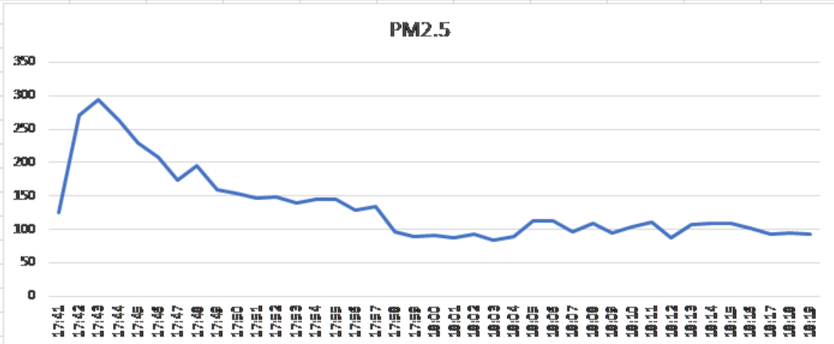


	Evening		
1st	Time:	PM0.5	PM2.5
	17:05	413	70
	17:06	440	67
	17:07	444	64
	17:08	451	71
	17:09	453	72
	17:10	433	73
	17:11	533	126
	17:12	811	271
	17:13	832	295
	17:14	755	263
	17:15	721	229
	17:16	696	208
	17:17	652	174
	17:18	651	196
	17:19	601	159
	17:20	595	154
	17:21	590	147
	17:22	574	149
	17:23	602	140
	17:24	597	145
	17:25	606	145
	17:26	581	128
	17:27	572	135
	17:28	546	129
	17:29	579	131
	17:30	564	123
	17:31	563	132
	17:32	573	125
	17:33	550	121
	17:34	549	110
	17:35	550	112
	17:36	519	113
	17:37	527	97
	17:38	525	109
	17:39	495	95
	Average:	575.5143	139.3714
2nd			
	17:41	501	126
	17:42	521	271
	17:43	505	295
	17:44	526	263
	17:45	510	229
	17:46	530	208
	17:47	510	174
	17:48	518	196
	17:49	512	159
	17:50	500	154
	17:51	502	147
	17:52	499	149
	17:53	476	140
	17:54	498	145
	17:55	495	145
	17:56	491	128
	17:57	464	135
	17:58	480	96
	17:59	470	90
	18:00	455	91
	18:01	492	88
	18:02	450	92
	18:03	463	84
	18:04	463	89
	18:05	457	112
	18:06	449	113
	18:07	442	97
	18:08	457	109
	18:09	454	95
	18:10	442	103
	18:11	456	110
	18:12	440	88
	18:13	438	107
	18:14	424	109
	18:15	421	109
	18:16	440	102
	18:17	430	93
	18:18	426	94
	18:19	432	92
	Average:	472.7949	134.0256

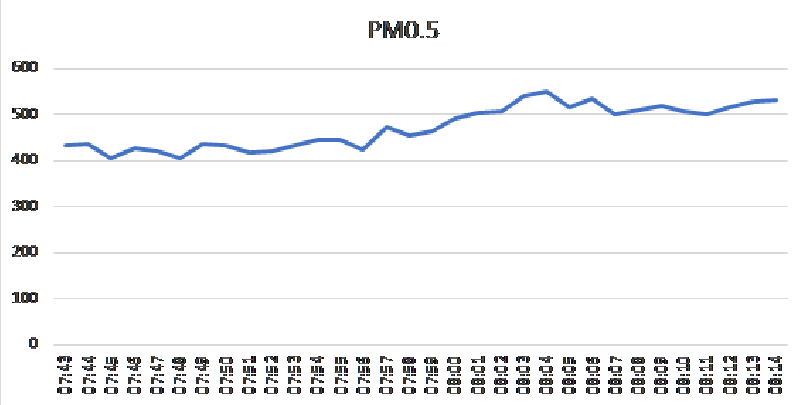


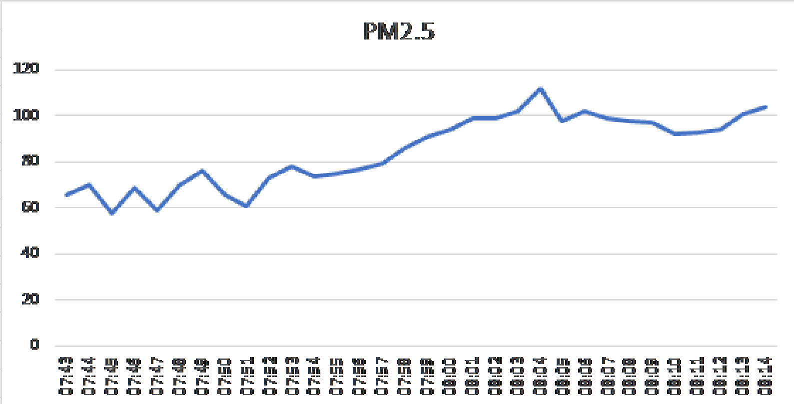


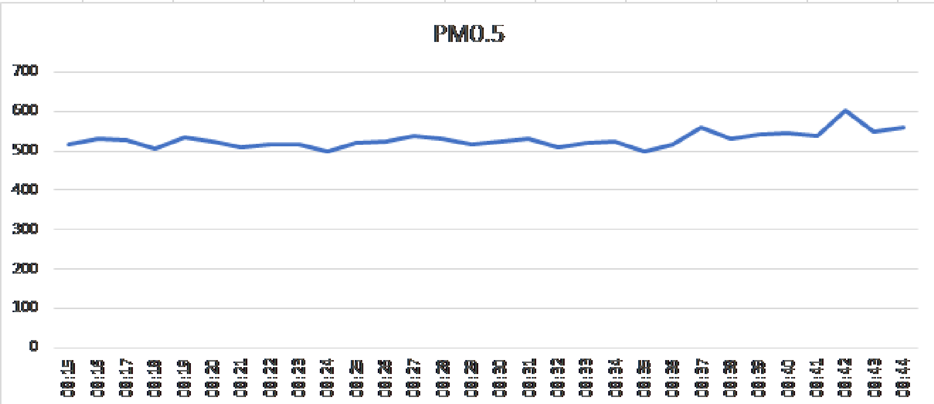


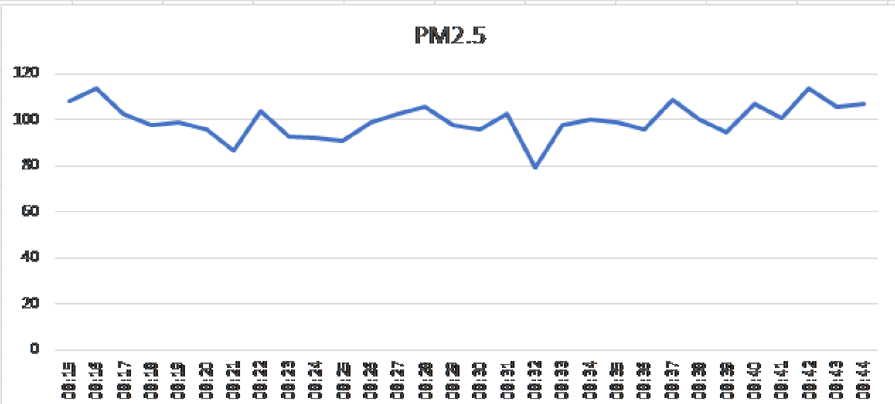


Date: 07/11/19		
Morning		
Time:	PM0.5	PM2.5
07:43	432	66
07:44	438	70
07:45	405	58
07:46	428	69
07:47	420	59
07:48	405	70
07:49	436	76
07:50	434	66
07:51	417	61
07:52	422	73
07:53	433	78
07:54	446	74
07:55	445	75
07:56	423	77
07:57	472	79
07:58	456	86
07:59	463	91
08:00	492	94
08:01	505	99
08:02	506	99
08:03	540	102
08:04	552	112
08:05	518	98
08:06	534	102
08:07	500	99
08:08	511	98
08:09	519	97
08:10	506	92
08:11	502	93
08:12	518	94
08:13	528	101
08:14	531	104
Average:	473.0313	84.75
08:15	517	108
08:16	530	114
08:17	526	103
08:18	507	98
08:19	535	99
08:20	522	96
08:21	511	87
08:22	518	104
08:23	516	93
08:24	499	92
08:25	519	91
08:26	525	99
08:27	538	103
08:28	532	106
08:29	518	98
08:30	523	96
08:31	531	103
08:32	508	79
08:33	520	98
08:34	522	100
08:35	500	99
08:36	518	96
08:37	560	109
08:38	531	100
08:39	541	95
08:40	547	107
08:41	539	101
08:42	603	114
08:43	550	106
08:44	559	107
Average:	528.8333	100.0333

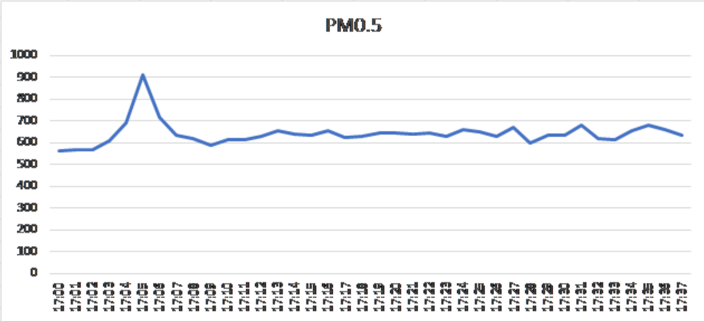


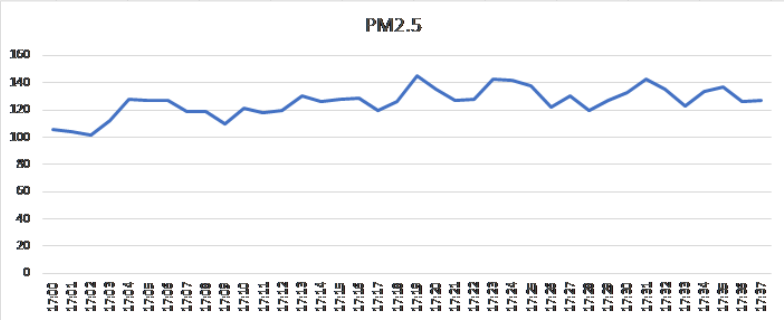


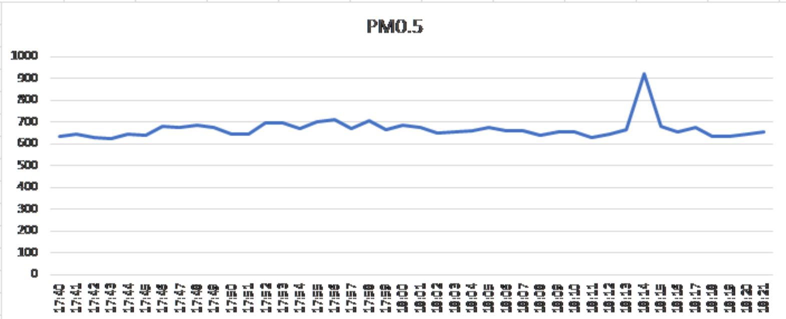


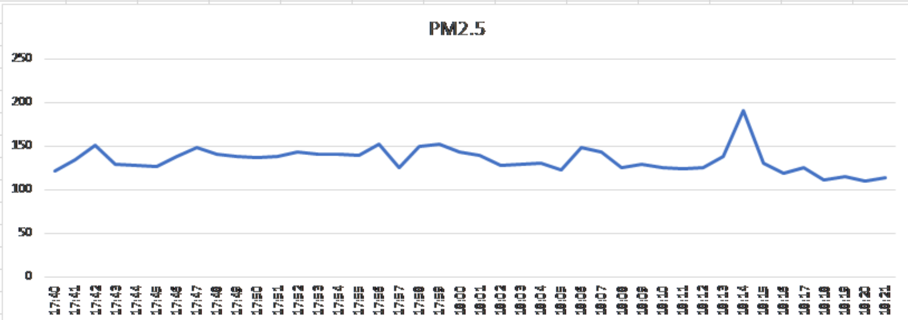


	Evening		
1st	Time:	PM0.5	PM2.5
	17:00	563	106
	17:01	568	104
	17:02	566	102
	17:03	610	112
	17:04	692	128
	17:05	914	127
	17:06	718	127
	17:07	637	119
	17:08	621	119
	17:09	590	110
	17:10	613	121
	17:11	613	118
	17:12	631	120
	17:13	658	130
	17:14	639	126
	17:15	633	128
	17:16	656	129
	17:17	625	120
	17:18	632	126
	17:19	645	145
	17:20	647	135
	17:21	640	127
	17:22	646	128
	17:23	628	143
	17:24	661	142
	17:25	650	138
	17:26	628	122
	17:27	670	130
	17:28	599	120
	17:29	634	127
	17:30	636	133
	17:31	681	143
	17:32	620	135
	17:33	614	123
	17:34	654	134
	17:35	682	137
	17:36	663	126
	17:37	634	127
	Average:	642.3947	125.9737
2nd	17:40	634	121
	17:41	645	134
	17:42	632	151
	17:43	626	129
	17:44	647	128
	17:45	642	127
	17:46	680	138
	17:47	674	148
	17:48	684	141
	17:49	677	138
	17:50	646	137
	17:51	645	138
	17:52	697	144
	17:53	697	141
	17:54	670	141
	17:55	703	140
	17:56	712	152
	17:57	671	126
	17:58	708	150
	17:59	667	152
	18:00	688	143
	18:01	675	140
	18:02	650	128
	18:03	658	129
	18:04	660	131
	18:05	676	123
	18:06	660	149
	18:07	660	144
	18:08	640	126
	18:09	657	129
	18:10	655	126
	18:11	631	124
	18:12	647	126
	18:13	668	138
	18:14	922	191
	18:15	683	130
	18:16	656	119
	18:17	674	125
	18:18	635	111
	18:19	637	115
	18:20	646	110
	18:21	658	114
	Average:	668.881	134.4524

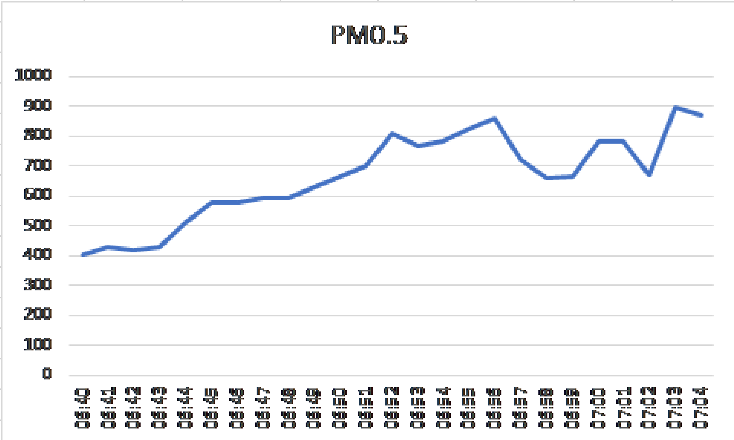


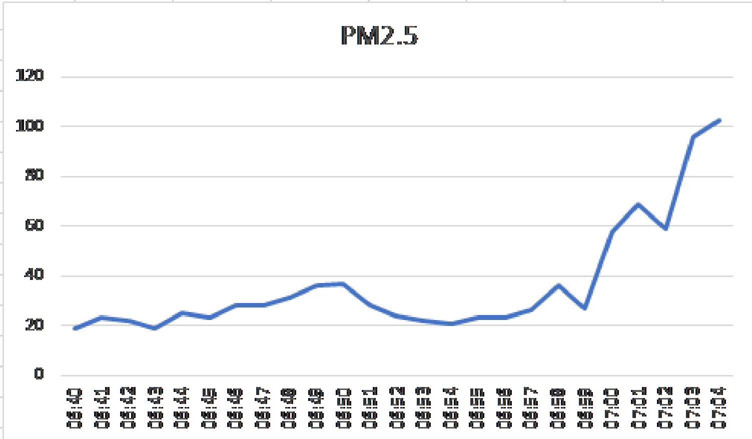


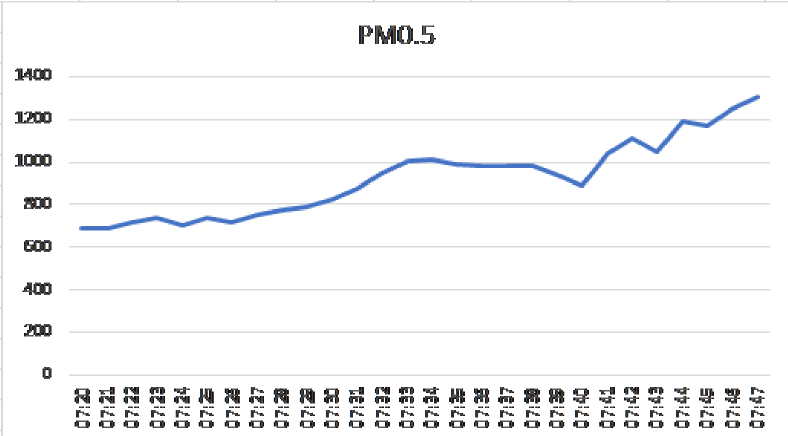


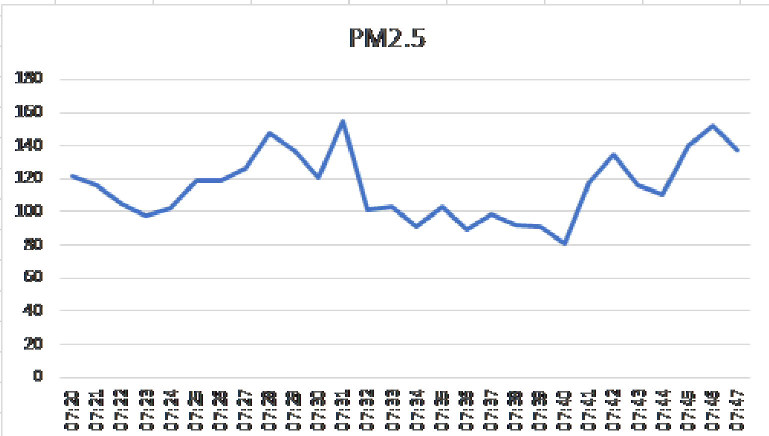


	Date: 10/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	06:40	406	19
	06:41	428	23
	06:42	422	22
	06:43	429	19
	06:44	510	25
	06:45	577	23
	06:46	577	28
	06:47	595	28
	06:48	595	31
	06:49	632	36
	06:50	668	37
	06:51	701	28
	06:52	810	24
	06:53	771	22
	06:54	785	21
	06:55	824	23
	06:56	859	23
	06:57	721	26
	06:58	660	36
	06:59	665	27
	07:00	783	58
	07:01	782	69
	07:02	670	59
	07:03	899	96
	07:04	871	103
	Average:	665.6	36.24
2nd	07:20	686	122
	07:21	685	116
	07:22	720	105
	07:23	739	98
	07:24	703	102
	07:25	737	119
	07:26	716	119
	07:27	751	126
	07:28	771	148
	07:29	789	137
	07:30	828	121
	07:31	872	155
	07:32	948	101
	07:33	1002	103
	07:34	1012	91
	07:35	989	103
	07:36	983	89
	07:37	984	99
	07:38	985	92
	07:39	943	91
	07:40	886	81
	07:41	1042	118
	07:42	1113	135
	07:43	1044	116
	07:44	1194	111
	07:45	1171	140
	07:46	1247	152
	07:47	1305	137
	Average:	923.0357	115.25

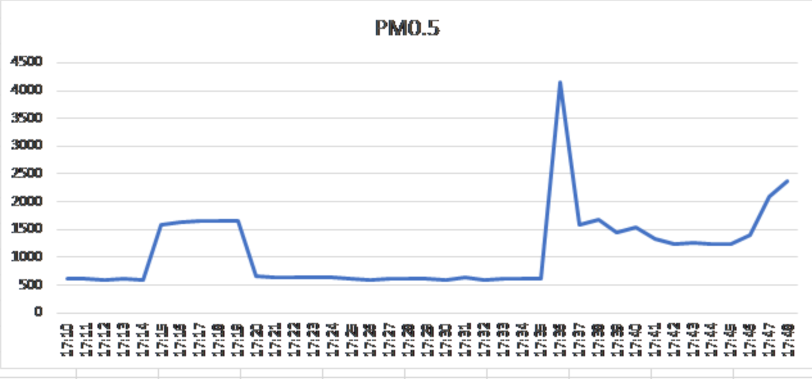


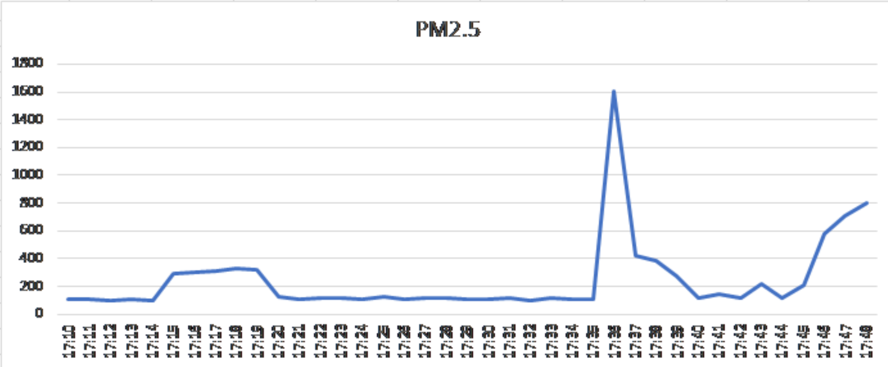


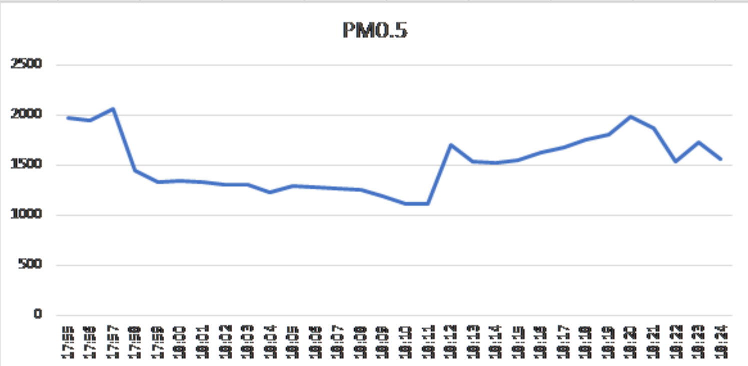


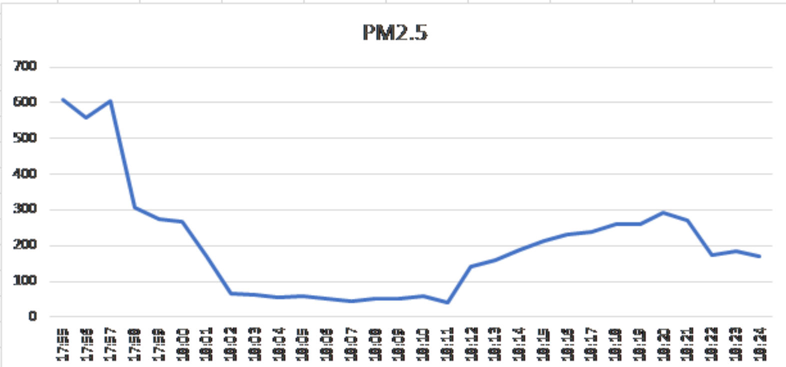


	Evening		
1st	Time:	PM0.5	PM2.5
	17:10	613	106
	17:11	610	108
	17:12	601	102
	17:13	616	105
	17:14	597	100
	17:15	1586	291
	17:16	1625	301
	17:17	1650	307
	17:18	1668	330
	17:19	1663	318
	17:20	670	123
	17:21	631	110
	17:22	648	116
	17:23	639	120
	17:24	644	108
	17:25	627	122
	17:26	603	107
	17:27	615	117
	17:28	608	116
	17:29	613	108
	17:30	604	107
	17:31	634	115
	17:32	595	102
	17:33	625	119
	17:34	623	112
	17:35	609	109
	17:36	4159	1601
	17:37	1588	423
	17:38	1690	389
	17:39	1438	270
	17:40	1540	113
	17:41	1330	142
	17:42	1231	121
	17:43	1258	219
	17:44	1237	114
	17:45	1232	211
	17:46	1392	582
	17:47	2096	711
	17:48	2365	801
	Average:	1122.385	245.5385
2nd	17:55	1975	608
	17:56	1949	560
	17:57	2057	604
	17:58	1449	307
	17:59	1336	275
	18:00	1338	267
	18:01	1334	172
	18:02	1301	65
	18:03	1300	64
	18:04	1225	55
	18:05	1297	58
	18:06	1283	53
	18:07	1267	45
	18:08	1254	52
	18:09	1196	53
	18:10	1117	57
	18:11	1116	40
	18:12	1708	140
	18:13	1534	158
	18:14	1523	187
	18:15	1547	214
	18:16	1624	231
	18:17	1676	238
	18:18	1750	259
	18:19	1806	260
	18:20	1991	292
	18:21	1875	271
	18:22	1532	173
	18:23	1734	183
	18:24	1562	169
	Average:	1521.867	203.6667



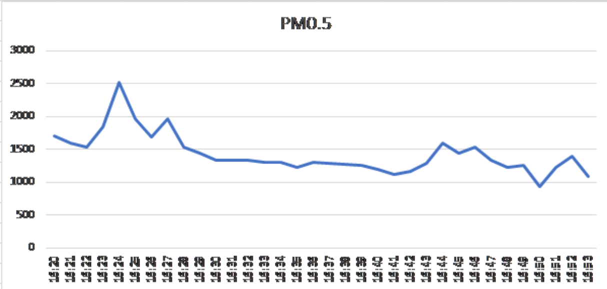


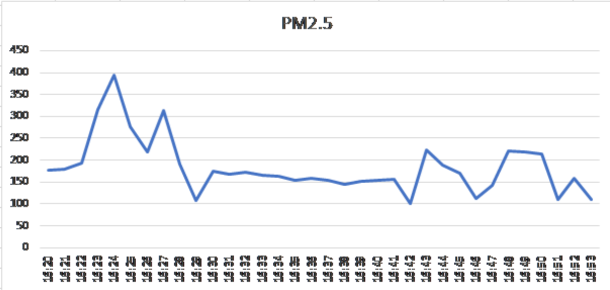


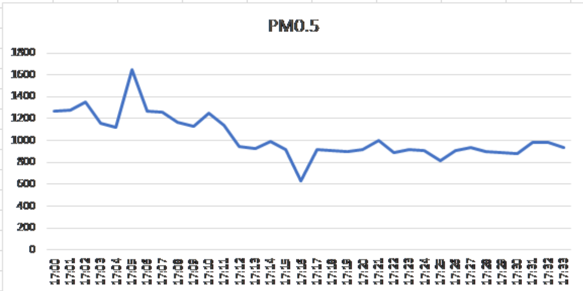


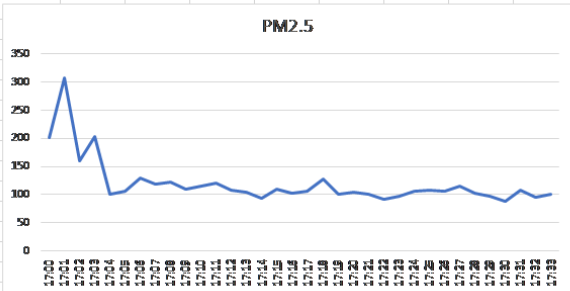
	Date:11/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	NO DATA		

	Evening		
1st	Time:	PM0.5	PM2.5
	16:20	1707	177
	16:21	1598	180
	16:22	1543	193
	16:23	1838	317
	16:24	2518	395
	16:25	1960	277
	16:26	1695	218
	16:27	1970	314
	16:28	1537	192
	16:29	1449	107
	16:30	1336	175
	16:31	1338	167
	16:32	1334	172
	16:33	1301	165
	16:34	1300	164
	16:35	1225	155
	16:36	1297	158
	16:37	1283	153
	16:38	1267	145
	16:39	1254	152
	16:40	1196	153
	16:41	1117	157
	16:42	1159	101
	16:43	1288	223
	16:44	1600	189
	16:45	1438	170
	16:46	1540	113
	16:47	1330	142
	16:48	1231	221
	16:49	1258	219
	16:50	937	214
	16:51	1232	111
	16:52	1392	158
	16:53	1096	111
	Average:	1428.353	184.0588
2nd	17:00	1265	201
	17:01	1275	308
	17:02	1349	160
	17:03	1157	204
	17:04	1125	101
	17:05	1650	107
	17:06	1268	130
	17:07	1263	118
	17:08	1170	123
	17:09	1131	110
	17:10	1248	116
	17:11	1139	120
	17:12	944	108
	17:13	923	104
	17:14	995	93
	17:15	913	110
	17:16	631	103
	17:17	913	106
	17:18	910	128
	17:19	901	101
	17:20	916	105
	17:21	997	100
	17:22	886	91
	17:23	915	97
	17:24	908	106
	17:25	813	108
	17:26	904	107
	17:27	934	115
	17:28	895	102
	17:29	892	97
	17:30	882	89
	17:31	981	108
	17:32	986	96
	17:33	932	100
	Average:	1029.735	119.7647

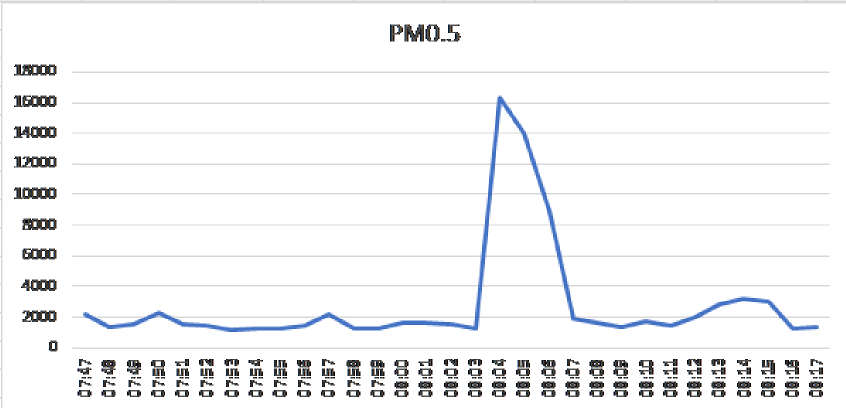


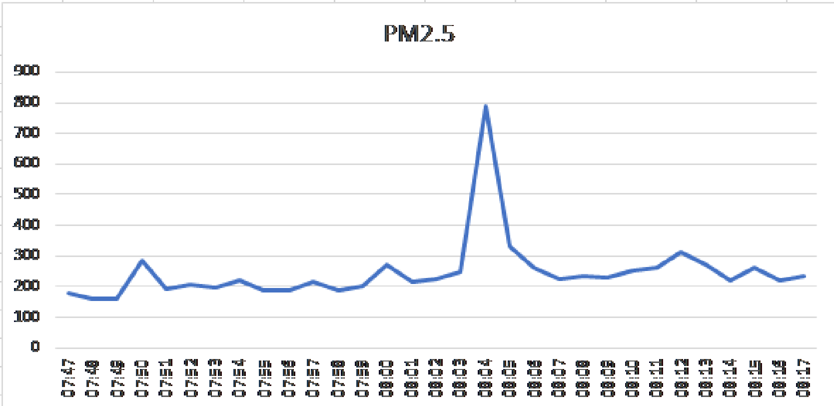


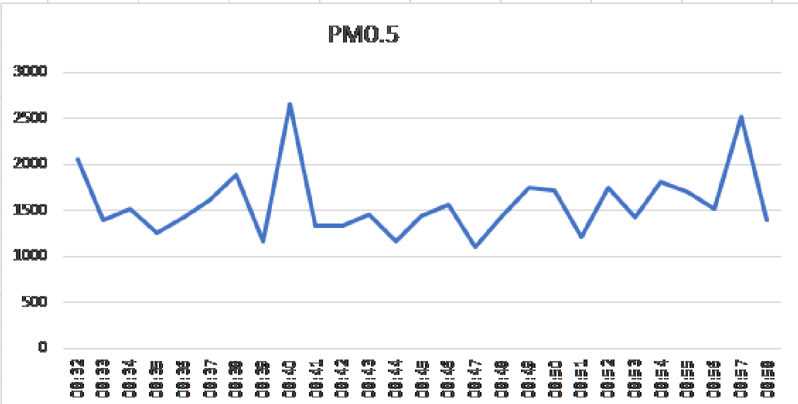


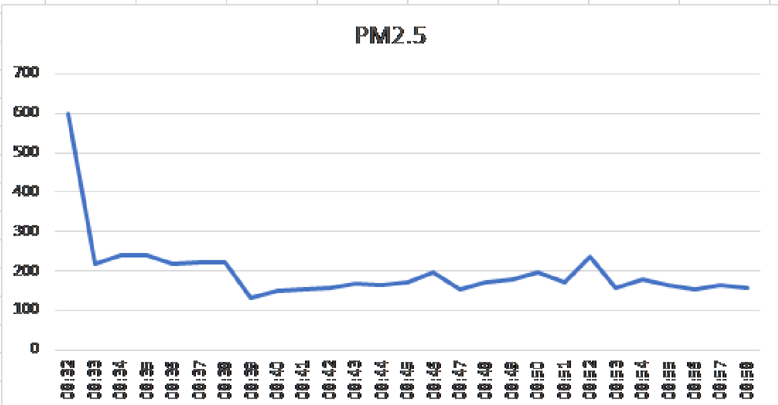


	Date: 14/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:47	2152	177
	07:48	1378	161
	07:49	1541	162
	07:50	2326	287
	07:51	1585	191
	07:52	1451	205
	07:53	1192	196
	07:54	1278	220
	07:55	1223	187
	07:56	1437	190
	07:57	2188	216
	07:58	1282	190
	07:59	1275	203
	08:00	1668	271
	08:01	1669	218
	08:02	1535	225
	08:03	1295	249
	08:04	16341	791
	08:05	13997	331
	08:06	8930	260
	08:07	1898	227
	08:08	1655	233
	08:09	1383	230
	08:10	1730	255
	08:11	1409	260
	08:12	2026	311
	08:13	2869	269
	08:14	3194	222
	08:15	2984	260
	08:16	1287	220
	08:17	1336	236
	Average:	2823.032	246.871
2nd	08:32	2067	598
	08:33	1403	218
	08:34	1519	239
	08:35	1263	238
	08:36	1429	218
	08:37	1611	221
	08:38	1884	221
	08:39	1164	131
	08:40	2653	150
	08:41	1332	152
	08:42	1332	158
	08:43	1454	168
	08:44	1165	163
	08:45	1439	170
	08:46	1574	197
	08:47	1102	154
	08:48	1446	171
	08:49	1745	180
	08:50	1714	198
	08:51	1212	171
	08:52	1753	235
	08:53	1426	156
	08:54	1817	180
	08:55	1710	165
	08:56	1525	153
	08:57	2525	165
	08:58	1404	156
	Average:	1580.296	197.2593

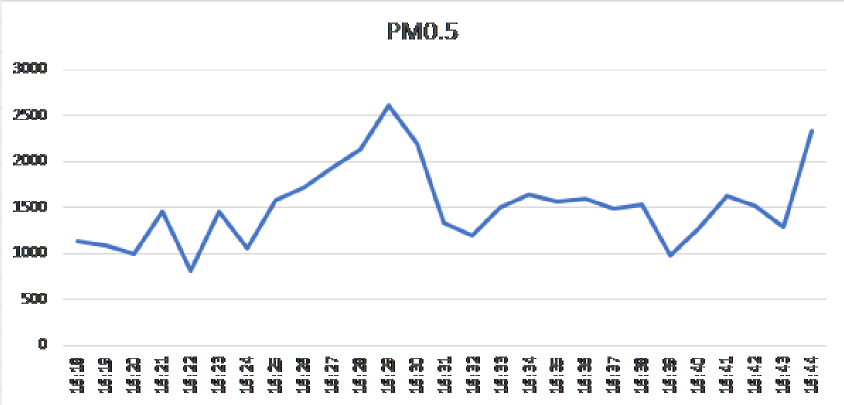


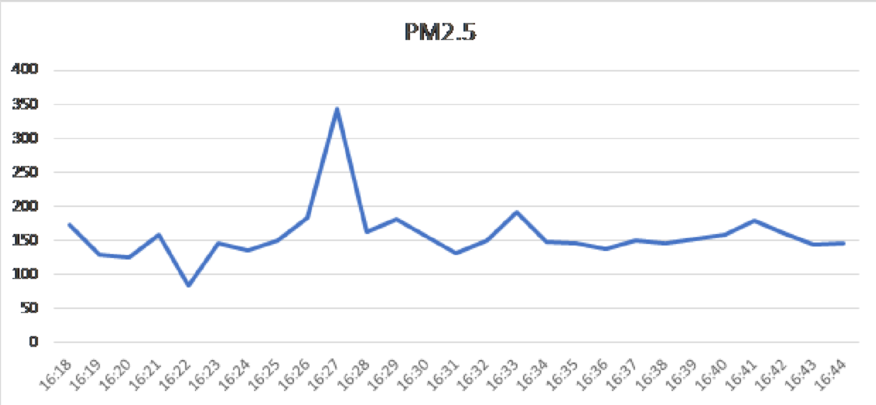






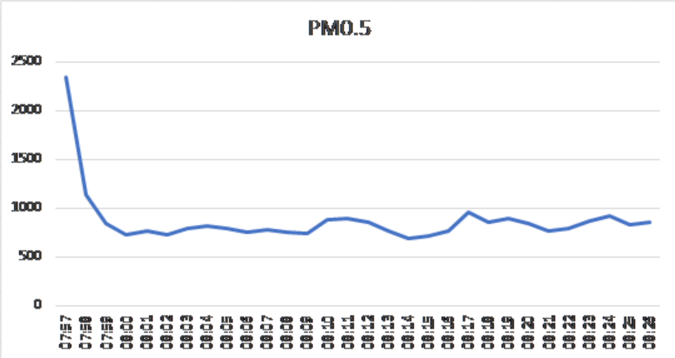
	Evening		
1st	Time:	PM0.5	PM2.5
	16:18	1136	173
	16:19	1091	130
	16:20	998	126
	16:21	1451	159
	16:22	819	84
	16:23	1463	147
	16:24	1054	135
	16:25	1576	151
	16:26	1719	184
	16:27	1930	344
	16:28	2140	163
	16:29	2613	182
	16:30	2205	157
	16:31	1341	131
	16:32	1199	151
	16:33	1499	192
	16:34	1638	149
	16:35	1564	146
	16:36	1601	137
	16:37	1485	150
	16:38	1536	146
	16:39	974	153
	16:40	1276	159
	16:41	1631	179
	16:42	1525	160
	16:43	1282	144
	16:44	2339	146
	Average:	1521.667	158.4444

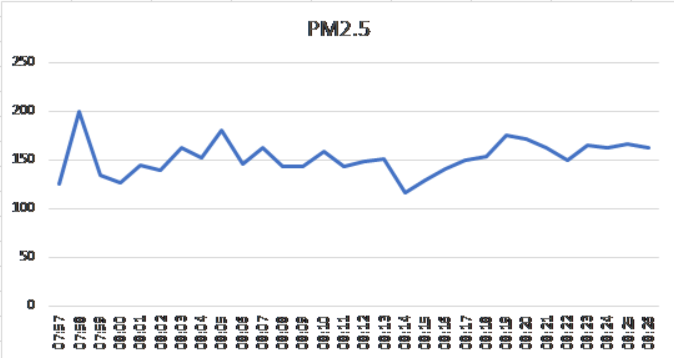


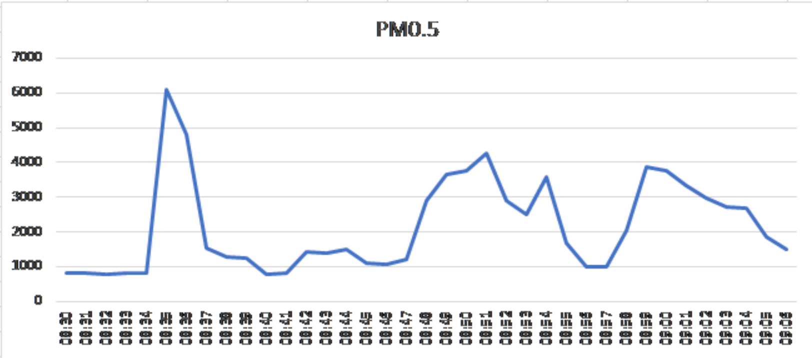


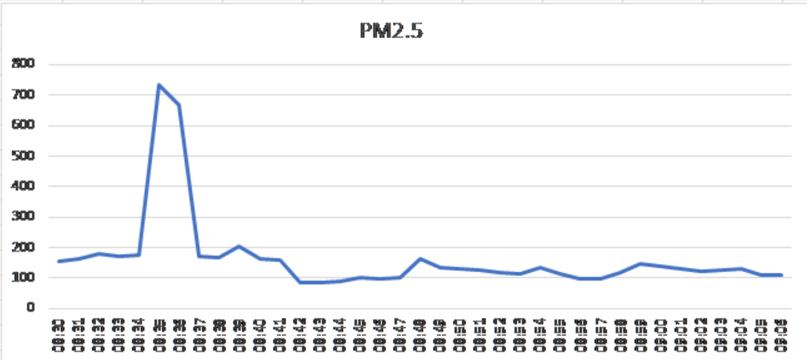
NO DATA FOR 2nd

	Date: 15/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:57	2339	126
	07:58	1142	200
	07:59	844	134
	08:00	727	127
	08:01	761	145
	08:02	725	140
	08:03	791	162
	08:04	816	153
	08:05	788	180
	08:06	747	146
	08:07	776	162
	08:08	755	144
	08:09	743	143
	08:10	882	159
	08:11	892	143
	08:12	858	149
	08:13	766	151
	08:14	694	116
	08:15	710	129
	08:16	761	141
	08:17	953	150
	08:18	857	154
	08:19	901	176
	08:20	846	171
	08:21	767	162
	08:22	794	150
	08:23	870	165
	08:24	918	163
	08:25	827	166
	08:26	856	163
	Average:	870.2	152.3333
	08:30	830	154
	08:31	826	161
	08:32	797	179
	08:33	817	173
	08:34	816	177
	08:35	6087	733
	08:36	4819	670
	08:37	1534	170
	08:38	1287	168
	08:39	1239	205
	08:40	791	161
	08:41	802	157
	08:42	1424	86
	08:43	1393	86
	08:44	1512	91
	08:45	1107	101
	08:46	1064	99
	08:47	1212	102
	08:48	2904	165
	08:49	3649	136
	08:50	3769	130
	08:51	4265	125
	08:52	2888	117
	08:53	2522	113
	08:54	3589	134
	08:55	1669	115
	08:56	984	99
	08:57	982	96
	08:58	2044	116
	08:59	3880	145
	09:00	3753	138
	09:01	3322	130
	09:02	2977	120
	09:03	2731	126
	09:04	2684	132
	09:05	1850	108
	09:06	1485	108
	Average:	2170.378	162.8649

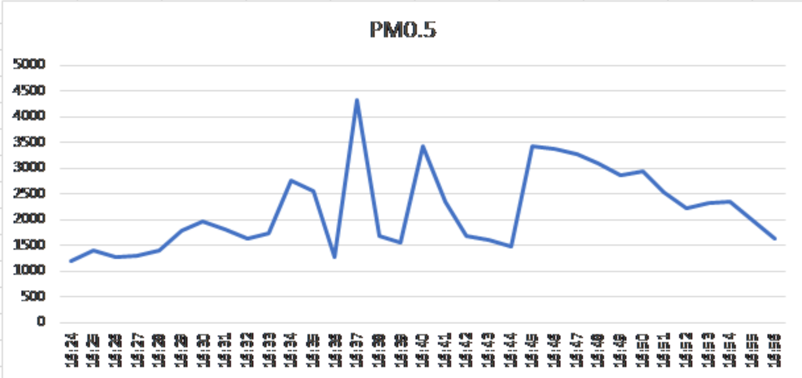


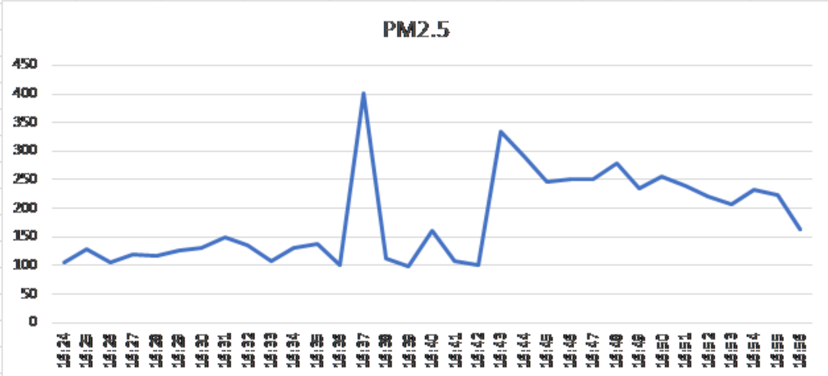


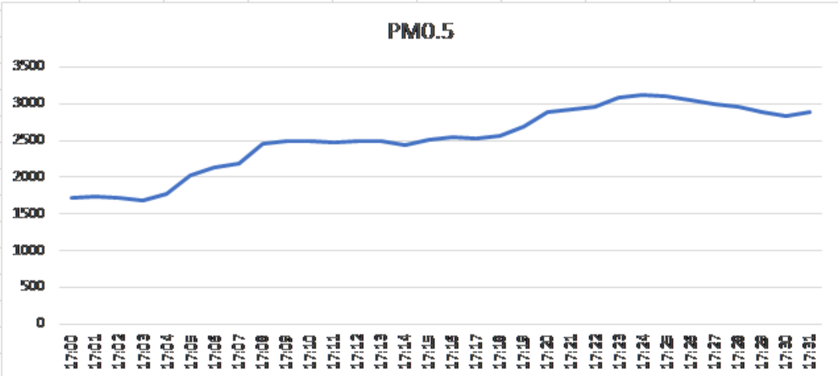


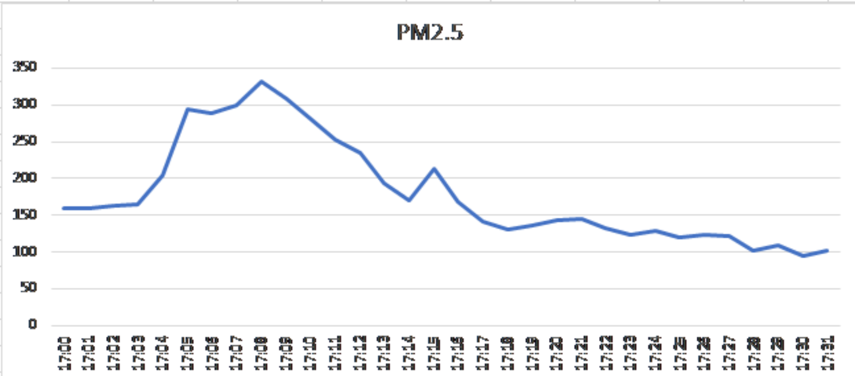


	Evening		
1st	Time:	PM0.5	PM2.5
	16:24	1197	105
	16:25	1403	128
	16:26	1271	106
	16:27	1300	119
	16:28	1401	116
	16:29	1788	127
	16:30	1968	131
	16:31	1822	149
	16:32	1644	136
	16:33	1735	107
	16:34	2774	132
	16:35	2572	138
	16:36	1263	100
	16:37	4327	402
	16:38	1677	113
	16:39	1553	98
	16:40	3444	162
	16:41	2354	108
	16:42	1683	101
	16:43	1603	334
	16:44	1476	290
	16:45	3434	246
	16:46	3386	250
	16:47	3284	252
	16:48	3093	280
	16:49	2861	235
	16:50	2950	255
	16:51	2530	239
	16:52	2235	220
	16:53	2329	208
	16:54	2360	233
	16:55	1986	224
	16:56	1640	163
	Average:	2192.212	182.0303
	2nd		
	17:00	1715	160
	17:01	1732	160
	17:02	1725	163
	17:03	1683	164
	17:04	1776	205
	17:05	2019	294
	17:06	2134	288
	17:07	2180	300
	17:08	2459	332
	17:09	2484	308
	17:10	2501	282
	17:11	2483	253
	17:12	2493	234
	17:13	2501	193
	17:14	2430	170
	17:15	2503	213
	17:16	2550	169
	17:17	2537	141
	17:18	2556	131
	17:19	2699	136
	17:20	2896	143
	17:21	2923	145
	17:22	2968	133
	17:23	3080	124
	17:24	3115	128
	17:25	3103	120
	17:26	3045	123
	17:27	3002	121
	17:28	2958	101
	17:29	2894	109
	17:30	2842	95
	17:31	2895	102
	Average:	2527.531	179.375

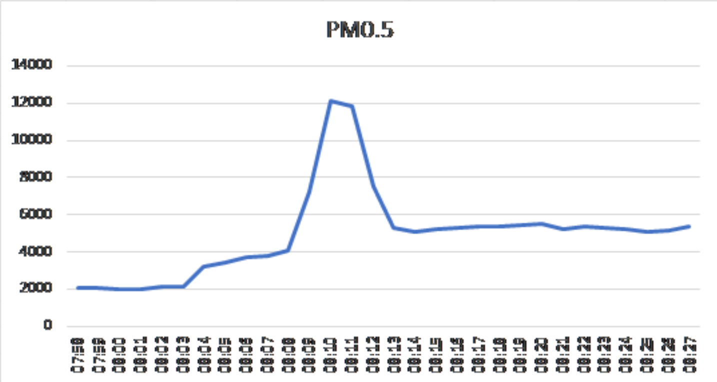


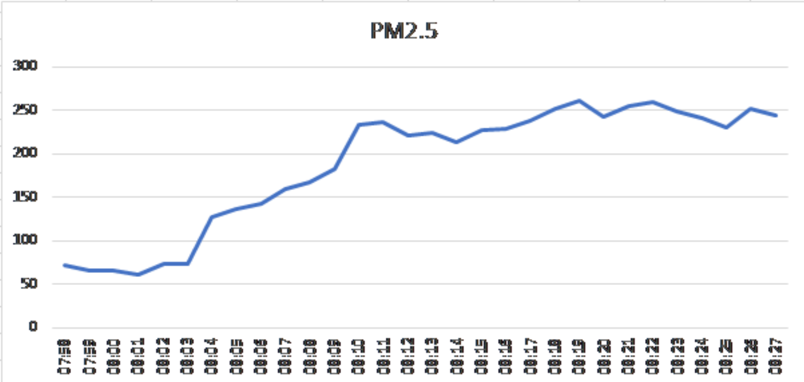


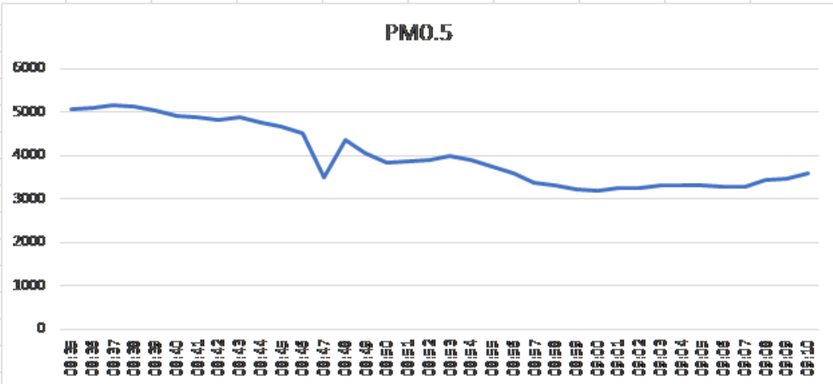


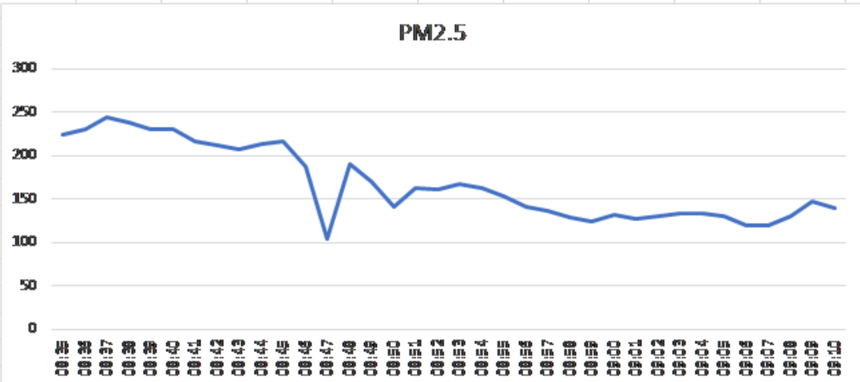


	Date:18/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:58	2042	72
	07:59	2030	65
	08:00	2010	65
	08:01	2012	61
	08:02	2099	73
	08:03	2132	73
	08:04	3205	127
	08:05	3431	137
	08:06	3713	143
	08:07	3818	160
	08:08	4063	168
	08:09	7224	183
	08:10	12145	234
	08:11	11821	236
	08:12	7503	221
	08:13	5273	224
	08:14	5093	214
	08:15	5234	227
	08:16	5286	229
	08:17	5371	238
	08:18	5351	252
	08:19	5423	261
	08:20	5498	243
	08:21	5225	256
	08:22	5383	260
	08:23	5296	249
	08:24	5230	241
	08:25	5091	230
	08:26	5153	252
	08:27	5336	244
	Average	4949.7	187.9333
2nd	08:35	5085	224
	08:36	5104	231
	08:37	5159	244
	08:38	5138	239
	08:39	5029	231
	08:40	4909	230
	08:41	4884	217
	08:42	4823	212
	08:43	4889	208
	08:44	4756	213
	08:45	4676	217
	08:46	4508	187
	08:47	3517	105
	08:48	4377	190
	08:49	4051	170
	08:50	3836	141
	08:51	3884	163
	08:52	3889	162
	08:53	3984	168
	08:54	3900	163
	08:55	3763	154
	08:56	3585	142
	08:57	3368	136
	08:58	3326	129
	08:59	3211	125
	09:00	3185	132
	09:01	3246	127
	09:02	3241	130
	09:03	3328	134
	09:04	3324	133
	09:05	3324	130
	09:06	3274	120
	09:07	3293	120
	09:08	3455	130
	09:09	3482	147
	09:10	3592	139
	Average	4010.972	167.8611

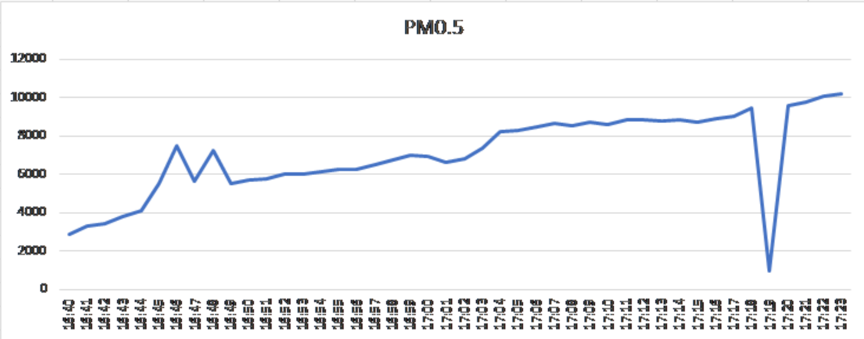


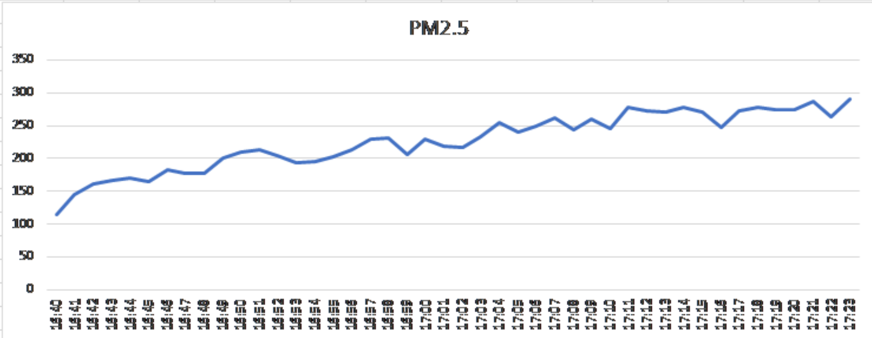


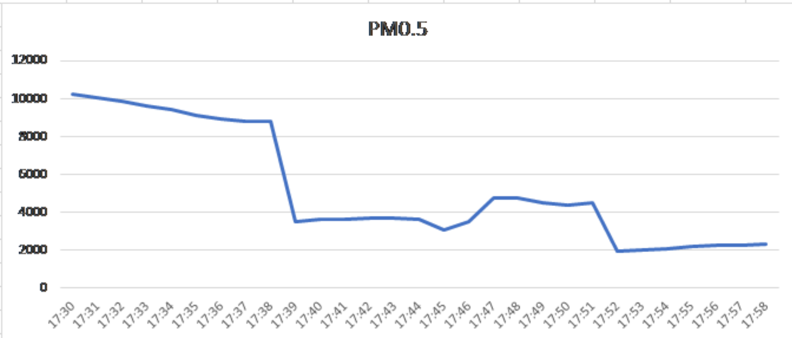


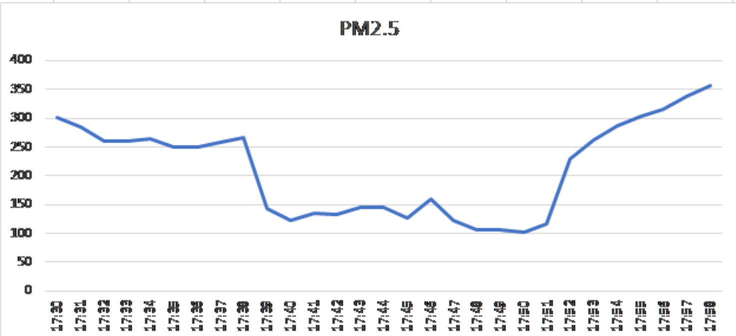


	Evening		
1st	Time:	PM0.5	PM2.5
	16:40	2882	115
	16:41	3309	145
	16:42	3401	161
	16:43	3805	167
	16:44	4136	170
	16:45	5550	165
	16:46	7493	183
	16:47	5677	178
	16:48	7235	178
	16:49	5543	201
	16:50	5699	209
	16:51	5768	214
	16:52	6010	205
	16:53	6032	194
	16:54	6133	196
	16:55	6281	202
	16:56	6289	213
	16:57	6535	229
	16:58	6745	232
	16:59	6976	206
	17:00	6939	229
	17:01	6646	218
	17:02	6809	217
	17:03	7372	233
	17:04	8253	255
	17:05	8329	241
	17:06	8492	250
	17:07	8682	262
	17:08	8547	244
	17:09	8753	260
	17:10	8603	246
	17:11	8879	278
	17:12	8832	273
	17:13	8792	270
	17:14	8872	278
	17:15	8737	271
	17:16	8912	248
	17:17	9042	272
	17:18	9442	278
	17:19	969	275
	17:20	9600	275
	17:21	9801	287
	17:22	10111	263
	17:23	10225	290
	Average:	7071.318	226.7273
2ND	17:30	10237	301
	17:31	10052	285
	17:32	9864	261
	17:33	9652	260
	17:34	9433	264
	17:35	9123	250
	17:36	8939	249
	17:37	8829	259
	17:38	8837	266
	17:39	3533	143
	17:40	3636	122
	17:41	3618	135
	17:42	3725	133
	17:43	3723	146
	17:44	3656	145
	17:45	3080	127
	17:46	3520	160
	17:47	4776	123
	17:48	4772	107
	17:49	4519	106
	17:50	4384	102
	17:51	4498	117
	17:52	1960	229
	17:53	2009	263
	17:54	2075	286
	17:55	2193	304
	17:56	2255	315
	17:57	2264	339
	17:58	2301	356
	Average:	5222.862	212.1724

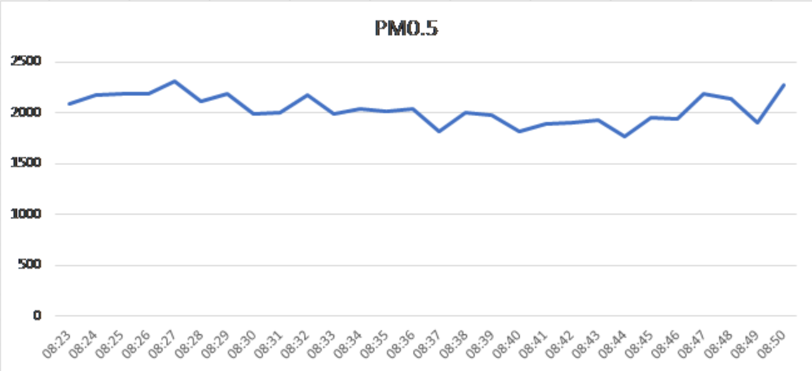


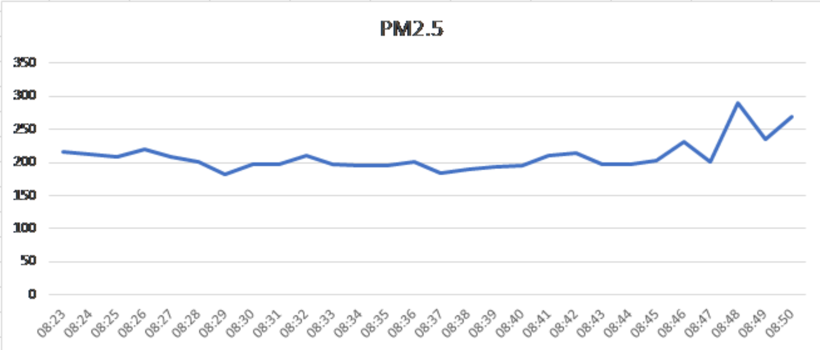


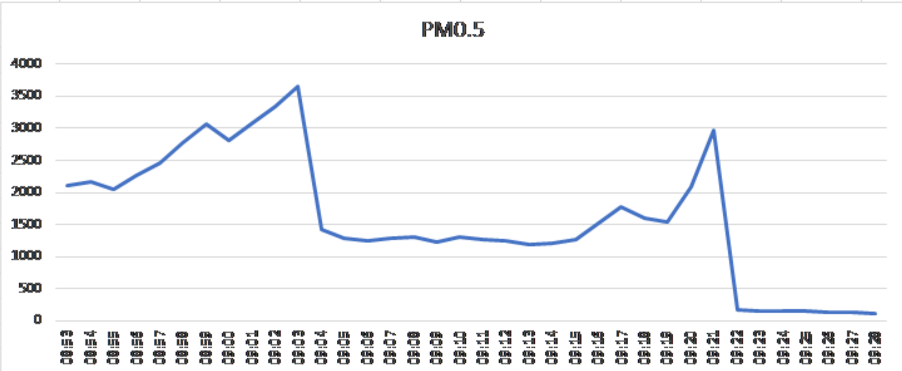


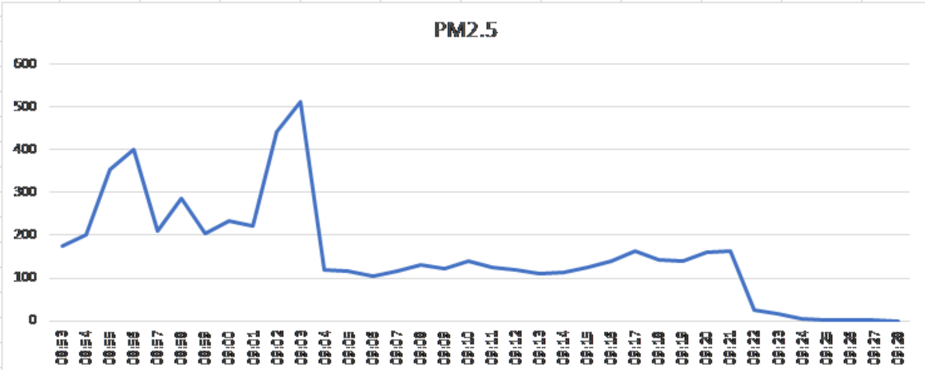


	Date:26/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	08:23	2093	216
	08:24	2178	212
	08:25	2193	208
	08:26	2189	221
	08:27	2312	209
	08:28	2121	201
	08:29	2191	183
	08:30	1988	198
	08:31	2002	197
	08:32	2175	211
	08:33	1987	197
	08:34	2036	195
	08:35	2015	196
	08:36	2037	201
	08:37	1821	185
	08:38	2010	190
	08:39	1983	194
	08:40	1818	196
	08:41	1892	210
	08:42	1903	215
	08:43	1927	198
	08:44	1764	198
	08:45	1957	203
	08:46	1943	232
	08:47	2194	201
	08:48	2143	290
	08:49	1903	236
	08:50	2271	269
	Average:	2037.357	209.3571
2nd	08:53	2118	175
	08:54	2166	202
	08:55	2052	353
	08:56	2260	401
	08:57	2465	211
	08:58	2765	285
	08:59	3062	203
	09:00	2807	235
	09:01	3092	223
	09:02	3333	442
	09:03	3657	512
	09:04	1432	119
	09:05	1285	115
	09:06	1248	105
	09:07	1280	117
	09:08	1299	130
	09:09	1231	123
	09:10	1298	140
	09:11	1267	125
	09:12	1246	119
	09:13	1184	111
	09:14	1205	114
	09:15	1275	126
	09:16	1530	141
	09:17	1778	163
	09:18	1593	144
	09:19	1537	139
	09:20	2094	159
	09:21	2965	163
	09:22	180	24
	09:23	143	16
	09:24	142	6
	09:25	150	3
	09:26	123	2
	09:27	124	2
	09:28	105	0
	Average:	1596.972	156.8889

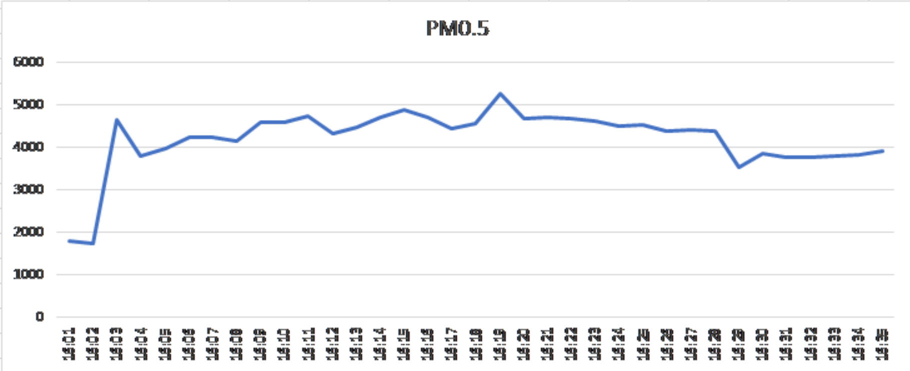


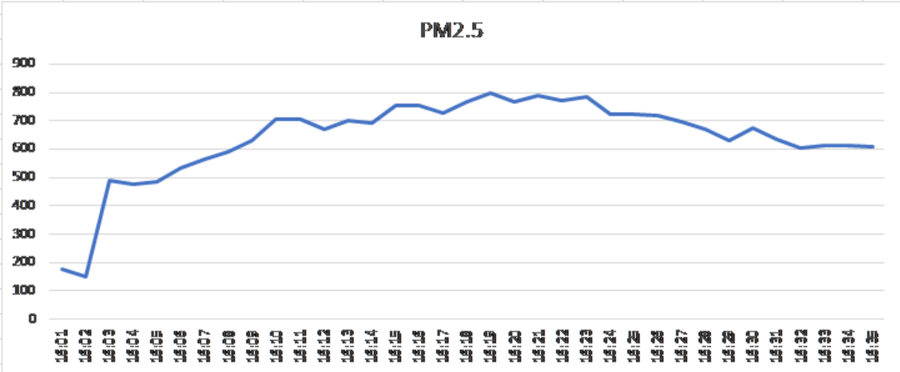


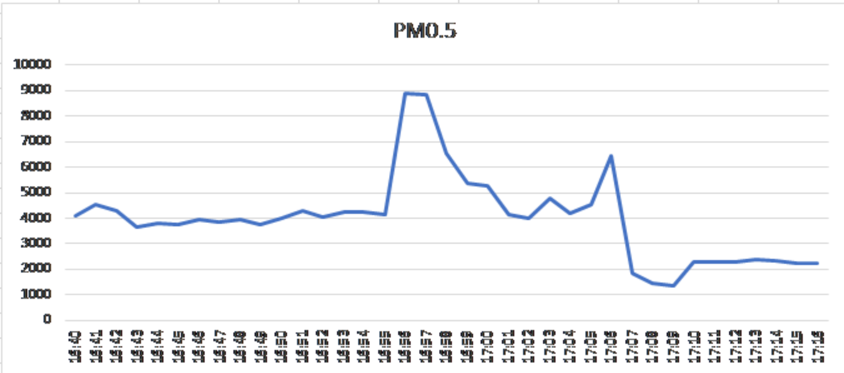


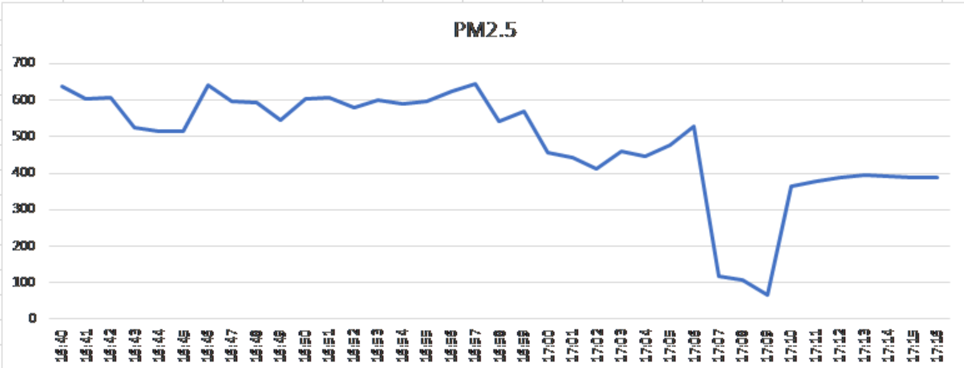


	Evening		
1st	Time:	PM0.5	PM2.5
	16:01	1791	178
	16:02	1752	151
	16:03	4655	490
	16:04	3806	475
	16:05	3972	485
	16:06	4233	535
	16:07	4226	564
	16:08	4147	592
	16:09	4593	632
	16:10	4587	705
	16:11	4729	705
	16:12	4337	669
	16:13	4469	703
	16:14	4700	693
	16:15	4873	755
	16:16	4719	753
	16:17	4438	728
	16:18	4571	769
	16:19	5280	800
	16:20	4692	768
	16:21	4712	790
	16:22	4665	773
	16:23	4613	786
	16:24	4514	722
	16:25	4519	724
	16:26	4381	720
	16:27	4426	697
	16:28	4386	671
	16:29	3533	631
	16:30	3869	674
	16:31	3769	637
	16:32	3761	603
	16:33	3809	613
	16:34	3833	614
	16:35	3926	609
	Average:	4208.171	640.4
	16:40	4076	638
	16:41	4522	603
	16:42	4274	609
	16:43	3659	525
	16:44	3802	514
	16:45	3735	515
	16:46	3961	642
	16:47	3848	598
	16:48	3945	592
	16:49	3746	546
	16:50	4018	604
	16:51	4307	606
	16:52	4040	581
	16:53	4243	601
	16:54	4225	590
	16:55	4170	597
	16:56	8897	626
	16:57	8867	646
	16:58	6523	542
	16:59	5384	570
	17:00	5281	456
	17:01	4161	444
	17:02	4001	411
	17:03	4790	459
	17:04	4211	446
	17:05	4557	478
	17:06	6436	529
	17:07	1864	119
	17:08	1456	108
	17:09	1385	68
	17:10	2313	364
	17:11	2314	378
	17:12	2283	389
	17:13	2364	394
	17:14	2326	391
	17:15	2231	388
	17:16	2257	388
	Average:	4012.757	485.2703

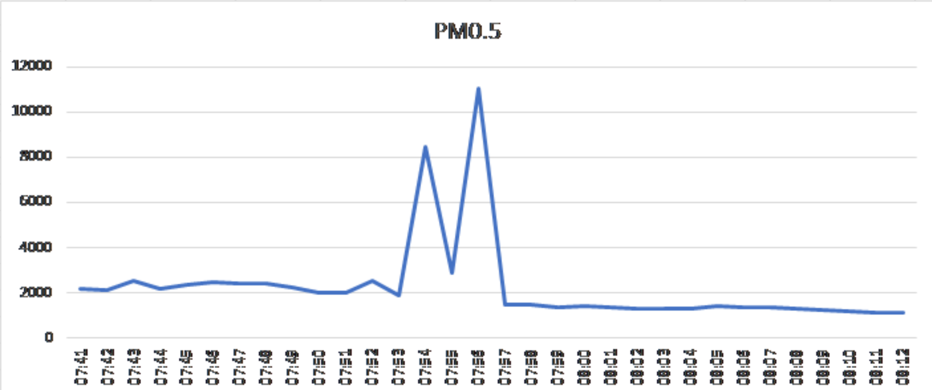


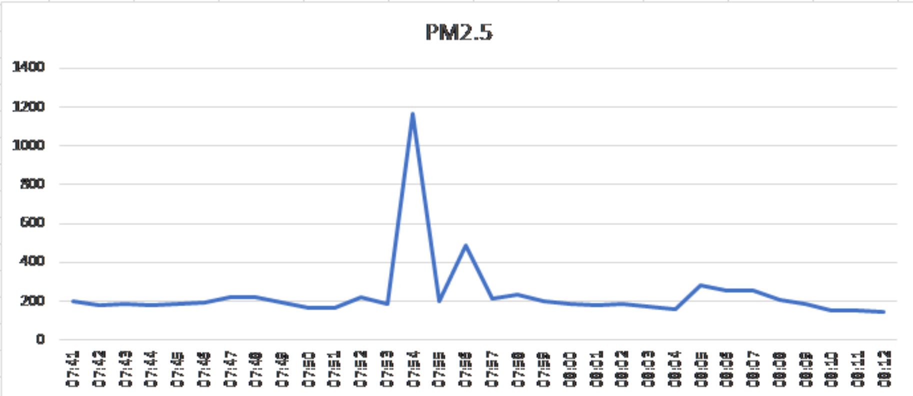


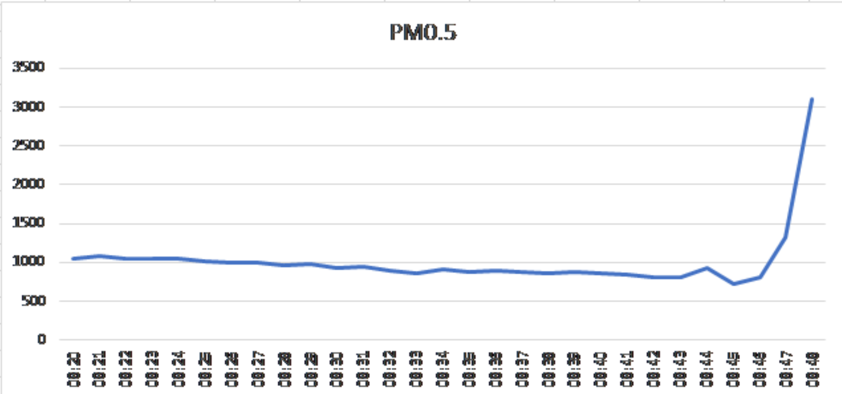


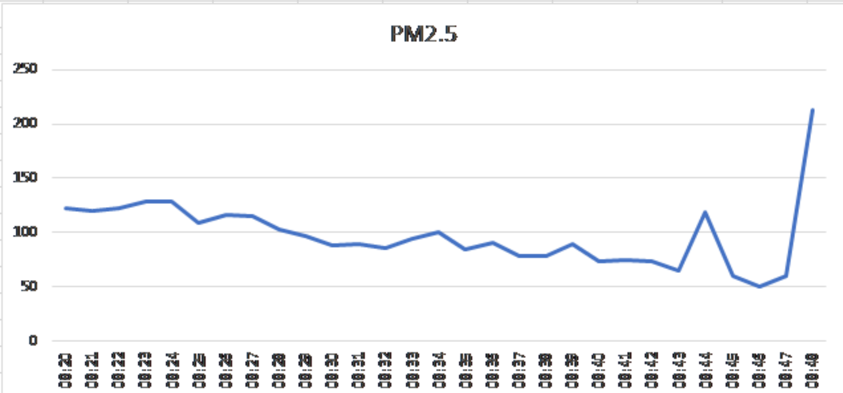


	Date:27/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:41	2186	200
	07:42	2145	180
	07:43	2536	184
	07:44	2197	179
	07:45	2380	189
	07:46	2502	195
	07:47	2427	223
	07:48	2432	222
	07:49	2267	196
	07:50	2019	165
	07:51	1983	167
	07:52	2545	222
	07:53	1910	187
	07:54	8476	1163
	07:55	2864	201
	07:56	11071	489
	07:57	1465	213
	07:58	1487	233
	07:59	1365	198
	08:00	1433	190
	08:01	1354	181
	08:02	1325	187
	08:03	1312	171
	08:04	1272	156
	08:05	1413	280
	08:06	1387	258
	08:07	1363	255
	08:08	1301	206
	08:09	1214	188
	08:10	1158	150
	08:11	1136	153
	08:12	1128	144
	Average:	2282.906	235.1563
	08:20	1056	122
	08:21	1086	120
	08:22	1046	122
	08:23	1051	129
	08:24	1047	129
	08:25	1007	109
	08:26	999	116
	08:27	990	115
	08:28	967	103
	08:29	975	97
	08:30	927	88
	08:31	946	89
	08:32	899	86
	08:33	853	94
	08:34	915	101
	08:35	874	85
	08:36	902	91
	08:37	875	79
	08:38	863	78
	08:39	881	90
	08:40	857	74
	08:41	843	75
	08:42	808	74
	08:43	815	65
	08:44	922	119
	08:45	724	60
	08:46	803	50
	08:47	1327	60
	08:48	3097	213
	Average:	1012.241	97.68966

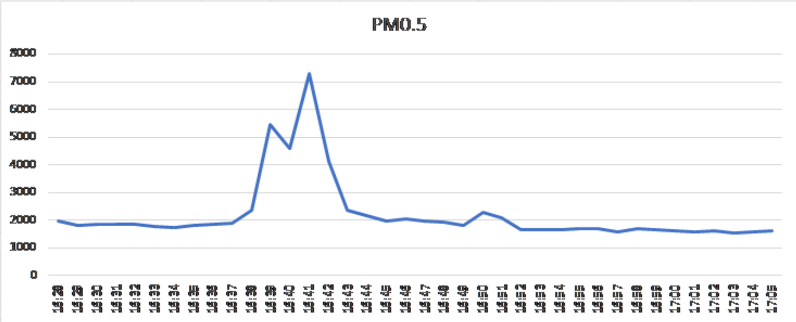


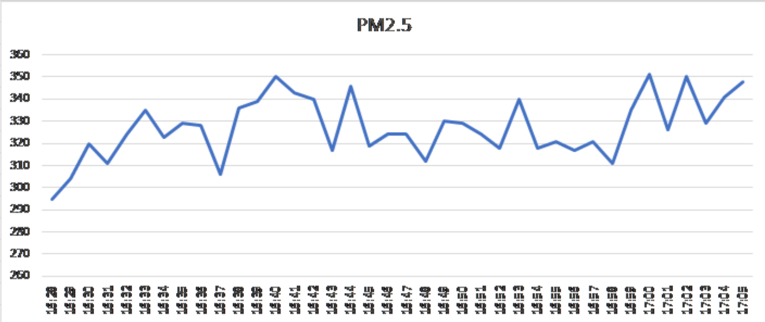


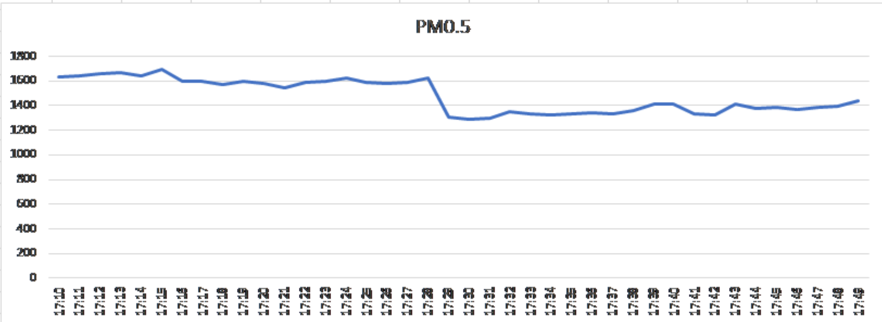


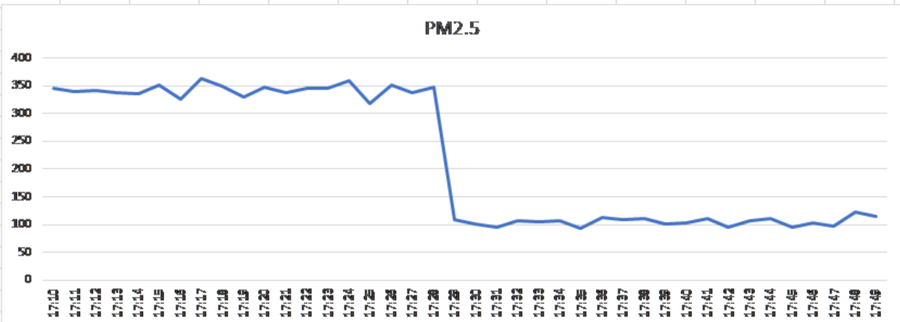


	Evening		
1st	Time:	PM0.5	PM2.5
	16:28	1986	295
	16:29	1820	304
	16:30	1856	320
	16:31	1837	311
	16:32	1841	324
	16:33	1756	335
	16:34	1751	323
	16:35	1815	329
	16:36	1834	328
	16:37	1887	306
	16:38	2366	336
	16:39	5452	339
	16:40	4593	350
	16:41	7313	343
	16:42	4137	340
	16:43	2345	317
	16:44	2172	346
	16:45	1959	319
	16:46	2034	324
	16:47	1981	324
	16:48	1933	312
	16:49	1822	330
	16:50	2287	329
	16:51	2085	324
	16:52	1672	318
	16:53	1640	340
	16:54	1673	318
	16:55	1680	321
	16:56	1704	317
	16:57	1599	321
	16:58	1689	311
	16:59	1673	335
	17:00	1621	351
	17:01	1587	326
	17:02	1608	350
	17:03	1544	329
	17:04	1591	341
	17:05	1617	348
	Average:	2204.211	327.2105
	17:10	1632	346
	17:11	1642	339
	17:12	1655	341
	17:13	1670	338
	17:14	1638	336
	17:15	1691	352
	17:16	1601	326
	17:17	1601	364
	17:18	1570	350
	17:19	1598	331
	17:20	1582	348
	17:21	1546	338
	17:22	1590	346
	17:23	1600	345
	17:24	1621	359
	17:25	1592	319
	17:26	1582	352
	17:27	1590	337
	17:28	1621	347
	17:29	1309	108
	17:30	1290	102
	17:31	1301	95
	17:32	1352	107
	17:33	1337	105
	17:34	1325	106
	17:35	1332	93
	17:36	1339	112
	17:37	1334	108
	17:38	1358	110
	17:39	1412	101
	17:40	1412	103
	17:41	1336	111
	17:42	1327	96
	17:43	1409	107
	17:44	1376	111
	17:45	1387	95
	17:46	1372	104
	17:47	1383	97
	17:48	1394	122
	17:49	1438	114
	Average:	1478.625	218.025

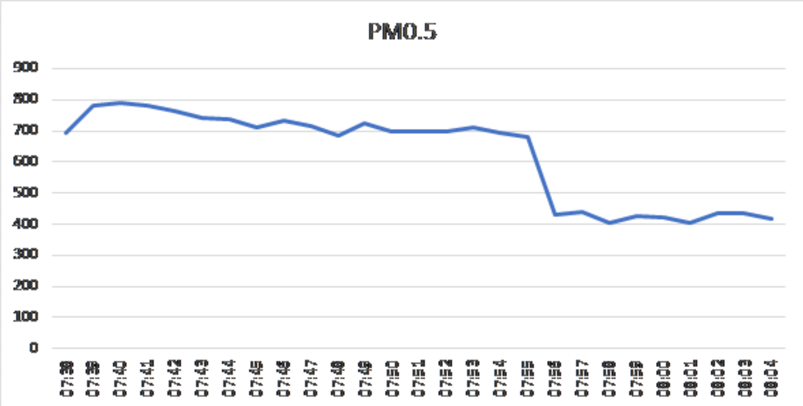


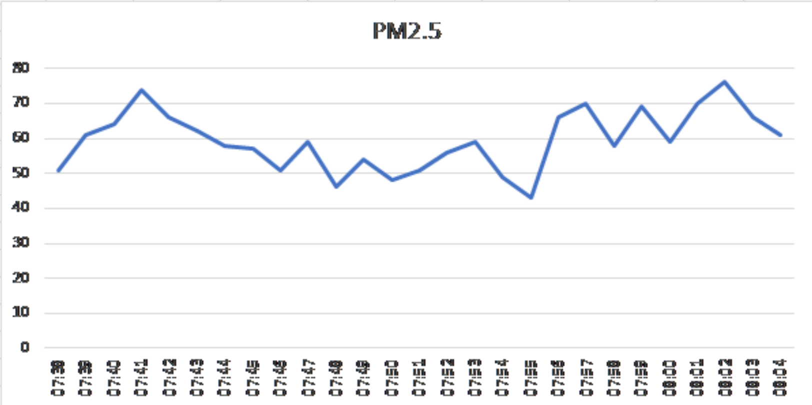


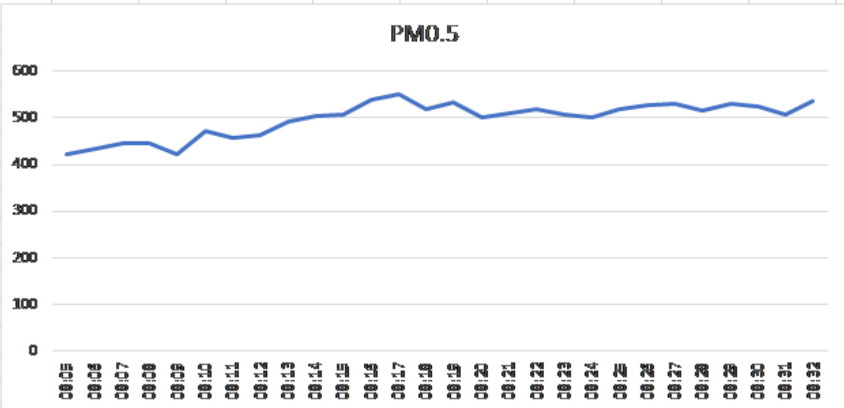


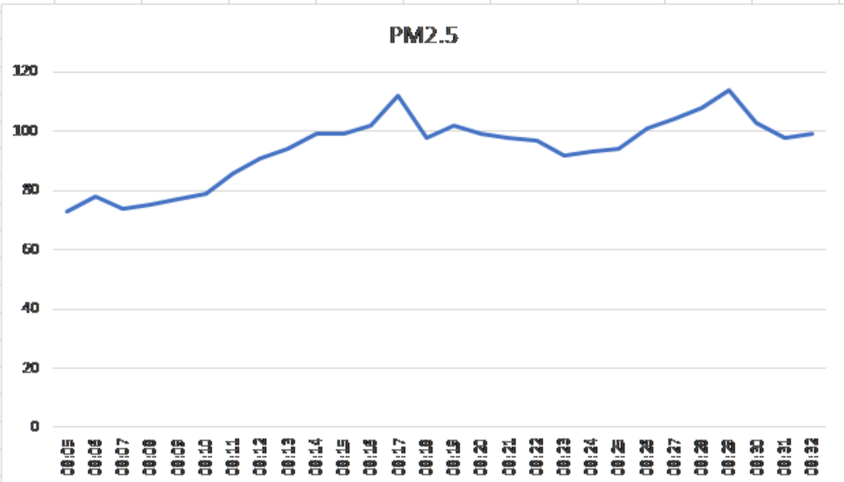


	Date: 29/11/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:38	694	51
	07:39	781	61
	07:40	788	64
	07:41	781	74
	07:42	765	66
	07:43	744	62
	07:44	737	58
	07:45	711	57
	07:46	733	51
	07:47	717	59
	07:48	686	46
	07:49	723	54
	07:50	699	48
	07:51	698	51
	07:52	700	56
	07:53	712	59
	07:54	695	49
	07:55	682	43
	07:56	432	66
	07:57	438	70
	07:58	405	58
	07:59	428	69
	08:00	420	59
	08:01	405	70
	08:02	436	76
	08:03	434	66
	08:04	417	61
	Average:	624.4815	59.40741
2nd	08:05	422	73
	08:06	433	78
	08:07	446	74
	08:08	445	75
	08:09	423	77
	08:10	472	79
	08:11	456	86
	08:12	463	91
	08:13	492	94
	08:14	505	99
	08:15	506	99
	08:16	540	102
	08:17	552	112
	08:18	518	98
	08:19	534	102
	08:20	500	99
	08:21	511	98
	08:22	519	97
	08:23	506	92
	08:24	502	93
	08:25	518	94
	08:26	528	101
	08:27	531	104
	08:28	517	108
	08:29	530	114
	08:30	526	103
	08:31	507	98
	08:32	535	99
	Average:	497.75	94.25

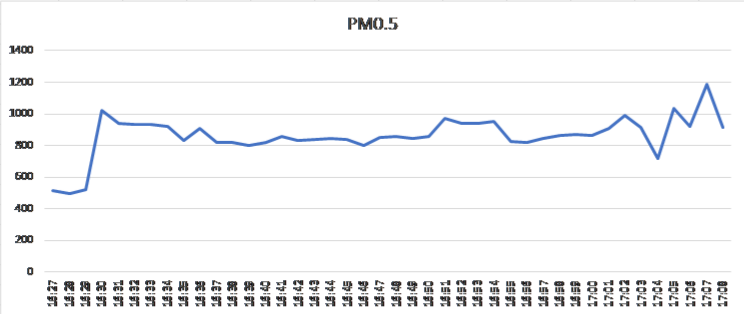


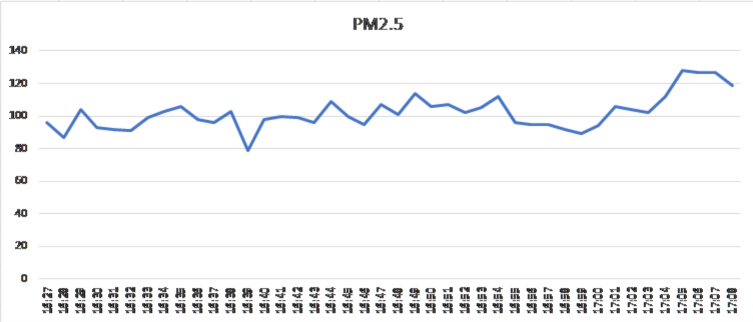


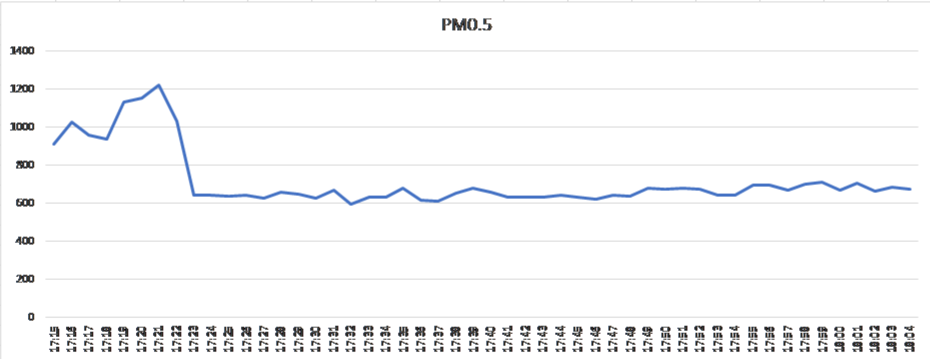


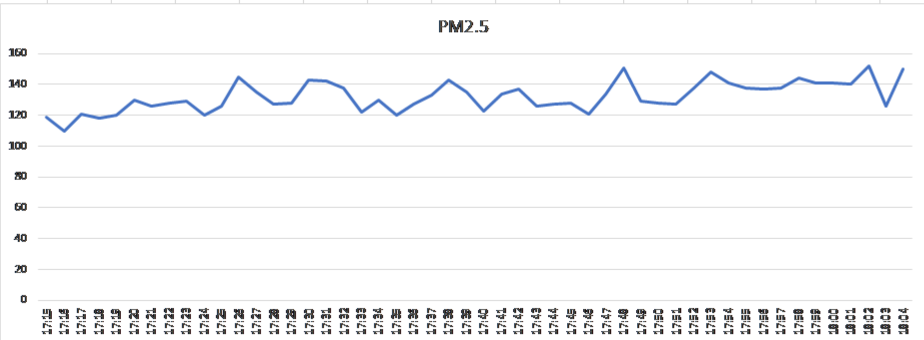


	Evening		
1st	Time:	PM0.5	PM2.5
	16:27	516	96
	16:28	499	87
	16:29	519	104
	16:30	1025	93
	16:31	938	92
	16:32	932	91
	16:33	932	99
	16:34	923	103
	16:35	831	106
	16:36	908	98
	16:37	820	96
	16:38	822	103
	16:39	800	79
	16:40	818	98
	16:41	860	100
	16:42	831	99
	16:43	841	96
	16:44	847	109
	16:45	839	100
	16:46	803	95
	16:47	850	107
	16:48	859	101
	16:49	846	114
	16:50	856	106
	16:51	973	107
	16:52	943	102
	16:53	940	105
	16:54	952	112
	16:55	828	96
	16:56	819	95
	16:57	844	95
	16:58	863	92
	16:59	868	89
	17:00	866	94
	17:01	910	106
	17:02	992	104
	17:03	914	102
	17:04	718	112
	17:05	1037	128
	17:06	921	127
	17:07	1190	127
	17:08	913	119
	Average:	862.0476	102
2nd	17:15	913	119
	17:16	1031	110
	17:17	958	121
	17:18	939	118
	17:19	1133	120
	17:20	1156	130
	17:21	1225	126
	17:22	1032	128
	17:23	645	129
	17:24	647	120
	17:25	640	126
	17:26	646	145
	17:27	628	135
	17:28	661	127
	17:29	650	128
	17:30	628	143
	17:31	670	142
	17:32	599	138
	17:33	634	122
	17:34	636	130
	17:35	681	120
	17:36	620	127
	17:37	614	133
	17:38	654	143
	17:39	682	135
	17:40	663	123
	17:41	634	134
	17:42	634	137
	17:43	634	126
	17:44	645	127
	17:45	632	128
	17:46	626	121
	17:47	647	134
	17:48	642	151
	17:49	680	129
	17:50	674	128
	17:51	684	127
	17:52	677	138
	17:53	646	148
	17:54	645	141
	17:55	697	138
	17:56	697	137
	17:57	670	138
	17:58	703	144
	17:59	712	141
	18:00	671	141
	18:01	708	140
	18:02	667	152
	18:03	688	126
	18:04	675	150
	Average:	719.46	132.28

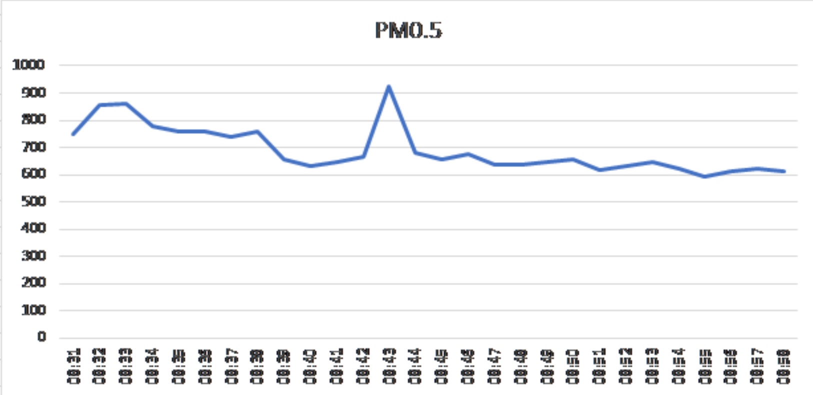


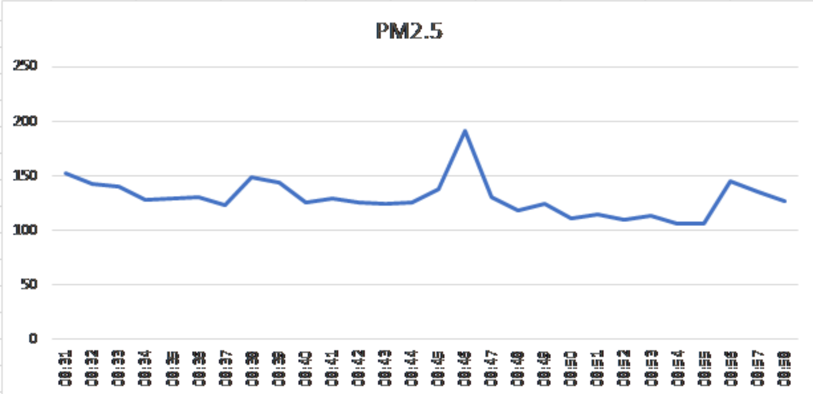


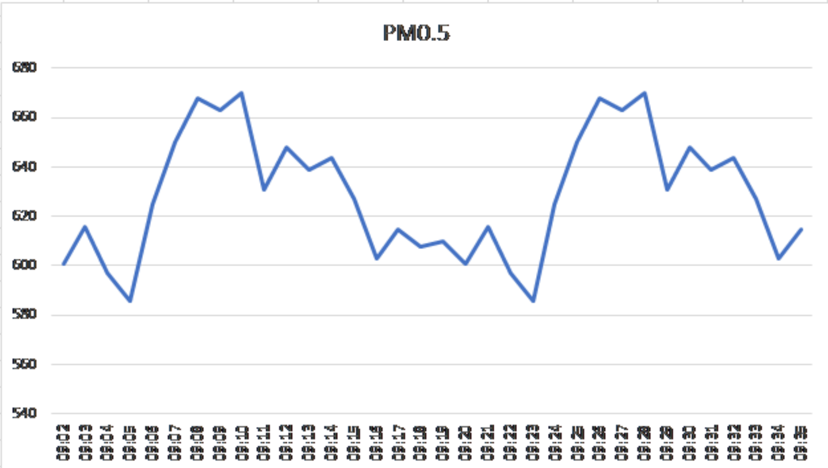


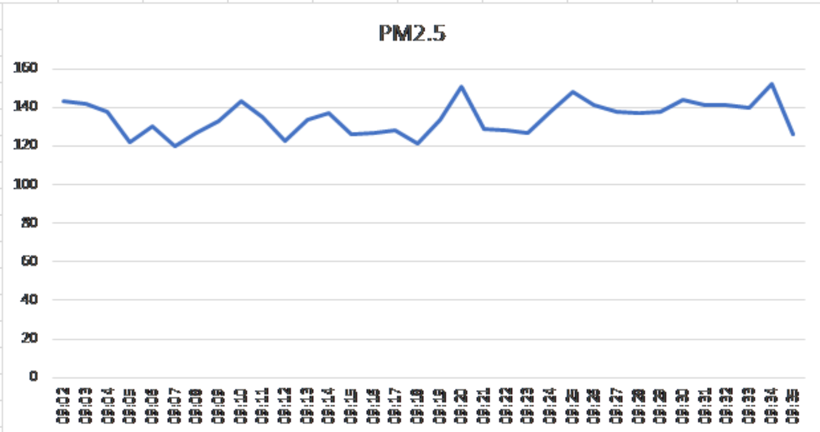


	Date:01/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	08:31	750	152
	08:32	858	143
	08:33	860	140
	08:34	776	128
	08:35	760	129
	08:36	760	131
	08:37	740	123
	08:38	757	149
	08:39	655	144
	08:40	631	126
	08:41	647	129
	08:42	668	126
	08:43	922	124
	08:44	683	126
	08:45	656	138
	08:46	674	191
	08:47	635	130
	08:48	637	119
	08:49	646	125
	08:50	658	111
	08:51	617	115
	08:52	634	110
	08:53	647	114
	08:54	623	106
	08:55	595	106
	08:56	613	145
	08:57	621	135
	08:58	613	127
	Average:	690.5714	130.0714
	2nd		
	09:02	601	143
	09:03	616	142
	09:04	597	138
	09:05	586	122
	09:06	625	130
	09:07	650	120
	09:08	668	127
	09:09	663	133
	09:10	670	143
	09:11	631	135
	09:12	648	123
	09:13	639	134
	09:14	644	137
	09:15	627	126
	09:16	603	127
	09:17	615	128
	09:18	608	121
	09:19	610	134
	09:20	601	151
	09:21	616	129
	09:22	597	128
	09:23	586	127
	09:24	625	138
	09:25	650	148
	09:26	668	141
	09:27	663	138
	09:28	670	137
	09:29	631	138
	09:30	648	144
	09:31	639	141
	09:32	644	141
	09:33	627	140
	09:34	603	152
	09:35	615	126
	Average:	628.9412	134.7647

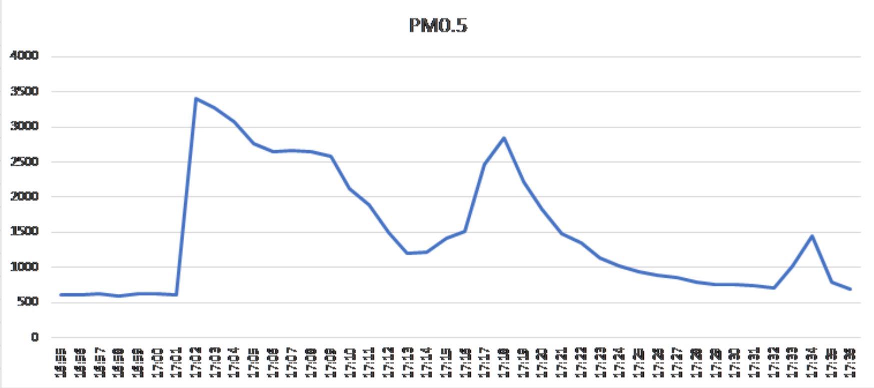


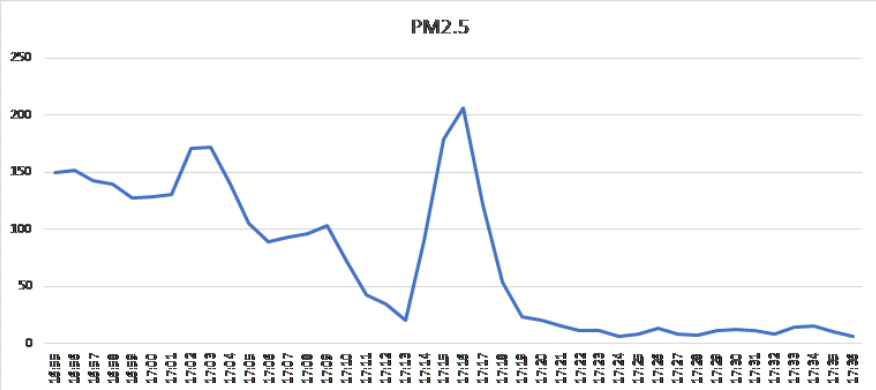


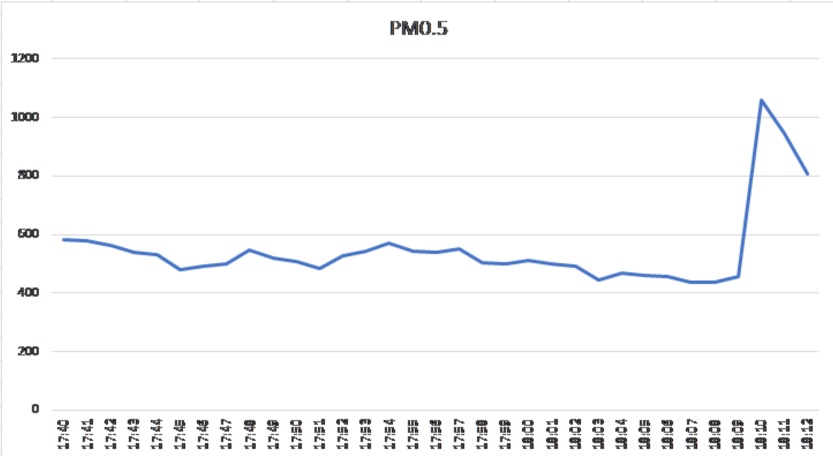


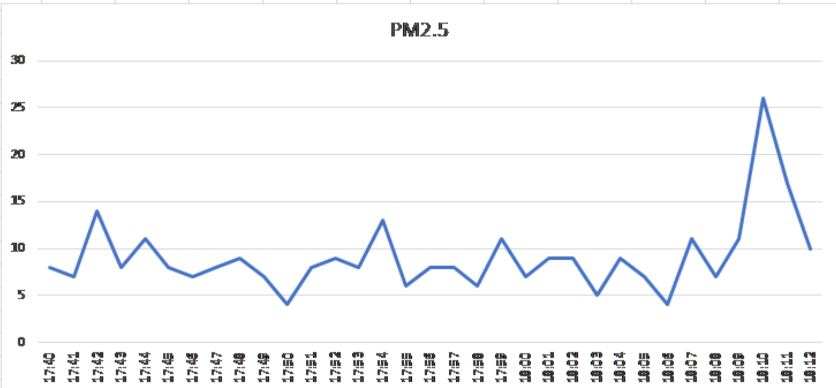


	Evening		
1st	Time:	PM0.5	PM2.5
	16:55	613	150
	16:56	604	152
	16:57	634	143
	16:58	595	140
	16:59	625	128
	17:00	623	129
	17:01	609	131
	17:02	3399	171
	17:03	3276	172
	17:04	3079	140
	17:05	2770	105
	17:06	2643	89
	17:07	2668	93
	17:08	2650	96
	17:09	2576	103
	17:10	2129	72
	17:11	1896	43
	17:12	1503	35
	17:13	1201	21
	17:14	1217	90
	17:15	1415	179
	17:16	1520	206
	17:17	2467	122
	17:18	2846	54
	17:19	2227	24
	17:20	1820	21
	17:21	1478	16
	17:22	1346	12
	17:23	1139	12
	17:24	1019	6
	17:25	936	9
	17:26	884	14
	17:27	850	9
	17:28	790	8
	17:29	758	12
	17:30	754	13
	17:31	740	12
	17:32	702	9
	17:33	1024	15
	17:34	1449	16
	17:35	788	11
	17:36	695	6
	Average:	1498.976	71.16667
	2nd		
	17:40	582	8
	17:41	580	7
	17:42	564	14
	17:43	540	8
	17:44	533	11
	17:45	481	8
	17:46	491	7
	17:47	501	8
	17:48	548	9
	17:49	520	7
	17:50	507	4
	17:51	484	8
	17:52	527	9
	17:53	543	8
	17:54	569	13
	17:55	543	6
	17:56	539	8
	17:57	551	8
	17:58	503	6
	17:59	499	11
	18:00	511	7
	18:01	498	9
	18:02	491	9
	18:03	446	5
	18:04	469	9
	18:05	459	7
	18:06	456	4
	18:07	437	11
	18:08	437	7
	18:09	457	11
	18:10	1059	26
	18:11	944	17
	18:12	808	10
	Average:	547.7879	9.090909

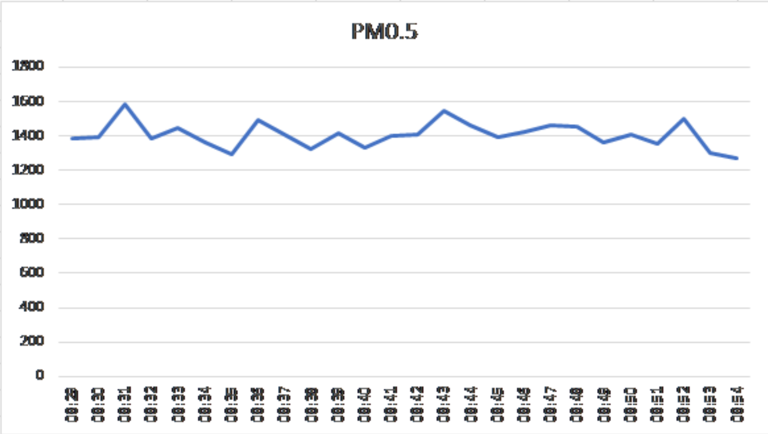


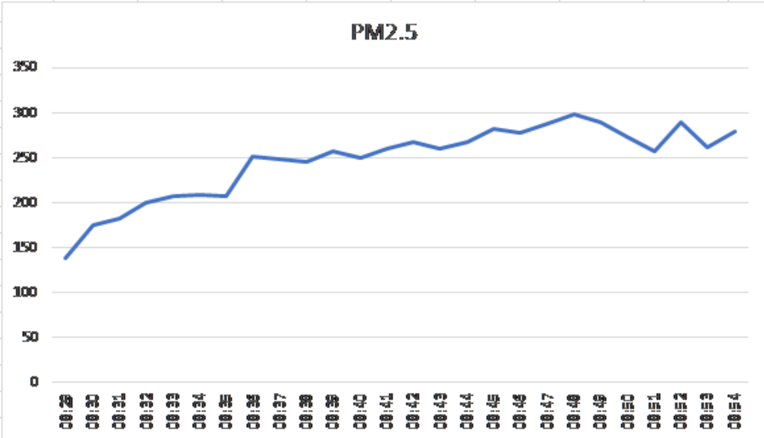


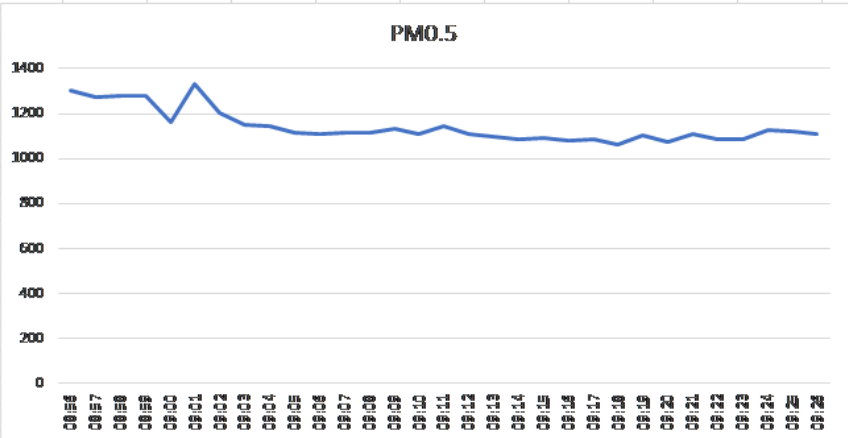


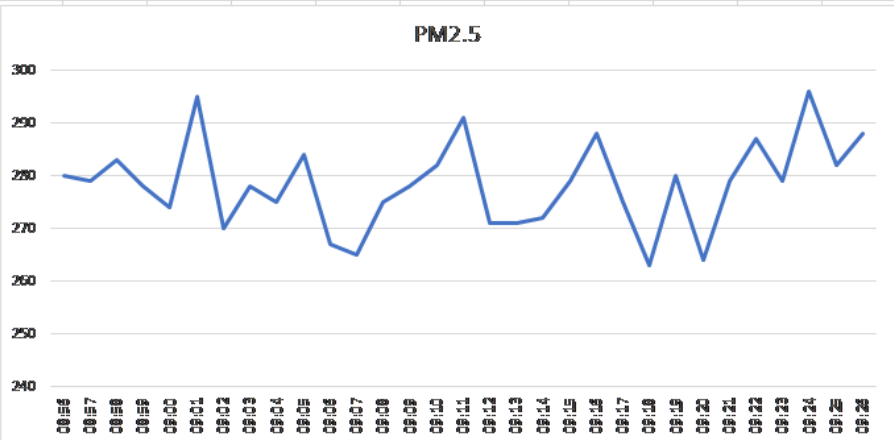


	Date:04/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	08:29	1389	138
	08:30	1396	175
	08:31	1585	183
	08:32	1385	200
	08:33	1447	207
	08:34	1365	209
	08:35	1292	208
	08:36	1492	251
	08:37	1408	248
	08:38	1328	246
	08:39	1414	258
	08:40	1333	250
	08:41	1400	260
	08:42	1409	268
	08:43	1545	260
	08:44	1459	268
	08:45	1394	283
	08:46	1421	278
	08:47	1463	288
	08:48	1453	299
	08:49	1365	289
	08:50	1408	274
	08:51	1354	258
	08:52	1504	289
	08:53	1298	262
	08:54	1267	279
	Average:	1406.692	247.2308
	08:56	1302	280
	08:57	1271	279
	08:58	1282	283
	08:59	1277	278
	09:00	1164	274
	09:01	1330	295
	09:02	1202	270
	09:03	1153	278
	09:04	1144	275
	09:05	1118	284
	09:06	1112	267
	09:07	1116	265
	09:08	1115	275
	09:09	1134	278
	09:10	1107	282
	09:11	1146	291
	09:12	1111	271
	09:13	1101	271
	09:14	1085	272
	09:15	1093	279
	09:16	1083	288
	09:17	1084	275
	09:18	1064	263
	09:19	1103	280
	09:20	1077	264
	09:21	1111	279
	09:22	1086	287
	09:23	1084	279
	09:24	1127	296
	09:25	1121	282
	09:26	1111	288
	Average:	1142.387	278.3226

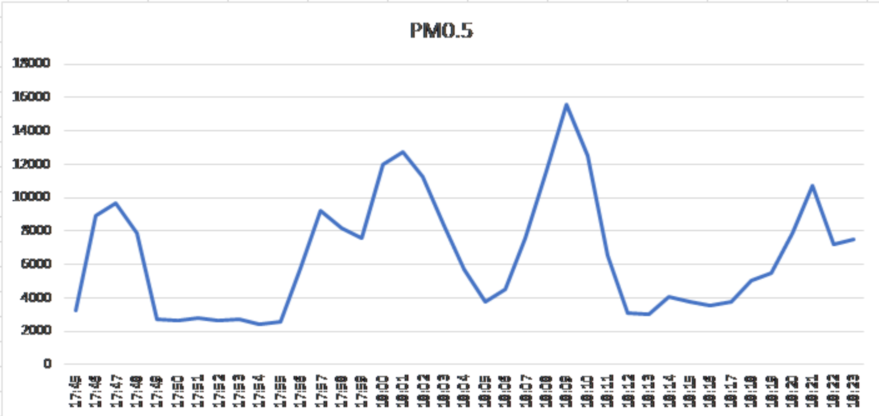


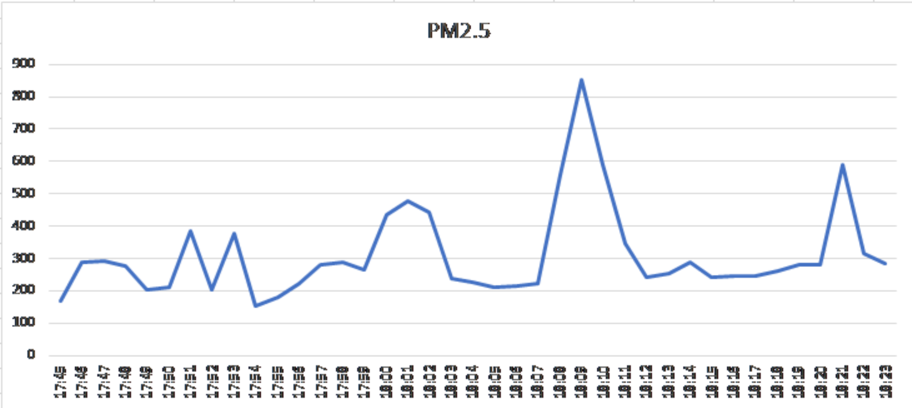


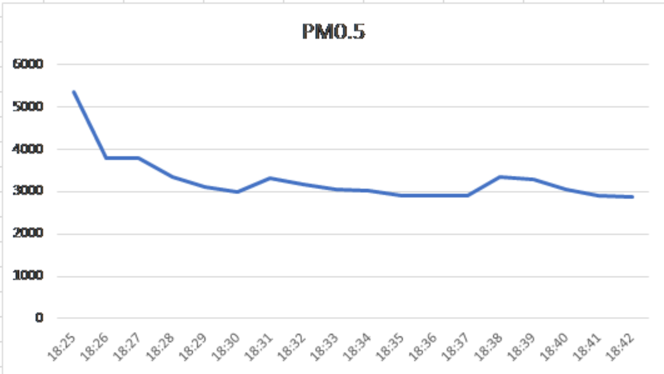


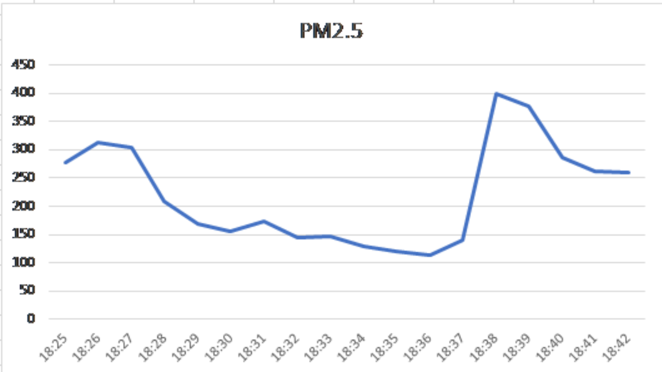


	Evening		
1st	Time:	PM0.5	PM2.5
	17:45	3237	168
	17:46	8955	289
	17:47	9649	294
	17:48	7873	277
	17:49	2735	205
	17:50	2637	210
	17:51	2801	387
	17:52	2628	204
	17:53	2718	379
	17:54	2392	154
	17:55	2608	181
	17:56	5792	224
	17:57	9261	282
	17:58	8198	287
	17:59	7604	264
	18:00	12006	435
	18:01	12709	479
	18:02	11261	443
	18:03	8351	240
	18:04	5744	227
	18:05	3783	212
	18:06	4519	216
	18:07	7566	224
	18:08	11632	558
	18:09	15599	852
	18:10	12539	590
	18:11	6552	347
	18:12	3122	243
	18:13	3047	254
	18:14	4055	287
	18:15	3763	241
	18:16	3527	245
	18:17	3738	246
	18:18	5011	263
	18:19	5504	282
	18:20	7899	282
	18:21	10760	590
	18:22	7248	317
	18:23	7513	286
	Average:	6577.846	311.8974
	18:25	5362	277
	18:26	3793	313
	18:27	3790	304
	18:28	3348	208
	18:29	3113	169
	18:30	2997	156
	18:31	3332	173
	18:32	3185	144
	18:33	3053	147
	18:34	3024	128
	18:35	2904	120
	18:36	2903	113
	18:37	2911	140
	18:38	3356	400
	18:39	3284	377
	18:40	3043	287
	18:41	2908	261
	18:42	2868	260
	Average:	3287.444	220.9444
	stopped early		

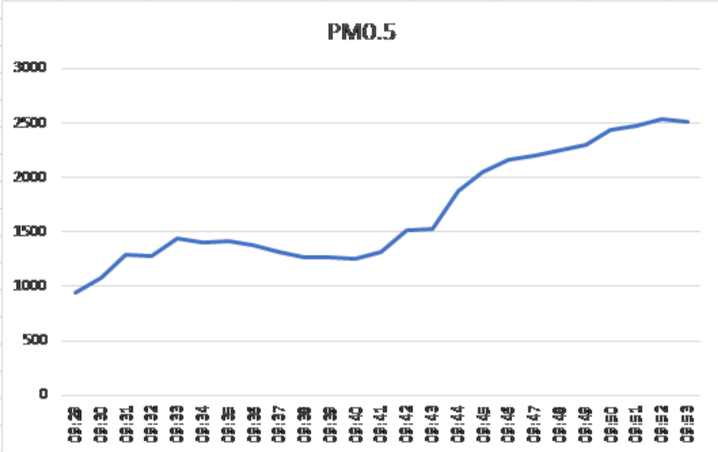


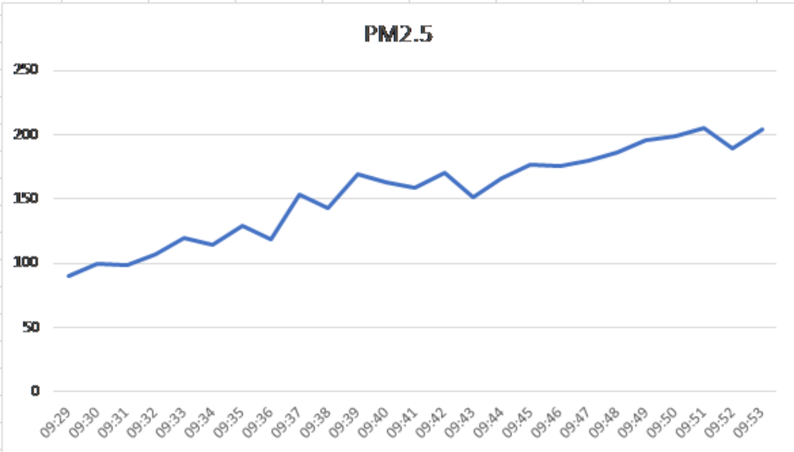


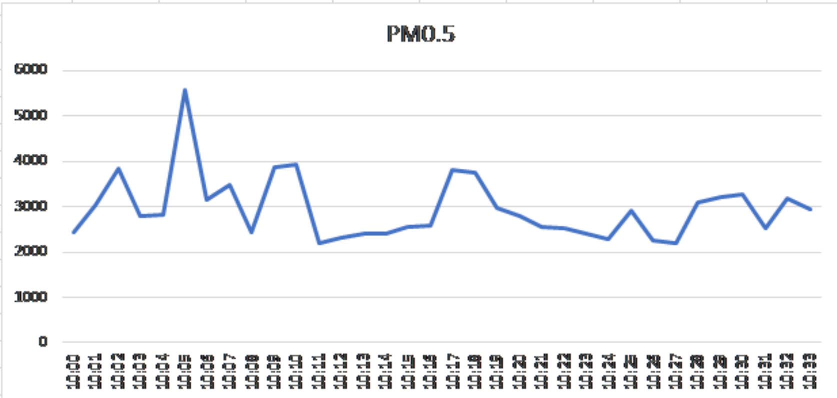


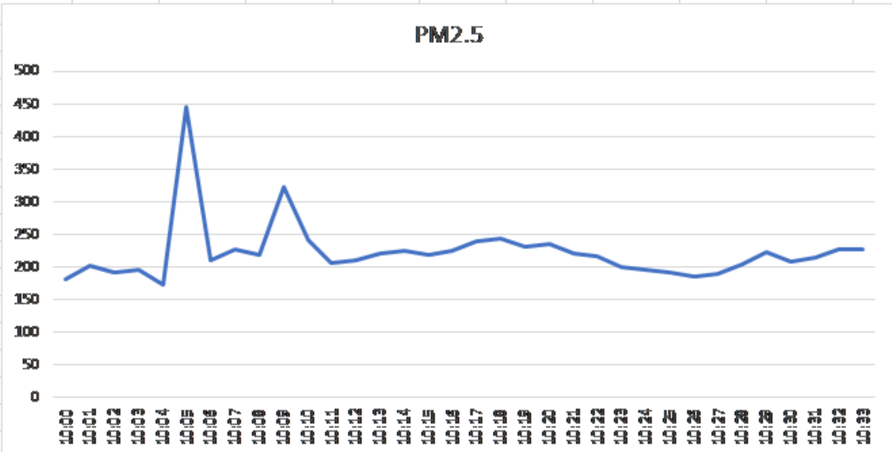


	Date:05/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	09:29	944	90
	09:30	1074	100
	09:31	1294	99
	09:32	1273	107
	09:33	1438	120
	09:34	1400	115
	09:35	1419	129
	09:36	1378	119
	09:37	1314	154
	09:38	1270	143
	09:39	1268	169
	09:40	1256	163
	09:41	1315	159
	09:42	1521	171
	09:43	1523	152
	09:44	1872	166
	09:45	2052	177
	09:46	2168	176
	09:47	2199	180
	09:48	2254	186
	09:49	2301	196
	09:50	2441	199
	09:51	2476	205
	09:52	2535	190
	09:53	2518	204
	Average:	1700.12	154.76
2nd	10:00	2423	182
	10:01	3040	203
	10:02	3836	193
	10:03	2802	196
	10:04	2836	173
	10:05	5575	446
	10:06	3166	210
	10:07	3482	227
	10:08	2438	219
	10:09	3869	323
	10:10	3928	242
	10:11	2202	207
	10:12	2314	211
	10:13	2397	221
	10:14	2415	226
	10:15	2560	220
	10:16	2600	225
	10:17	3804	239
	10:18	3746	244
	10:19	2989	232
	10:20	2796	235
	10:21	2550	221
	10:22	2525	217
	10:23	2408	200
	10:24	2287	196
	10:25	2929	193
	10:26	2244	186
	10:27	2208	190
	10:28	3085	204
	10:29	3226	224
	10:30	3283	209
	10:31	2511	214
	10:32	3178	227
	10:33	2955	228
	Average:	2959.029	223.0294

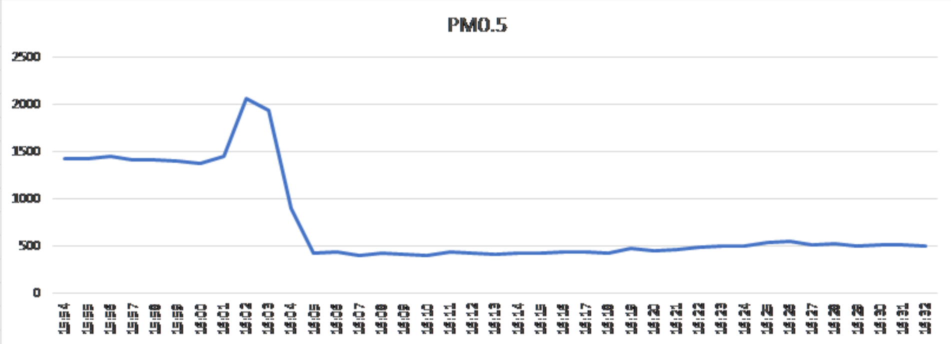


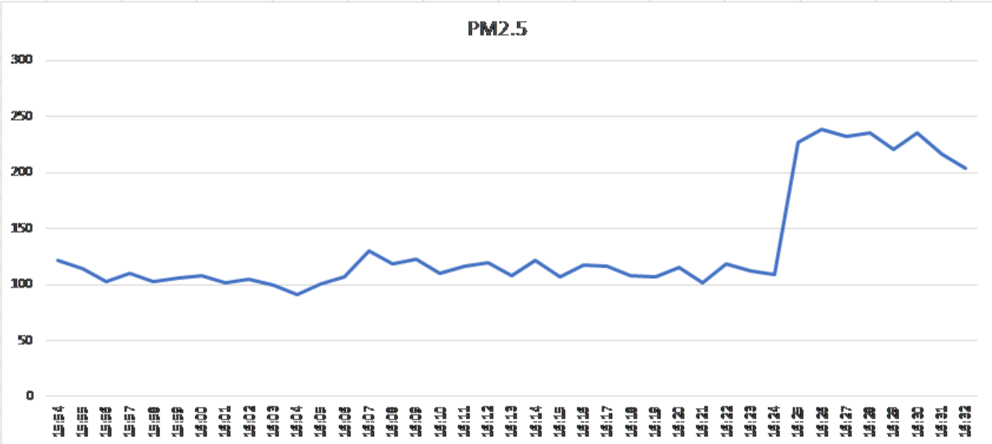


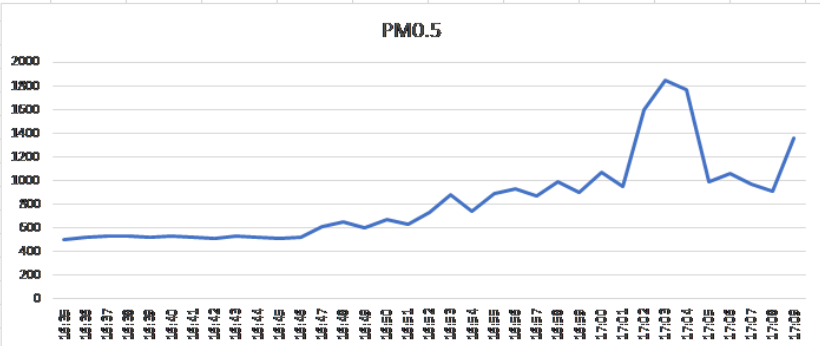


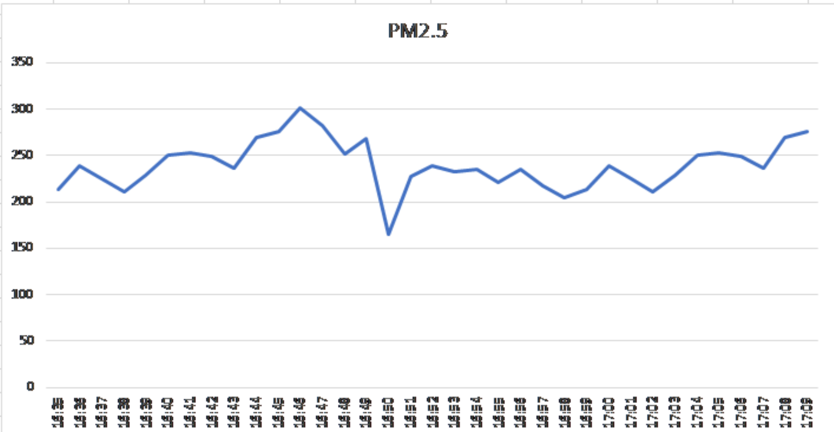


	Evening		
1st	Time:	PM0.5	PM2.5
	15:54	1426	122
	15:55	1427	114
	15:56	1448	103
	15:57	1411	110
	15:58	1410	103
	15:59	1396	106
	16:00	1380	108
	16:01	1457	102
	16:02	2059	105
	16:03	1944	100
	16:04	908	91
	16:05	432	101
	16:06	438	107
	16:07	405	130
	16:08	428	118
	16:09	420	123
	16:10	405	110
	16:11	436	116
	16:12	434	120
	16:13	417	108
	16:14	422	122
	16:15	433	107
	16:16	446	117
	16:17	445	116
	16:18	423	108
	16:19	472	107
	16:20	456	115
	16:21	463	102
	16:22	492	119
	16:23	505	112
	16:24	506	109
	16:25	540	227
	16:26	552	239
	16:27	518	232
	16:28	534	235
	16:29	500	221
	16:30	511	235
	16:31	519	217
	16:32	506	204
	Average:	751.8974	134.3846
	16:35	502	214
	16:36	518	239
	16:37	528	225
	16:38	531	211
	16:39	517	229
	16:40	530	251
	16:41	526	253
	16:42	507	249
	16:43	535	236
	16:44	522	270
	16:45	511	276
	16:46	518	302
	16:47	612	282
	16:48	653	252
	16:49	599	268
	16:50	673	165
	16:51	627	227
	16:52	735	239
	16:53	879	232
	16:54	743	235
	16:55	890	221
	16:56	929	235
	16:57	867	217
	16:58	989	204
	16:59	903	214
	17:00	1069	239
	17:01	948	225
	17:02	1602	211
	17:03	1853	229
	17:04	1768	251
	17:05	989	253
	17:06	1061	249
	17:07	969	236
	17:08	907	270
	17:09	1362	276
	Average:	824.9143	239.5714

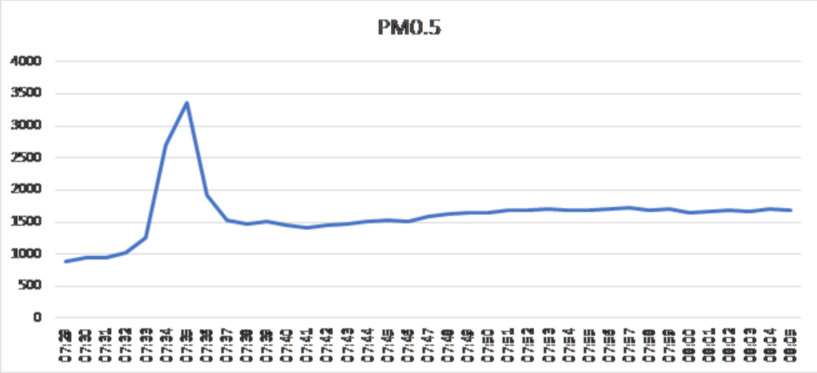


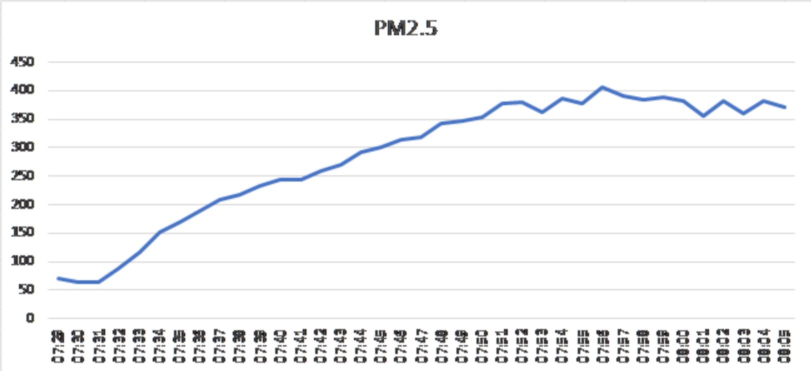


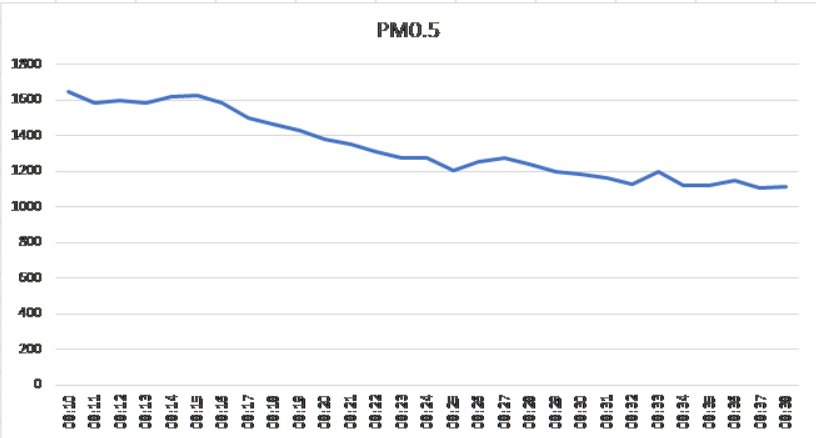


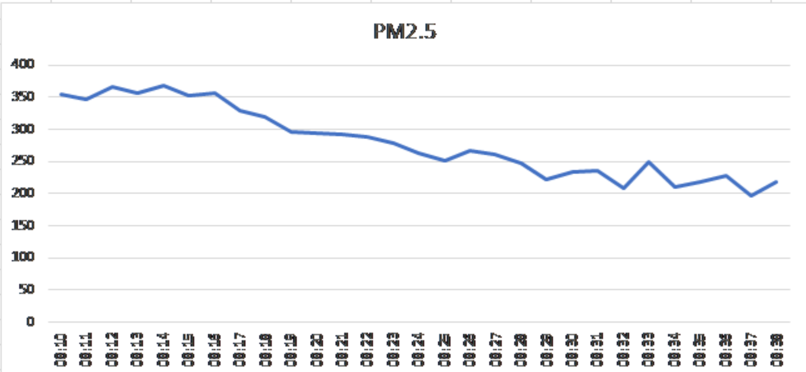


	Date:06/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:29	896	70
	07:30	953	64
	07:31	951	63
	07:32	1019	88
	07:33	1257	116
	07:34	2701	151
	07:35	3366	170
	07:36	1920	189
	07:37	1538	208
	07:38	1476	218
	07:39	1507	233
	07:40	1461	244
	07:41	1421	244
	07:42	1442	260
	07:43	1463	270
	07:44	1502	291
	07:45	1535	300
	07:46	1514	315
	07:47	1590	319
	07:48	1622	343
	07:49	1654	347
	07:50	1646	354
	07:51	1690	377
	07:52	1685	380
	07:53	1709	362
	07:54	1677	386
	07:55	1682	378
	07:56	1698	407
	07:57	1725	391
	07:58	1691	384
	07:59	1707	389
	08:00	1648	383
	08:01	1664	356
	08:02	1685	381
	08:03	1673	361
	08:04	1705	383
	08:05	1683	372
	Average:	1615.027	285.0541
	08:10	1648	355
	08:11	1581	346
	08:12	1600	367
	08:13	1585	356
	08:14	1622	369
	08:15	1623	353
	08:16	1582	357
	08:17	1502	329
	08:18	1466	319
	08:19	1431	296
	08:20	1378	294
	08:21	1355	292
	08:22	1310	288
	08:23	1274	278
	08:24	1273	263
	08:25	1208	252
	08:26	1256	267
	08:27	1274	262
	08:28	1238	247
	08:29	1198	222
	08:30	1182	233
	08:31	1166	236
	08:32	1126	209
	08:33	1195	250
	08:34	1122	211
	08:35	1118	219
	08:36	1152	228
	08:37	1104	197
	08:38	1117	219
	Average:	1334	279.7931

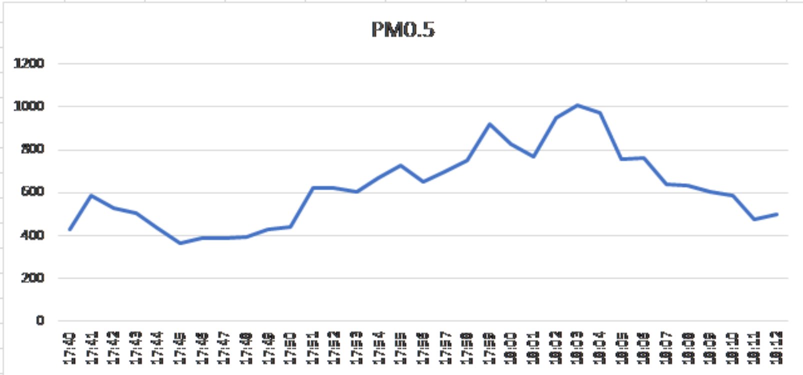


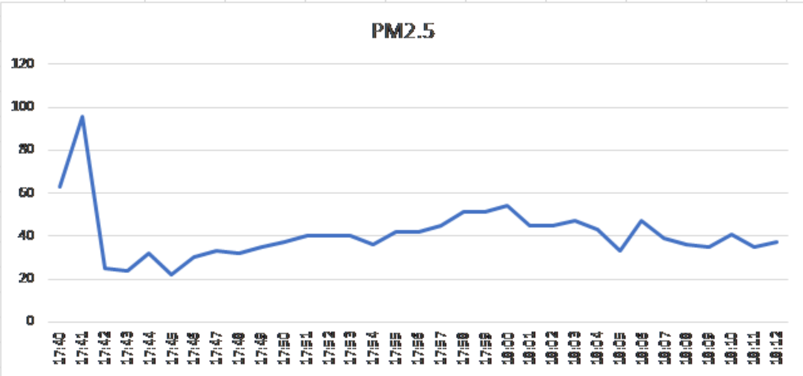


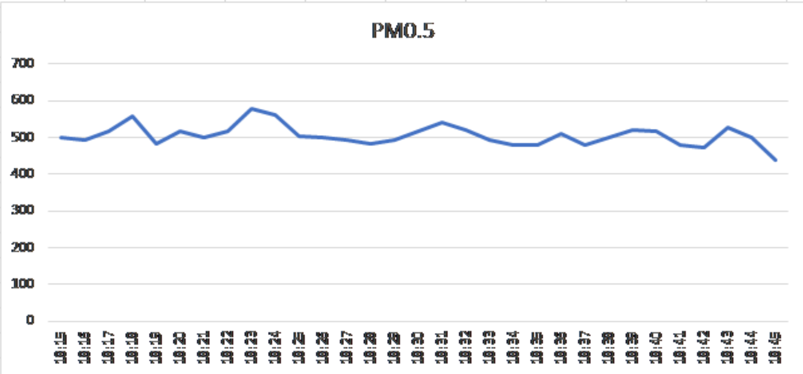


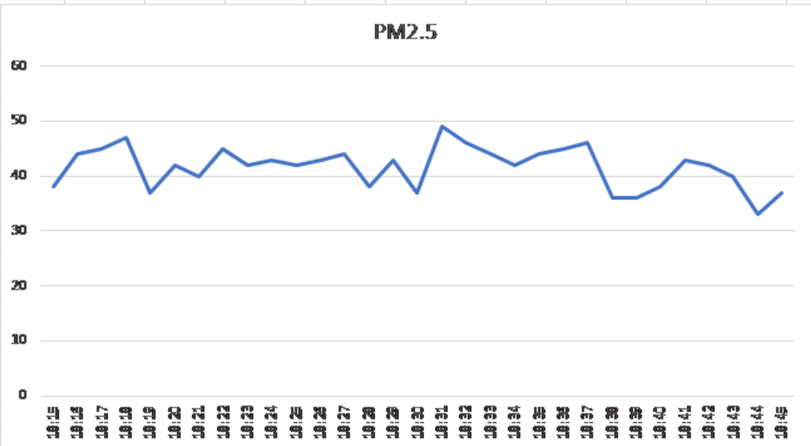


	Evening		
1st	Time:	PM0.5	PM2.5
	17:40	431	63
	17:41	587	96
	17:42	529	25
	17:43	508	24
	17:44	433	32
	17:45	364	22
	17:46	387	30
	17:47	390	33
	17:48	395	32
	17:49	432	35
	17:50	442	37
	17:51	624	40
	17:52	624	40
	17:53	606	40
	17:54	671	36
	17:55	727	42
	17:56	654	42
	17:57	696	45
	17:58	753	51
	17:59	919	51
	18:00	827	54
	18:01	769	45
	18:02	948	45
	18:03	1007	47
	18:04	973	43
	18:05	754	33
	18:06	762	47
	18:07	639	39
	18:08	632	36
	18:09	607	35
	18:10	589	41
	18:11	479	35
	18:12	502	37
	Average:	626.0606	41
	18:15	501	38
	18:16	492	44
	18:17	519	45
	18:18	557	47
	18:19	485	37
	18:20	516	42
	18:21	502	40
	18:22	516	45
	18:23	579	42
	18:24	562	43
	18:25	503	42
	18:26	501	43
	18:27	493	44
	18:28	482	38
	18:29	492	43
	18:30	518	37
	18:31	540	49
	18:32	520	46
	18:33	492	44
	18:34	480	42
	18:35	480	44
	18:36	511	45
	18:37	481	46
	18:38	499	36
	18:39	520	36
	18:40	519	38
	18:41	479	43
	18:42	472	42
	18:43	528	40
	18:44	500	33
	18:45	440	37
	Average:	505.7742	41.64516

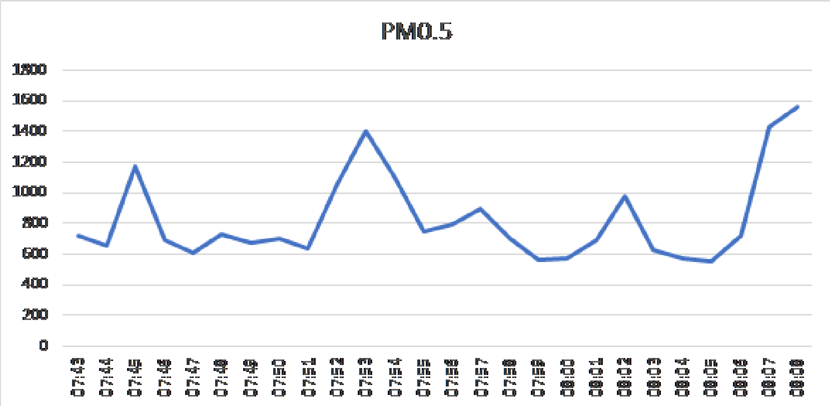


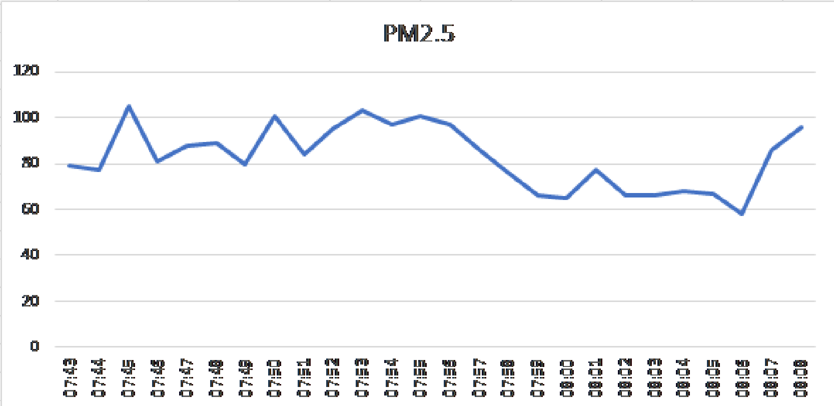


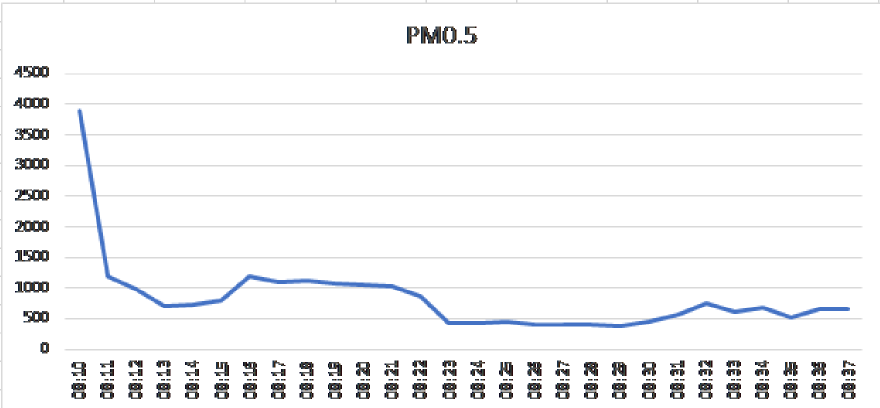


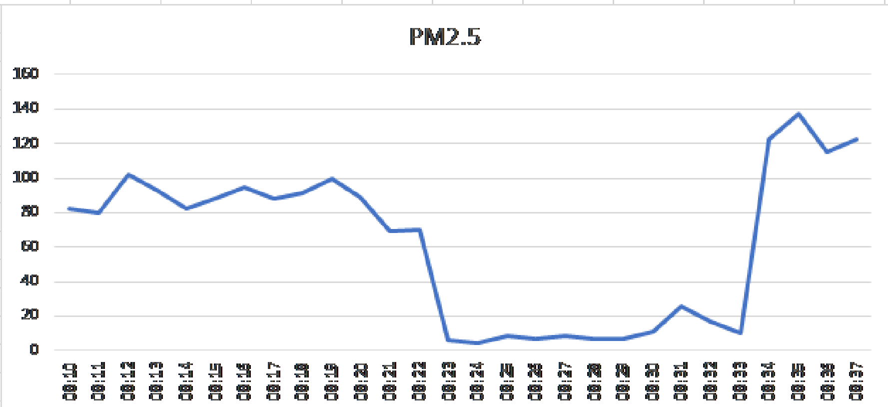


	Date:07/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:43	722	79
	07:44	657	77
	07:45	1171	105
	07:46	691	81
	07:47	611	88
	07:48	728	89
	07:49	672	80
	07:50	702	101
	07:51	641	84
	07:52	1058	95
	07:53	1408	103
	07:54	1106	97
	07:55	750	101
	07:56	796	97
	07:57	897	86
	07:58	698	76
	07:59	565	66
	08:00	577	65
	08:01	694	77
	08:02	982	66
	08:03	630	66
	08:04	573	68
	08:05	552	67
	08:06	719	58
	08:07	1429	86
	08:08	1566	96
	Average:	830.5769	82.84615
2nd	08:10	3904	82
	08:11	1184	80
	08:12	990	102
	08:13	695	93
	08:14	732	82
	08:15	791	88
	08:16	1201	95
	08:17	1088	88
	08:18	1125	91
	08:19	1073	100
	08:20	1046	89
	08:21	1017	69
	08:22	858	70
	08:23	426	6
	08:24	427	4
	08:25	448	8
	08:26	411	7
	08:27	410	8
	08:28	396	7
	08:29	380	7
	08:30	457	11
	08:31	559	26
	08:32	744	17
	08:33	608	10
	08:34	679	123
	08:35	520	137
	08:36	667	115
	08:37	660	123
	Average:	839.1429	62.07143

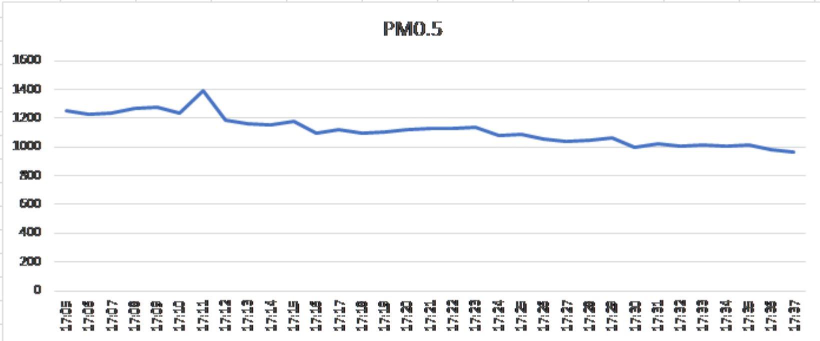


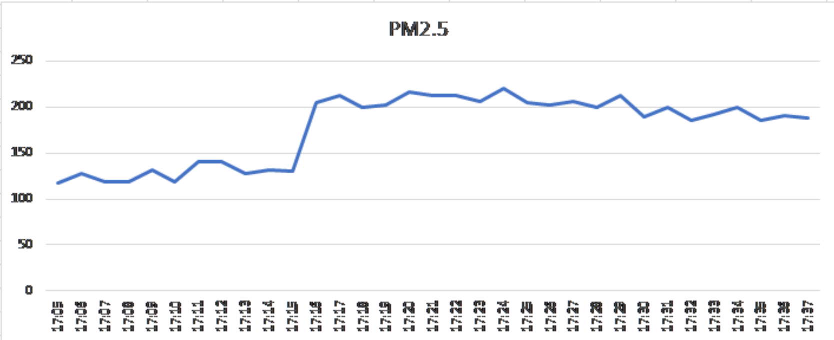




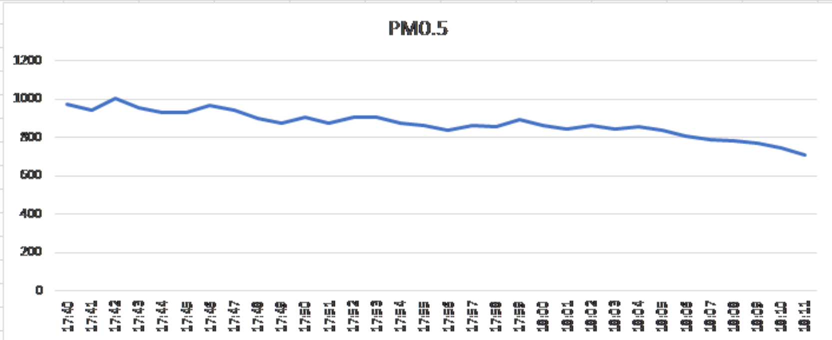


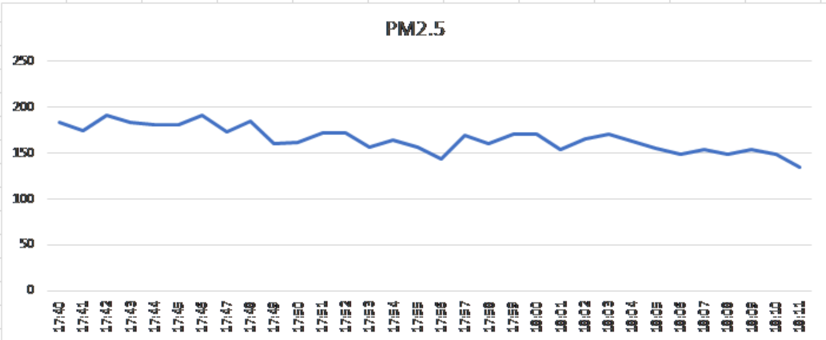
	Evening		
1st	Time:	PM0.5	PM2.5
	17:05	1249	117
	17:06	1225	128
	17:07	1234	119
	17:08	1268	119
	17:09	1281	131
	17:10	1234	118
	17:11	1389	141
	17:12	1188	141
	17:13	1162	128
	17:14	1156	131
	17:15	1179	130
	17:16	1093	205
	17:17	1120	213
	17:18	1095	199
	17:19	1103	202
	17:20	1125	216
	17:21	1128	213
	17:22	1133	213
	17:23	1135	206
	17:24	1083	220
	17:25	1089	205
	17:26	1056	202
	17:27	1040	206
	17:28	1047	200
	17:29	1061	212
	17:30	999	189
	17:31	1022	199
	17:32	1005	185
	17:33	1011	192
	17:34	1005	200
	17:35	1016	186
	17:36	982	190
	17:37	963	188
	Average:	1117.455	177.0909



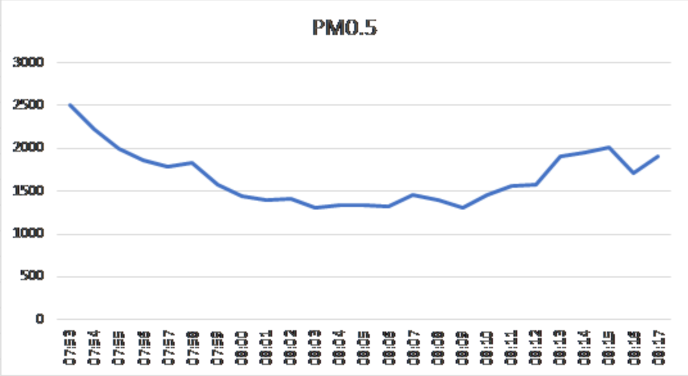


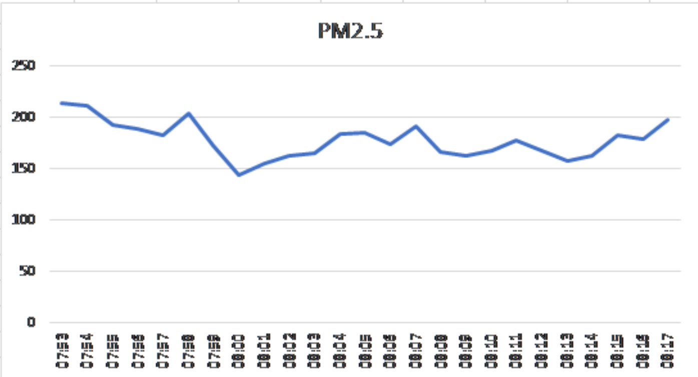
	17:40	971	184
	17:41	944	175
	17:42	1002	191
	17:43	955	183
	17:44	932	181
	17:45	929	181
	17:46	966	191
	17:47	941	173
	17:48	902	185
	17:49	876	160
	17:50	906	161
	17:51	874	172
	17:52	907	172
	17:53	904	157
	17:54	873	164
	17:55	861	157
	17:56	841	143
	17:57	863	169
	17:58	859	160
	17:59	896	171
	18:00	862	170
	18:01	844	154
	18:02	864	166
	18:03	846	170
	18:04	858	163
	18:05	837	155
	18:06	806	149
	18:07	791	154
	18:08	785	149
	18:09	770	154
	18:10	749	149
	18:11	710	134
	Average:	872.625	165.5313

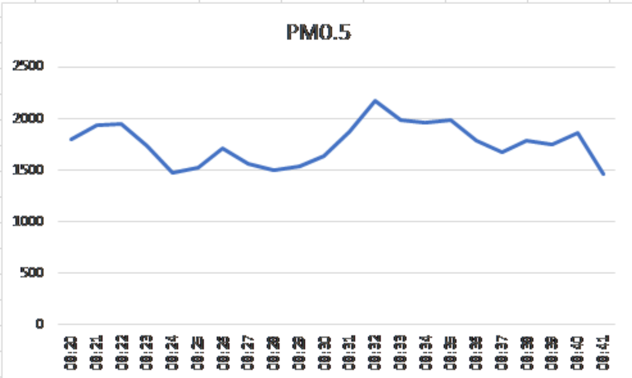


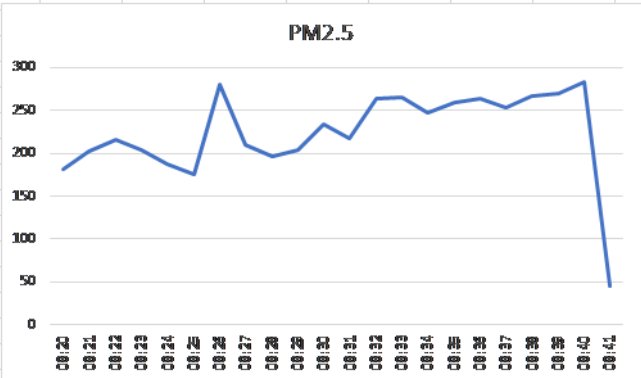


	Date:09/12/19		
	Morning		
1st	Time:	PM0.5	PM2.5
	07:53	2510	214
	07:54	2220	211
	07:55	2002	193
	07:56	1860	189
	07:57	1786	182
	07:58	1825	204
	07:59	1574	172
	08:00	1438	144
	08:01	1403	155
	08:02	1410	162
	08:03	1310	165
	08:04	1333	184
	08:05	1336	185
	08:06	1324	174
	08:07	1456	191
	08:08	1393	166
	08:09	1313	163
	08:10	1465	167
	08:11	1564	177
	08:12	1578	168
	08:13	1910	158
	08:14	1948	162
	08:15	2011	183
	08:16	1708	179
	08:17	1910	198
	Average:	1663.48	177.84
	08:20	1801	182
	08:21	1934	202
	08:22	1944	216
	08:23	1737	204
	08:24	1479	187
	08:25	1528	176
	08:26	1714	280
	08:27	1567	210
	08:28	1502	197
	08:29	1538	204
	08:30	1640	234
	08:31	1870	218
	08:32	2170	263
	08:33	1987	265
	08:34	1965	248
	08:35	1992	260
	08:36	1788	264
	08:37	1675	253
	08:38	1786	267
	08:39	1745	270
	08:40	1865	283
	08:41	1470	46
	Average:	1758.955	224.0455

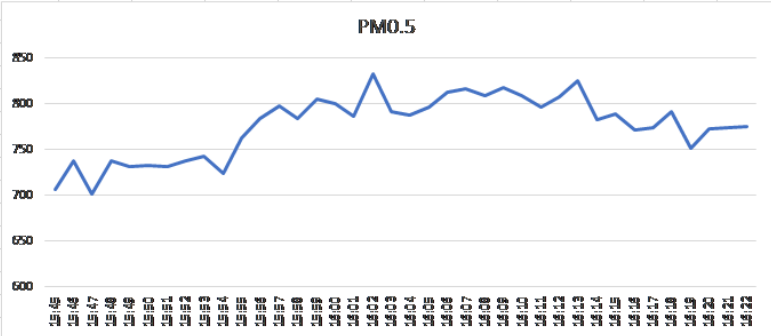


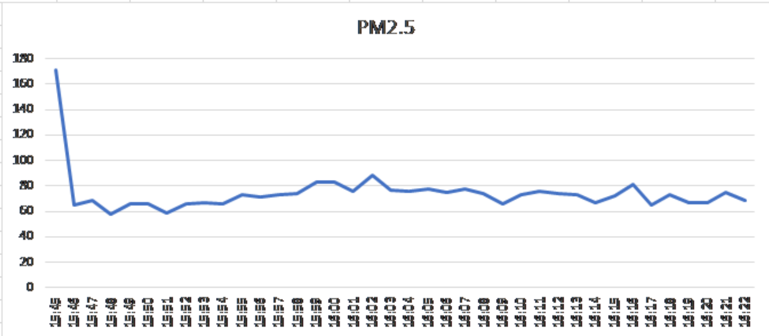


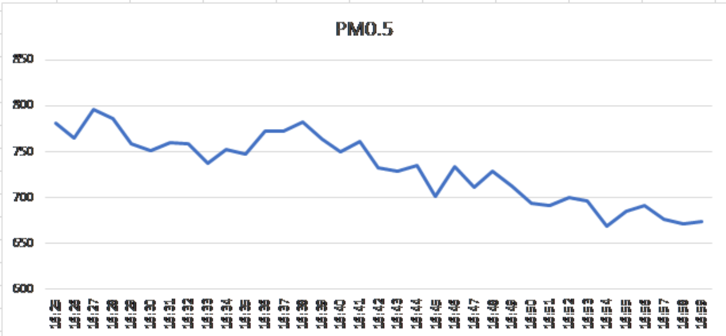


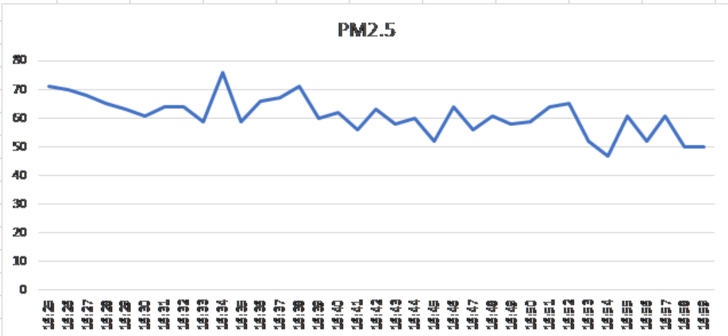


	Evening		
1st	Time:	PM0.5	PM2.5
	15:45	707	171
	15:46	737	65
	15:47	702	69
	15:48	738	58
	15:49	731	66
	15:50	732	66
	15:51	731	59
	15:52	738	66
	15:53	743	67
	15:54	724	66
	15:55	763	73
	15:56	784	71
	15:57	798	73
	15:58	784	74
	15:59	805	83
	16:00	800	83
	16:01	786	76
	16:02	832	88
	16:03	791	77
	16:04	788	76
	16:05	796	78
	16:06	813	75
	16:07	816	78
	16:08	809	74
	16:09	817	66
	16:10	809	73
	16:11	796	76
	16:12	807	74
	16:13	825	73
	16:14	783	67
	16:15	789	72
	16:16	771	81
	16:17	774	65
	16:18	791	73
	16:19	751	67
	16:20	773	67
	16:21	774	75
	16:22	775	69
	Average:	775.8684211	74.47368
	16:25	781	71
	16:26	765	70
	16:27	796	68
	16:28	786	65
	16:29	759	63
	16:30	751	61
	16:31	760	64
	16:32	759	64
	16:33	738	59
	16:34	753	76
	16:35	747	59
	16:36	772	66
	16:37	772	67
	16:38	782	71
	16:39	764	60
	16:40	750	62
	16:41	761	56
	16:42	732	63
	16:43	729	58
	16:44	735	60
	16:45	702	52
	16:46	734	64
	16:47	712	56
	16:48	729	61
	16:49	713	58
	16:50	694	59
	16:51	691	64
	16:52	700	65
	16:53	696	52
	16:54	669	47
	16:55	685	61
	16:56	692	52
	16:57	677	61
	16:58	671	50
	16:59	674	50
	Average:	732.3142857	61









Appendix C

Average count for Ultrafine and Fine particulate matter - summarized (Read $PM_{0.5}$ – Ultrafine PM; $PM_{2.5}$ – Fine PM) including meteorological factors (humidity, temperature and weather). Zero amounts correspond to no data collected on particular day.

Table C.1: Average count for UFP and Fine particles (Cathal Brugha Street to Kevin Street) – summary:

			Pedestrianised		mixed				
			PM0.5:	PM2.5:	PM0.5	PM2.5	Humidity (%)	Temperature (°C)	Weather
MORNING	Cathal Brugha st - Kevin st	Date:							
		15/05/2019	773.559	67.5	767.522	72.087	70%	9	Sunny
		17/05/2019	2239.286	250.8571	2019.87	293.161	76%	11	
		19/05/2019	2071	191.5	2366	236.2	94	10	cloudy
		19/06/2019	1187	151.6	1536	166.2	90	11	partly cloudy
		02/07/2019	0	0	0	0	74	14	cloudy
		11/07/2019	0	0	0	0	74	14	cloudy
		11/08/2019	959.455	73.6818	963.828	69.7931	92	13	cloudy
		18/06/2019	907.1	73.3465	811.1	104.03	76	12	partly cloudy
		25/08/2019	3343	101	3634	128.2	100	14	cloudy
		26/08/2019	152.58	17.606	554.7	64.7	97	11	partly cloudy
		03/09/2019	1191.54	102.643	1516.16	149.48	87	13	cloudy
		10/09/2019	1365.88	193.703	1878.24	286.03	100	6	partly cloudy
		12/09/2019	841.6	131.4	849.5	143.3	89	15	rain
		19/09/2019	4593	301.6	2984	374.6	96	8	Sunny
		20/09/2019	1895	456.3	1566	181.3	93	12	partly cloudy
		23/09/2019	0	0	0	0	92	9	partly cloudy
		03/11/2019	1060	123.4	1455	172.6	100	6	Fog
		10/11/2019	665.6	36.24	923	115.3	94	3	cloudy
		11/11/2019	0	0	0	0	85	4	partly cloudy
		14/11/2019	1580	197.3	246.9	2823	87	5	partly cloudy
		27/11/2019	1012	97.69	2283	235.2	97	6	cloudy
		29/11/2019	624.5	59.41	497.8	94.25	90	2	partly cloudy
		06/12/2019	1334	279.8	1615	285.1	86	11	cloudy
		07/12/2019	839	62.1	831	177.8	91	8	cloudy
		08/12/2019	1663	177.8	11759	224	81	6	partly cloudy
			Pedestrianised		mixed				
			PM0.5:	PM2.5:	PM0.5	PM2.5	Humidity (%)	Temperature (°C)	Weather
EVENING	Cathal Brugha st - Kevin st	Date:							
		15/05/2019	1865.17	145.931	2200	152.912	54%	16	partly cloudy
		17/05/2019	6	0.09677	20.973	2.89189	82	13	rain
		19/05/2019	1103	61.48	1308	61.64	65	14	cloudy
		19/06/2019	625.9	57.64	529.8	89	57	17	cloudy
		02/07/2019	1082	136	1394	177	61	17	cloudy
		11/07/2019	1030.952	48.333333	399.4222	57.93333	60	22	cloudy
		11/08/2019	941.242	87.3	996.48	133.968	67	16	cloudy
		18/08/2019	0	0	2246.84	258.08	78	15	rain
		25/08/2019	0	0	0	0	82	18	cloudy
		26/08/2019	0	0	0	0	74	19	partly cloudy
		03/09/2019	0	0	0	0	78	18	cloudy
		10/09/2019	1328.22	133.64	2198.33	288.821	83	16	cloudy
		12/09/2019	0	0	0	0	82	18	cloudy
		19/09/2019	1795	177.4	2433	268.4	62	19	Sunny
		20/09/2019	0	0	0	0	68	16	partly cloudy
		23/09/2019	255.8	11.9	1111	114.6	96	14	rain
		03/11/2019	1331	161.3	1439	179.3	98	8	fog
		10/11/2019	1522	203.7	1122	245.5	81	6	cloudy
		11/11/2019	1030	119.8	1428	184.1	76	7	partly cloudy
		14/11/2019	0	0	1522	158.4	73	6	partly cloudy
		27/11/2019	1479	218	2204	327.2	94	9	cloudy
		29/11/2019	862	102	719.5	132.3	86	5	rain
		06/12/2019	626.1	41	505.8	41.65	84	9	cloudy
		07/12/2019	873	166	1117	177	85	11	cloudy
		08/12/2019	732.3143	61	775.8684	74.47	79	6	partly cloudy

Table C.2 shows the average count for UFP and Fine particles) (Cathal Brugha Street to Grangegorman) – summary:

			Pedestrianised		mixed				
			PM0.5:	PM2.5:	PM0.5	PM2.5	Humidity (%)	Temperature (°C)	Weather
		Date:							
MORNING	Cathal Brugha st - Grangegorman	26/05/2019	149.714	15.1786	417.764	45.7308	90%	15	cloudy
		28/05/2019	2507	181.1	1865	243.8	76	11	cloudy
		01/06/2019	2428	224.3	3901	236.6	92	10	cloudy
		20/06/2019	163.4	19.22	1433	278.5	81	12	partly cloudy
		21/06/2019	962.7	184	1304	195.1	89	8	sunny
		26/06/2019	2158	239.7	1307	257.9	89	15	cloudy
		01/07/2019	153.2	15.91	0	0	82	14	cloudy
		03/07/2010	858.9	97.95	1185	216	75	13	sunny
		10/07/2019	500.2	72.56	760.6	155.3	86	13	cloudy
		21/08/2019	2594.043	196.8261	4968.276	644.3103	79	13	partly cloudy
		24/08/2019	1298	86.88	0	0	91	13	partly cloudy
		27/08/2019	561.2	56.24	1235	132.9	83	10	cloudy
		28/08/2019	966.2	117	1418	203.8	81	13	cloudy
		02/09/2019	825.4	81	950.2	85.7	84	11	cloudy
		11/09/2019	601.3	99.03	647.9	108.1	90	13	cloudy
		15/09/2019	310.9	43.1	381.6	56.27	50	16	cloudy
		17/09/2019	1352	123.3	1821	182.2	96	6	sunny
		04/11/2019	631.5	125.4	1624	211.8	99	5	rain
		05/11/2019	231.6	24.59	287.8	37.63	86	7	cloudy
		07/11/2019	473	84.75	528.8	100	93	6	rain
		15/11/2019	2170	162.9	870.2	152.3	81	5	partly cloudy
		18/11/2019	4011	167.9	4950	187.9	93	1	partly cloudy
		26/11/2019	1597	156.9	2037	209.4	95	9	rain
		01/12/2019	628.9	134.8	690.6	130.1	94	2	cloudy
		04/12/2019	1407	247.2	1142	278.3	73	9	cloudy
		05/12/2019	1700	154.8	2959	223	79	9	cloudy
			Pedestrianised		mixed				
			PM0.5:	PM2.5:	PM0.5	PM2.5	Humidity (%)	Temperature (°C)	Weather
		Date:							
EVENING	Cathal Brugha st - Grangegorman	26/05/2019	841.926	87.33	971.567	88.88	50%	18	windy
		28/05/2019	1643	109.6	1954	579.3	55	15	cloudy
		01/06/2019	1423	135.3	2338	545	80	16	
		20/06/2019	673.2	108.9	619.5	186.8	55	15	partly cloudy
		21/06/2019	858.1	123.5	1316	172.4	60	16	cloudy
		26/06/2019	1508	154.7	1959	487.1	77	17	sunny
		01/07/2019	16.29	1.176	1504	65.46	63	18	partly cloudy
		03/07/2019	970.5	93.69	1239	142	58	17	sunny
		10/07/2019	1416	162.9	2522	185.3	80	19	cloudy
		21/08/2019	0	0	0	0	81	16	rain
		24/08/2019	0	0	0	0	68	20	cloudy
		27/08/2019	754.6	71.68	2723	110.7	66	21	cloudy
		28/08/2019	1263	122.8	2123	234.4	62	19	partly cloudy
		02/09/2019	0	0	0	0	86	15	cloudy
		11/09/2019	1713	203.4	1770	222.3	80	15	cloudy
		15/09/2019	607.1	25.67	659.3	25.78	94	13	rain
		17/09/2019	0	0	0	0	91	14	sunny
		04/11/2019	579.2	87.74	689	126.6	92	9	rain
		05/11/2019	472.8	134	575.5	139.4	84	9	cloudy
		07/11/2019	642.4	126	668.9	134.5	94	8	rain
		15/11/2019	2528	179.4	2192	182	76	6	cloudy
		18/11/2019	5223	212.2	7071	226.7	84	6	cloudy
		26/11/2019	4013	485.3	4208	640.4	81	11	cloudy
		01/12/2019	547.8	9.091	1499	71.17	89	4	partly cloudy
		04/12/2019	3287	220.9	6578	311.9	85	8	partly cloudy
		05/12/2019	751.9	134.4	824.9	233.6	87	12	cloudy

Appendix D

PM2.5 concentration [µg/m^3] workings from Dylos air quality monitor for mixed (pedestrianised and heavy traffic streets) streets.

The grey area shows the correct converted count for all particles less than 2.5 µg in diameter in .01 cubic foot of air. Zero amounts correspond to no data collected on particular day:

		Date:	Dylos Particle Count (all particles less than 2.5 um in diameter)	PM2.5 concentration [ug/m3]
		15/05/2019	767.522	4.19
		17/05/2019	2019.87	11.97
		19/05/2019	2366	3.82
		19/06/2019	1536	2.37
		02/07/2019	0	0.00
		11/07/2019	0	0.00
		11/08/2019	963.828	1.52
		18/06/2019	811.1	4.81
		25/08/2019	3634	39.68
		26/08/2019	554.7	5.88
		03/09/2019	1516.16	4.12
		10/09/2019	1878.24	20.51
	Cathal Brughast - Kevin st	12/09/2019	849.5	2.36
MORNING		19/09/2019	2984	31.28
		20/09/2019	1566	2.50
		23/09/2019	0	0.00
		03/11/2019	1455	15.89
		10/11/2019	923	1.49
		11/11/2019	0	0.00
		14/11/2019	246.9	0.67
		27/11/2019	2283	24.18
		29/11/2019	497.8	0.77
		06/12/2019	1615	4.33
		07/12/2019	831	1.30
		08/12/2019	11759	44.58
		15/05/2019	2200	9.27
		17/05/2019	20.973	0.08
		19/05/2019	1308	6.63
EVEN	Cath	19/06/2019	529.8	2.36
		02/07/2019	1394	6.63

ING	al Brughast - Kevinst	11/07/2019	399.4222	1.87
		11/08/2019	996.48	5.21
		18/08/2019	2246.84	13.67
		25/08/2019	0	0.00
		26/08/2019	0	0.00
		03/09/2019	0	0.00
		10/09/2019	2198.33	8.54
		12/09/2019	0	0.00
		19/09/2019	2433	11.77
		20/09/2019	0	0.00
		23/09/2019	1111	11.65
		03/11/2019	1439	15.40
		10/11/2019	1122	4.25
		11/11/2019	1428	8.47
		14/11/2019	1522	8.67
		27/11/2019	2204	3.56
		29/11/2019	719.5	1.93
		06/12/2019	505.8	1.99
		07/12/2019	1117	2.96
		08/12/2019	775.8684	4.78
		26/05/2019	417.764	0.03
		28/05/2019	1865	11.06
		01/06/2019	3901	6.16
		20/06/2019	1433	5.43
	Cathal Brughast - Grangegorman	21/06/2019	1304	3.62
		26/06/2019	1307	3.63
		01/07/2019	0	0.00
MORNING		03/07/2010	1185	6.93
		10/07/2019	760.6	2.04
		21/08/2019	4968.276	30.62
		24/08/2019	0	0.00
		27/08/2019	1235	4.80
		28/08/2019	1418	5.38
		02/09/2019	950.2	3.74
		11/09/2019	647.9	1.00
		15/09/2019	381.6	1.49
		17/09/2019	1821	19.09
		04/11/2019	1624	17.56
		05/11/2019	287.8	0.77
		07/11/2019	528.8	0.84
		15/11/2019	870.2	3.30
		18/11/2019	4950	7.90
		26/11/2019	2037	3.32
		01/12/2019	690.6	1.11
		04/12/2019	1142	6.50
		05/12/2019	2959	18.23

		26/05/2019	971.567	0.04
		28/05/2019	1954	8.38
		01/06/2019	2338	8.75
		20/06/2019	619.5	2.66
		21/06/2019	1316	6.16
		26/06/2019	1959	11.77
	Cathal Brughast - Grangegorman	01/07/2019	1504	7.39
EVENING		03/07/2019	1239	5.61
		10/07/2019	2522	9.44
		21/08/2019	0	0.00
		24/08/2019	0	0.00
		27/08/2019	2723	14.02
		28/08/2019	2123	10.27
		02/09/2019	0	0.00
		11/09/2019	1770	6.63
		15/09/2019	659.3	1.06
		17/09/2019	0	0.00
		04/11/2019	689	1.09
		05/11/2019	575.5	2.26
		07/11/2019	668.9	1.08
		15/11/2019	2192	12.99
		18/11/2019	7071	27.80
		26/11/2019	4208	15.95
		01/12/2019	1499	4.16
		04/12/2019	6578	17.45
		05/12/2019	824.9	2.24
			Average:	**6.86**

Table D.1: PM2.5 concentration [ug/m3] workings from Dylos air quality monitor for mixed (pedestrianised and heavy traffic streets) streets

Appendix E

Survey - “Air Quality in Dublin City Centre” Layout:

Air Quality in Dublin City Centre

Air Quality in Dublin City Centre

Welcome!

The main aim of this survey is to establish whether the public is aware of what causes air pollution and the risks air pollution may cause to their health as well as understand the selection of transport the public favors the most and the reasons behind their transport preferences.

The survey will take approximately 5 minutes to complete (over 18’s only). Your participation in this study is completely voluntary.

* 1. Which answer describes you?

- ◯ Female
- ◯ Male
- ◯ Other
- ◯ Prefer not to answer

* 2. Which age group describes you?

- ◯ 18 to 24
- ◯ 25 to 34
- ◯ 35 to 44
- ◯ 45 to 54
- ◯ 55 to 64
- ◯ 65+

* 3. Do you work or study in Dublin City Centre?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer
- ◯ Other (please specify)

1

Figure E.1: “Air Quality in Dublin City Centre” Survey (Q1-3)

* 4. Approximately, how long does it take you to commute from home to place of work/educational institution?

- ◯ <10 minutes
- ◯ 10-20 minutes
- ◯ 20-30 minutes
- ◯ 30-40 minutes
- ◯ >40 minutes

* 5. How often do you visit Dublin City Centre (per week)?

- ◯ Every day
- ◯ A few times a week
- ◯ About once a week
- ◯ A few times a month
- ◯ Once a month
- ◯ Less than once a month
- ◯ N/A

* 6. What means of transport do you use to travel to Dublin City Centre?

Tick all that apply

- ☐ Dublin Bus
- ☐ Coach
- ☐ Light rail tram (*Luas*)
- ☐ Commuter/DART
- ☐ Private vehicle
- ☐ Bicycle
- ☐ Walking
- ☐ Other (please specify)

7. Approximately, how much do you spend on public transport to travel to Dublin City Centre (per week)?

- ◯ <€5
- ◯ €5-€10
- ◯ €10-€20
- ◯ >€20
- ◯ N/A

2

Figure E.2: "Air Quality in Dublin City Centre" Survey (Q4-7)

* 8. How do you feel about travelling on public transport?

- Very satisfied
- Satisfied
- Neither satisfied nor dissatisfied
- Dissatisfied
- Very dissatisfied
- N/A

Air Quality in Dublin City Centre

* 9. Do you currently suffer from any medical/health issues that make it difficult to use public transportation?

- Yes
- No
- Prefer not to answer

* 10. Have you suffered from any medical/health issues in the past that resulted in difficulty in accessing public transport?

- Yes
- No
- Prefer not to answer

* 11. Do you suffer from any respiratory health issues?

- Yes
- No
- Prefer not to answer

* 12. Do you believe that Dublin City Centre has an issue with air quality?

- Yes
- No
- Prefer not to answer

3

Figure E.3: "Air Quality in Dublin City Centre" Survey (Q8-12)

* 13. Do you think increased action should be taken to minimize air pollution in Dublin?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer

* 14. Do you think that access to private vehicles should be minimized in Dublin City Centre?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer

* 15. Do you think more streets in Dublin City Centre should be pedestrianized?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer

* 16. "Current air quality in Dublin City Centre poses a risk to your health". Do you agree with this statement?

- ◯ Strongly agree
- ◯ Agree
- ◯ Neither agree nor disagree
- ◯ Disagree
- ◯ Strongly disagree

* 17. Do you think additional safety measures should be considered for pedestrian footpaths exposed to traffic in Dublin City Centre to protect pedestrians from air pollution?

- ◯ Yes
- ◯ No
- ◯ Prefer not to answer

* 18. On a scale from 1 to 10, how satisfied are you with the pedestrianized walking space in Dublin City Centre (1 being least satisfied and 10 being most satisfied)?

1 5 10

4

Figure E.4: "Air Quality in Dublin City Centre" Survey (Q13-18)

Air Quality in Dublin City Centre

* 19. Do your decisions on mode of transport you use is influenced by your knowledge of air quality in Dublin?

- ◯ A great deal
- ◯ A lot
- ◯ A moderate amount
- ◯ A little
- ◯ None at all

* 20. Do you agree with the following statement: "Human activities contribute to poor air quality"?

- ◯ Strongly agree
- ◯ Agree
- ◯ Neither agree nor disagree
- ◯ Disagree
- ◯ Strongly disagree

* 21. Which of the following, do you think, are the sources of air pollution in Dublin?

Tick all that apply

- ☐ Modes of transport
- ☐ Agricultural activities
- ☐ Construction activities
- ☐ Factories and industries
- ☐ Mining operations
- ☐ Household activities and equipment/supplies, e.g. cleaning products, painting supplies, cooking, heating
- ☐ Natural causes, e.g. volcano eruptions, forest fires, dust storms
- ☐ Smoking

5

Figure E.5: "Air Quality in Dublin City Centre" Survey (Q19-21)

* 22. Which of the following, in your opinion, is the result of air pollution?
Tick all that apply

- [ ] Temperature increase
- [ ] Increased precipitation
- [ ] Sea-level rise
- [ ] Increased storms and rainfall
- [ ] Increased likelihood of river and coastal flooding
- [ ] Water shortages
- [ ] Increased droughts
- [ ] Negative impacts on water quality
- [ ] Changes in the distribution of species
- [ ] Early migration of species
- [ ] Impacts on fishery industry
- [ ] Increased wildfires
- [ ] Increased pest infestation
- [ ] Snow and ice are melting, and frozen ground is thawing
- [ ] Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus
- [ ] Increased indoor/outdoor air pollution
- [ ] Increased adverse health effects
- [ ] Increased waste management issues
- [ ] Increased forest degradation
- [ ] Impacts on agricultural industry
- [ ] Impacts on vegetation
- [ ] Decreased food availability
- [ ] Increased occurrences of acid rain
- [ ] Impacts on sea-life
- [ ] Depletion of the ozone layer
- [ ] Increased smog and soot

* 23. Which of the following modes of transport influence air quality in Dublin City Centre?
Tick all that apply

- [ ] Walking
- [ ] Cycling
- [ ] Diesel car
- [ ] Petrol car
- [ ] Electric car
- [ ] Hybrid car
- [ ] DART
- [ ] Light rail tram (Luas)
- [ ] Train
- [ ] Bus
- [ ] Coach

* 24. In your opinion, what time of the day air pollution is highest in Dublin City Centre?
Tick all that apply

- [ ] Early morning (3 am - 5 am)
- [ ] Morning (6 am - 10 am)
- [ ] Noon (11 am - 1 pm)
- [ ] Afternoon (2 pm - 4pm)
- [ ] Evening (5 pm - 8 pm)
- [ ] Night (9 pm - 11 pm)
- [ ] Midnight (12 am - 1 am)

6

Figure E.6: "Air Quality in Dublin City Centre" Survey (Q22-24)

Air Quality in Dublin City Centre

* 25. "Air pollutants contribute to climate change". Do you agree with this statement?

- ◯ Strongly agree
- ◯ Agree
- ◯ Neither agree nor disagree
- ◯ Disagree
- ◯ Strongly disagree

* 26. Which of the following, in your opinion, is the result of climate change?

Tick all that apply

- ☐ Temperature increase
- ☐ Increased precipitation
- ☐ Sea-level rise
- ☐ Increased storms and rainfall
- ☐ Increased likelihood of river and coastal flooding
- ☐ Water shortages
- ☐ Increased droughts
- ☐ Negative impacts on water quality
- ☐ Changes in the distribution of species
- ☐ Early migration of species
- ☐ Impacts on fishery industry
- ☐ Increased wildfires
- ☐ Increased pest infestation
- ☐ Snow and ice are melting, and frozen ground is thawing
- ☐ Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus
- ☐ Increased indoor/outdoor air pollution
- ☐ Increased adverse health effects
- ☐ Increased waste management issues
- ☐ Increased forest degradation
- ☐ Impacts on agricultural industry
- ☐ Impacts on vegetation
- ☐ Decreased food availability
- ☐ Increased occurrences of acid rain
- ☐ Impacts on sea-life
- ☐ Depletion of the ozone layer
- ☐ Increased smog and soot

* 27. Which of the following modes of transport influence climate change?

Tick all that apply

- ☐ Walking
- ☐ Cycling
- ☐ Diesel car
- ☐ Petrol car
- ☐ Electric car
- ☐ Hybrid car
- ☐ DART
- ☐ Light rail tram (Luas)
- ☐ Train
- ☐ Bus
- ☐ Coach

7

Figure E.7: "Air Quality in Dublin City Centre" Survey (Q25-27)

Air Quality in Dublin City Centre

* 28. Do you think mitigation of ambient air pollution is a costly expense?

- Yes
- No
- Don't know

* 29. Do you think tackling air pollution may be economically beneficial?

- Yes
- No
- Don't know

* 30. Do you agree with the following statement: "'Radical measures' are needed to combat air pollution"?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

8

Figure E.8: "Air Quality in Dublin City Centre" Survey (Q28-30)

Appendix F

Results obtained from the survey “Air Quality in Dublin City Centre”:

Air Quality in Dublin City Centre		
Q1. Which answer describes you?		
Answer Choices	Responses	
Female	53.33%	48
Male	44.44%	40
Other	0.00%	0
Prefer not to answer	2.22%	2
	Answered	**90**
	Skipped	**0**
Q2. Which age group describes you?		
Answer Choices	Responses	
18 to 24	30.00%	27
25 to 34	21.11%	19
35 to 44	18.89%	17
45 to 54	22.22%	20
55 to 64	4.44%	4
65+	3.33%	3
	Answered	**90**
	Skipped	**0**
Q3. Do you work or study in Dublin City Centre?		
Answer Choices	Responses	
Yes	68.89%	62
No	24.44%	22
Prefer not to answer	2.22%	2
Other (please specify)	4.44%	4
	Answered	**90**
	Skipped	**0**
Q4. Approximately, how long does it take you to commute from home to place of work/educational institution?		
Answer Choices	Responses	
<10 minutes	7.78%	7
10-20 minutes	10.00%	9
20-30 minutes	18.89%	17
30-40 minutes	27.78%	25
>40 minutes	35.56%	32
	Answered	**90**
	Skipped	**0**
Q5. How often do you visit Dublin City Centre (per week)?		
Answer Choices	Responses	
Every day	48.89%	44

A few times a week	28.89%	26
About once a week	6.67%	6
A few times a month	5.56%	5
Once a month	2.22%	2
Less than once a month	6.67%	6
N/A	1.11%	1
	Answered	**90**
	Skipped	**0**
Q6. What means of transport do you use to travel to Dublin City Centre? Tick all that apply		
Answer Choices	Responses	
Dublin Bus	57.78%	52
Coach	10.00%	9
Light rail tram (Luas)	23.33%	21
Commuter/DART	21.11%	19
Private vehicle	31.11%	28
Bicycle	7.78%	7
Walking	20.00%	18
Other (please specify)	3.33%	3
	Answered	**90**
	Skipped	**0**
Q7. Approximately, how much do you spend on public transport to travel to Dublin City Centre (per week)?		
Answer Choices	Responses	
<€5	10.00%	9
€5-€10	14.44%	13
€10-€20	18.89%	17
>€20	40.00%	36
N/A	16.67%	15
	Answered	**90**
	Skipped	**0**
Q8. How do you feel about travelling on public transport?		
Answer Choices	Responses	
Very satisfied	5.56%	5
Satisfied	24.44%	22
Neither satisfied nor dissatisfied	32.22%	29
Dissatisfied	28.89%	26
Very dissatisfied	6.67%	6
N/A	2.22%	2
	Answered	**90**
	Skipped	**0**
Q9. Do you currently suffer from any medical/health issues that make it difficult to use public transportation?		
Answer Choices	Responses	
Yes	2.53%	2

No	96.20%	76
Prefer not to answer	1.27%	1
	Answered	**79**
	Skipped	**11**
Q10. Have you suffered from any medical/health issues in the past that resulted in difficulty in accessing public transport?		
Answer Choices	Responses	
Yes	3.80%	3
No	96.20%	76
Prefer not to answer	0.00%	0
	Answered	**79**
	Skipped	**11**
Q11. Do you suffer from any respiratory health issues?		
Answer Choices	Responses	
Yes	13.92%	11
No	86.08%	68
Prefer not to answer	0.00%	0
	Answered	**79**
	Skipped	**11**
Q12. Do you believe that Dublin City Centre has an issue with air quality?		
Answer Choices	Responses	
Yes	68.35%	54
No	26.58%	21
Prefer not to answer	5.06%	4
	Answered	**79**
	Skipped	**11**
Q13. Do you think increased action should be taken to minimize air pollution in Dublin?		
Answer Choices	Responses	
Yes	84.81%	67
No	10.13%	8
Prefer not to answer	5.06%	4
	Answered	**79**
	Skipped	**11**
Q14. Do you think that access to private vehicles should be minimized in Dublin City Centre?		
Answer Choices	Responses	
Yes	70.89%	56
No	21.52%	17
Prefer not to answer	7.59%	6
	Answered	**79**
	Skipped	**11**
Q15. Do you think more streets in Dublin City Centre should be pedestrianized?		

Answer Choices	Responses	
Yes	77.22%	61
No	21.52%	17
Prefer not to answer	1.27%	1
	Answered	**79**
	Skipped	**11**

Q16. "Current air quality in Dublin City Centre poses a risk to your health". Do you agree with this statement?

Answer Choices	Responses	
Strongly agree	35.44%	28
Agree	27.85%	22
Neither agree nor disagree	30.38%	24
Disagree	5.06%	4
Strongly disagree	1.27%	1
	Answered	**79**
	Skipped	**11**

Q17. Do you think additional safety measures should be considered for pedestrian footpaths exposed to traffic in Dublin City Centre to protect pedestrians from air pollution?

Answer Choices	Responses	
Yes	70.89%	56
No	20.25%	16
Prefer not to answer	8.86%	7
	Answered	**79**
	Skipped	**11**

Q18. On a scale from 1 to 10, how satisfied are you with the pedestrianized walking space in Dublin City Centre (1 being least satisfied and 10 being most satisfied)?

Answer Choices	Average Number	Total Number	Responses	
(no label)	5.62025316	444	100.00%	79
			Answered	**79**
			Skipped	**11**

Q19. Do your decisions on mode of transport you use is influenced by your knowledge of air quality in Dublin?

Answer Choices	Responses	
A great deal	5.48%	4
A lot	2.74%	2
A moderate amount	31.51%	23
A little	19.18%	14
None at all	41.10%	30
	Answered	**73**
	Skipped	**17**

Q20. Do you agree with the following statement: “Human activities contribute to poor air quality”?

Answer Choices	Responses	
Strongly agree	58.90%	43
Agree	32.88%	24
Neither agree nor disagree	5.48%	4

Disagree	2.74%	2			
Strongly disagree	0.00%	0			
	Answered	**73**			
	Skipped	**17**			
Q21. Which of the following, do you think, are the sources of air pollution in Dublin? Tick all that apply					
Answer Choices	Responses				
Modes of transport	87.67%	64			
Agricultural activities	34.25%	25			
Construction activities	68.49%	50			
Factories and industries	71.23%	52			
Mining operations	24.66%	18			
Household activities and equipment/supplies, e.g. cleaning products, painting supplies, cooking, heating	52.05%	38			
Natural causes, e.g. volcano eruptions, forest fires, dust storms	23.29%	17			
Smoking	49.32%	36			
	Answered	**73**			
	Skipped	**17**			
Q22. Which of the following, in your opinion, is the result of air pollution?Tick all that apply					
Answer Choices	Responses				
Temperature increase	72.60%	53			
Increased precipitation	42.47%	31			
Sea-level rise	47.95%	35			
Increased storms and rainfall	49.32%	36			
Increased likelihood of river and coastal flooding	45.21%	33			
Water shortages	41.10%	30			
Increased droughts	43.84%	32			
Negative impacts on water quality	56.16%	41			
Changes in the distribution of species	50.68%	37			
Early migration of species	47.95%	35			
Impacts on fishery industry	45.21%	33			
Increased wildfires	49.32%	36			
Increased pest infestation	36.99%	27			
Snow and ice are melting, and frozen ground is thawing	52.05%	38			
Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus	34.25%	25			
Increased indoor/outdoor air pollution	75.34%	55			
Increased adverse health effects	60.27%	44			
Increased waste management issues	50.68%	37			
Increased forest degradation	46.58%	34			
Impacts on agricultural industry	39.73%	29			
Impacts on vegetation	57.53%	42			
Decreased food availability	39.73%	29			
Increased occurrences of acid rain	47.95%	35			
Impacts on sea-life	46.58%	34			
Depletion of the ozone layer	60.27%	44			
Increased smog and soot	67.12%	49			

	Answered	**73**
	Skipped	**17**
Q23. Which of the following modes of transport influence air quality in Dublin City Centre?Tick all that apply		
Answer Choices	Responses	
Walking	17.81%	13
Cycling	17.81%	13
Diesel car	83.56%	61
Petrol car	84.93%	62
Electric car	24.66%	18
Hybrid car	46.58%	34
DART	35.62%	26
Light rail tram (Luas)	26.03%	19
Train	63.01%	46
Bus	82.19%	60
Coach	79.45%	58
	Answered	**73**
	Skipped	**17**
Q24. In your opinion, what time of the day air pollution is highest in Dublin City Centre?Tick all that apply		
Answer Choices	Responses	
Early morning (3 am - 5 am)	5.48%	4
Morning (6 am - 10 am)	75.34%	55
Noon (11 am - 1 pm)	6.85%	5
Afternoon (2 pm - 4pm)	24.66%	18
Evening (5 pm - 8 pm)	86.30%	63
Night (9 pm - 11 pm)	6.85%	5
Midnight (12 am - 1 am)	0.00%	0
	Answered	**73**
	Skipped	**17**
Q25. "Air pollutants contribute to climate change". Do you agree with this statement?		
Answer Choices	Responses	
Strongly agree	75.00%	54
Agree	18.06%	13
Neither agree nor disagree	6.94%	5
Disagree	0.00%	0
Strongly disagree	0.00%	0
	Answered	**72**
	Skipped	**18**
Q26. Which of the following, in your opinion, is the result of climate change?Tick all that apply		
Answer Choices	Responses	
Temperature increase	87.32%	62
Increased precipitation	67.61%	48
Sea-level rise	74.65%	53

Increased storms and rainfall	70.42%	50
Increased likelihood of river and coastal flooding	67.61%	48
Water shortages	56.34%	40
Increased droughts	70.42%	50
Negative impacts on water quality	63.38%	45
Changes in the distribution of species	63.38%	45
Early migration of species	63.38%	45
Impacts on fishery industry	60.56%	43
Increased wildfires	77.46%	55
Increased pest infestation	56.34%	40
Snow and ice are melting, and frozen ground is thawing	71.83%	51
Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus	39.44%	28
Increased indoor/outdoor air pollution	67.61%	48
Increased adverse health effects	63.38%	45
Increased waste management issues	59.15%	42
Increased forest degradation	60.56%	43
Impacts on agricultural industry	57.75%	41
Impacts on vegetation	64.79%	46
Decreased food availability	61.97%	44
Increased occurrences of acid rain	57.75%	41
Impacts on sea-life	69.01%	49
Depletion of the ozone layer	70.42%	50
Increased smog and soot	69.01%	49
	Answered	**71**
	Skipped	**19**

Q27. Which of the following modes of transport influence climate change?Tick all that apply

Answer Choices	Responses	
Walking	11.11%	8
Cycling	12.50%	9
Diesel car	88.89%	64
Petrol car	90.28%	65
Electric car	25.00%	18
Hybrid car	52.78%	38
DART	41.67%	30
Light rail tram (Luas)	33.33%	24
Train	76.39%	55
Bus	88.89%	64
Coach	84.72%	61
	Answered	**72**
	Skipped	**18**

Q28. Do you think mitigation of ambient air pollution is a costly expense?

Answer Choices	Responses	
Yes	63.38%	45
No	5.63%	4

Don't know	30.99%	22
	Answered	**71**
	Skipped	**19**
Q29. Do you think tackling air pollution may be economically beneficial?		
Answer Choices	Responses	
Yes	80.28%	57
No	4.23%	3
Don't know	15.49%	11
	Answered	**71**
	Skipped	**19**
Q30. Do you agree with the following statement: "'Radical measures' are needed to combat air pollution"?		
Answer Choices	Responses	
Strongly agree	61.97%	44
Agree	26.76%	19
Neither agree nor disagree	9.86%	7
Disagree	0.00%	0
Strongly disagree	1.41%	1
	Answered	**71**
	Skipped	**19**

Table F.1: Detailed results obtained from the survey "Air Quality in Dublin City Centre"

Appendix G

Graphs from survey “Air Quality in Dublin City Centre”

- Q2.

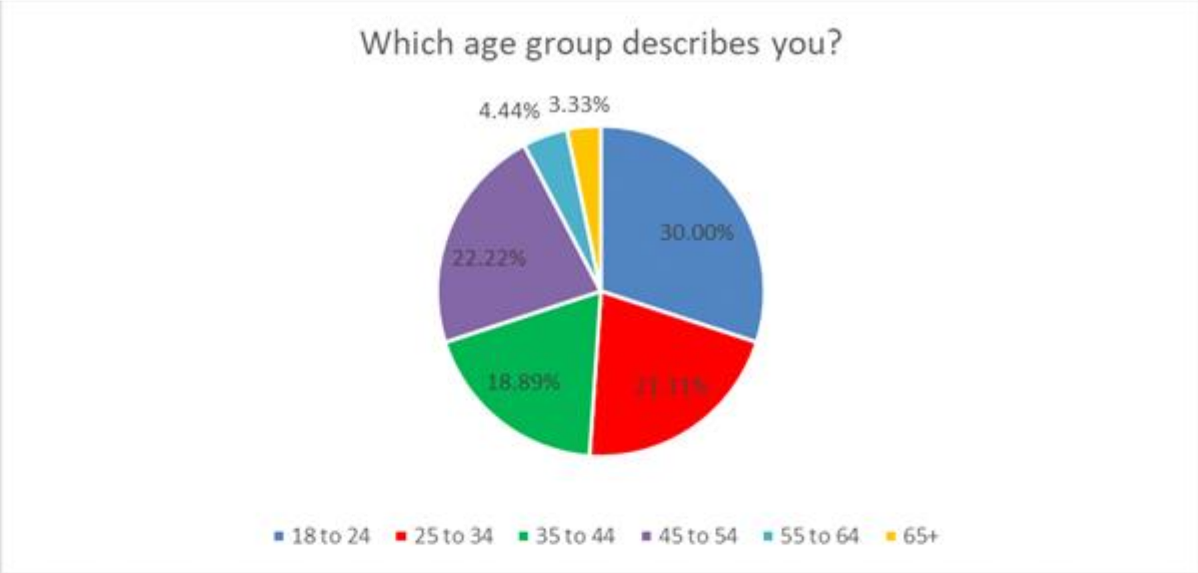


Figure G.1: Q2 – Survey results in percentages show that most of the participants were aged 18 – 24 (30%).

- Q3.

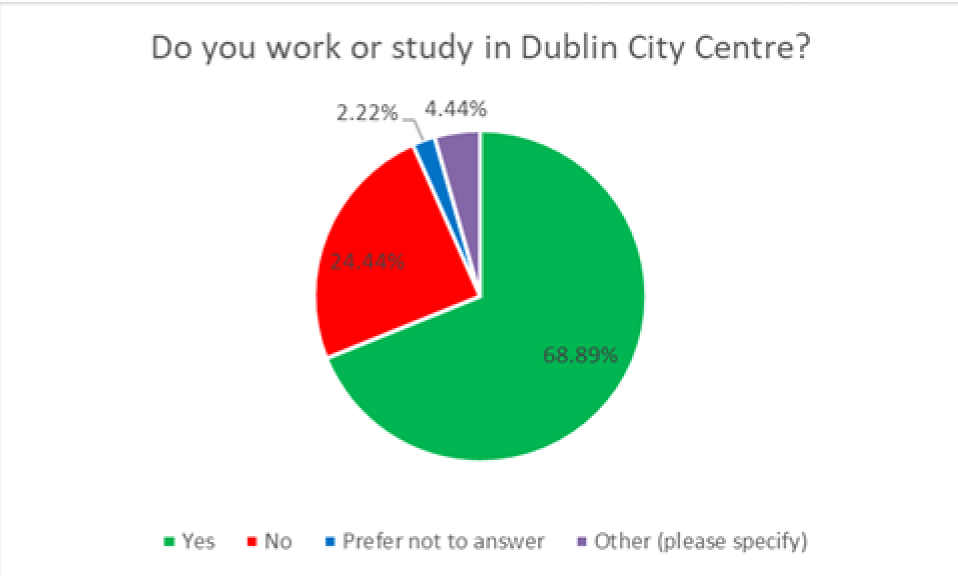


Figure G.2: Q3 – Survey results in percentages show that most of the participants work/study in Dublin City Centre (69%).

- Q7

Figure G.3: Q7 – Survey results show that most of the participants spend >€20 to get to get to Dublin City Centre per week.

- Q8

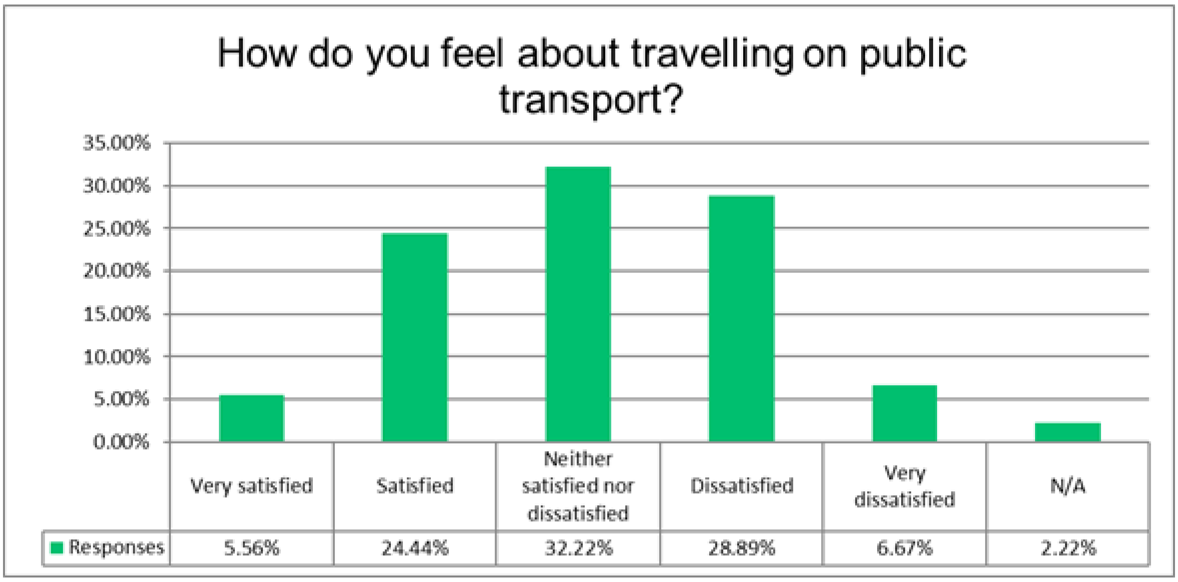


Figure G.4: Q8 – Survey results in the bar chart indicate that most of the participants are neither satisfied nor dissatisfied with public transport (32%).

- Q10

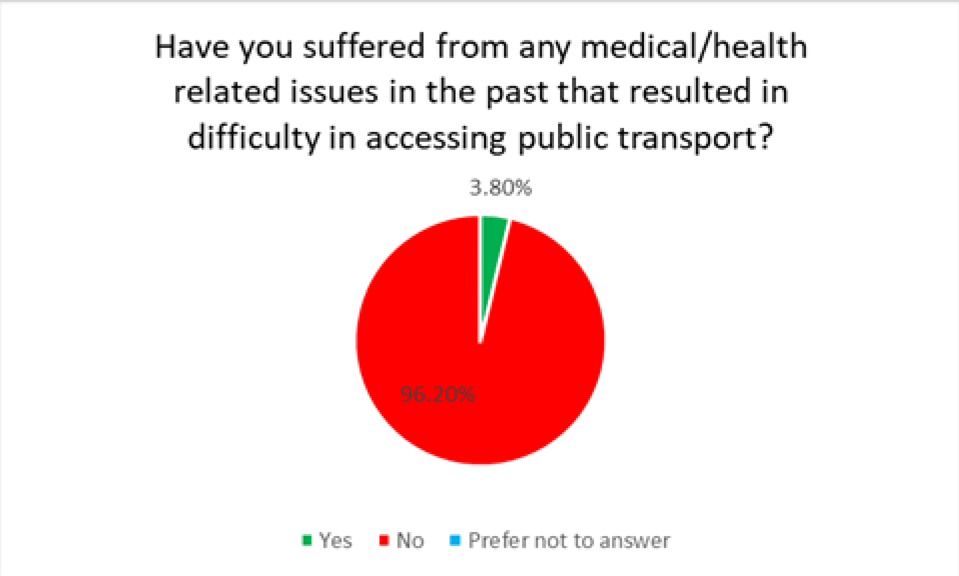


Figure G.5: Q10 – Survey results indicate that most of the participants have not suffered from medical/health related issues in the past which prevented them from using public transport (96%).

- Q11

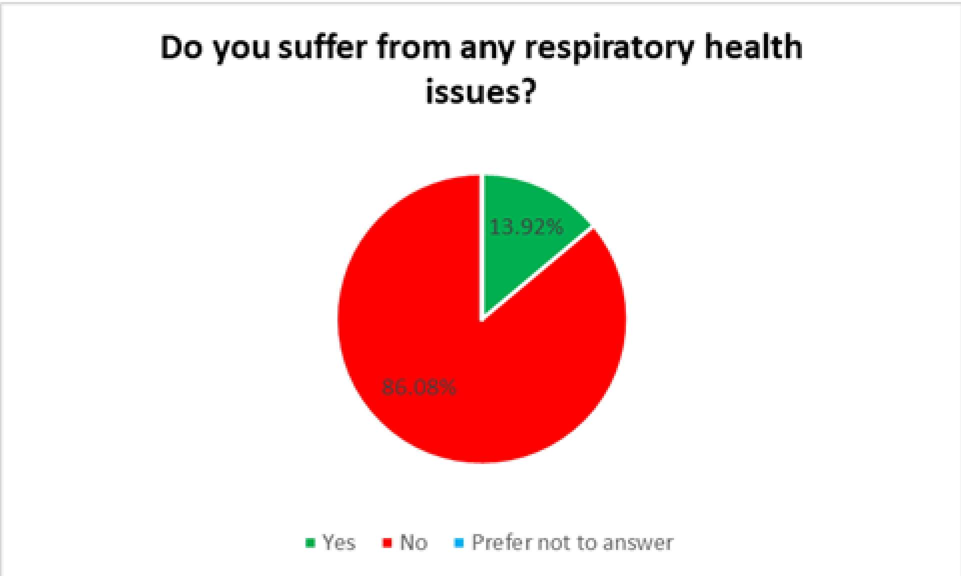


Figure G.6: Q11 – Survey results indicate that most of the participants do not suffer from any respiratory health issues (86%).

- Q12

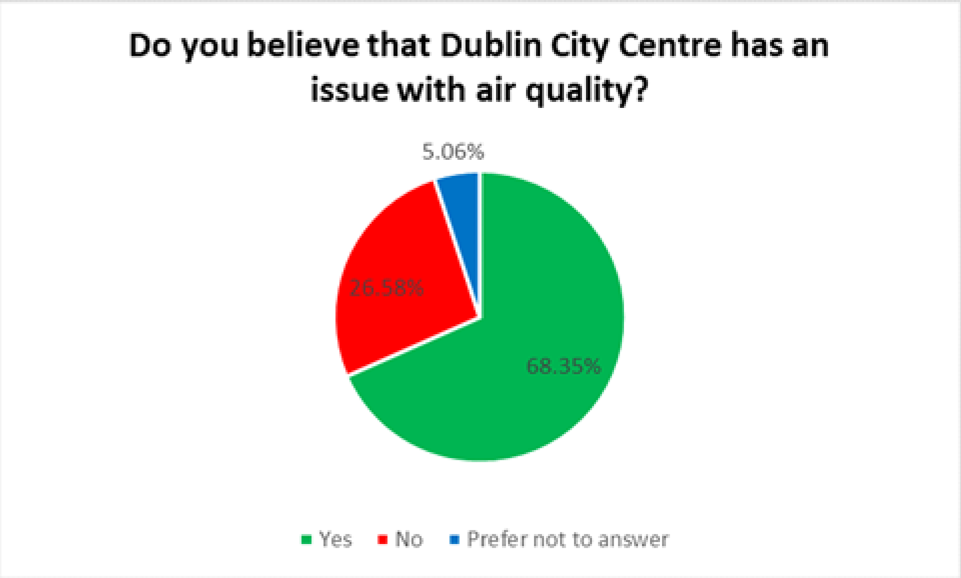


Figure G.7: Q12 – Survey results show that most of the participants (68%) believe there is an issue with air quality in Dublin City Centre.

- Q13

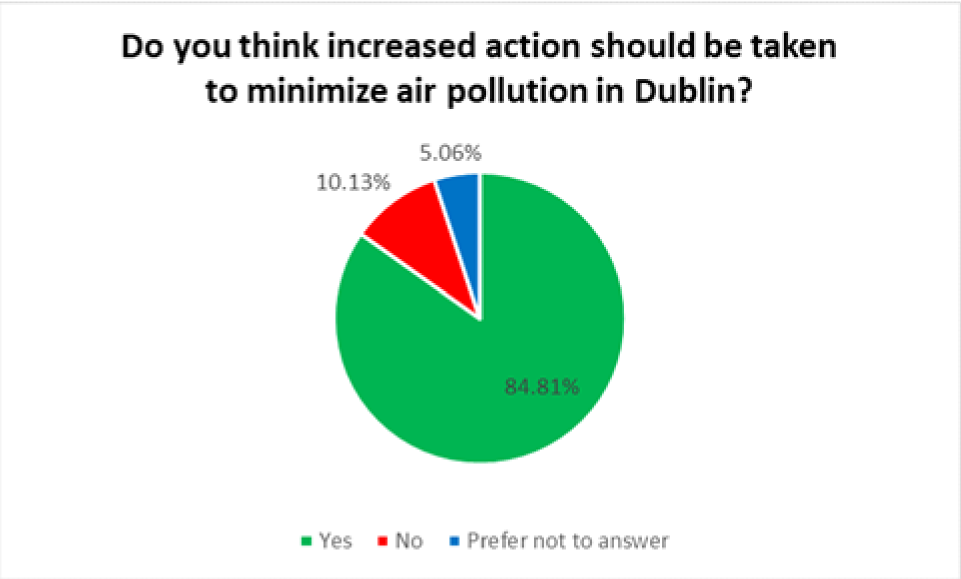


Figure G.8: Q13 – Survey results show that most of the respondents (84%) think that increased action should be taken to reduce air pollution in Dublin.

- Q14

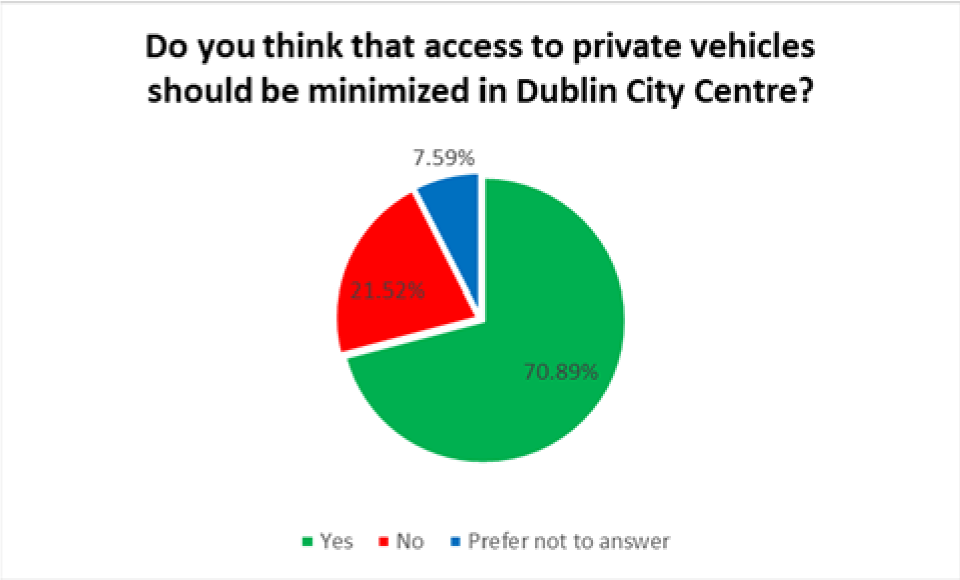


Figure G.9: Q14 – Survey results show majority of the respondents (71%) think that private vehicle access should be minimized in Dublin City Centre.

- Q15

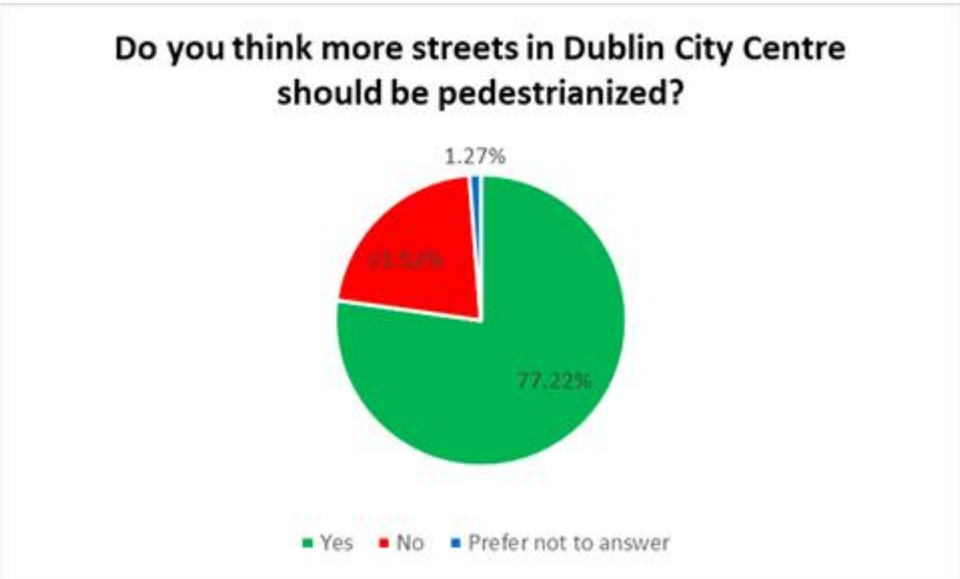


Figure G.10: Q15 – Survey results show that most of the participants (77%) think that more streets should be pedestrianised.

- Q16

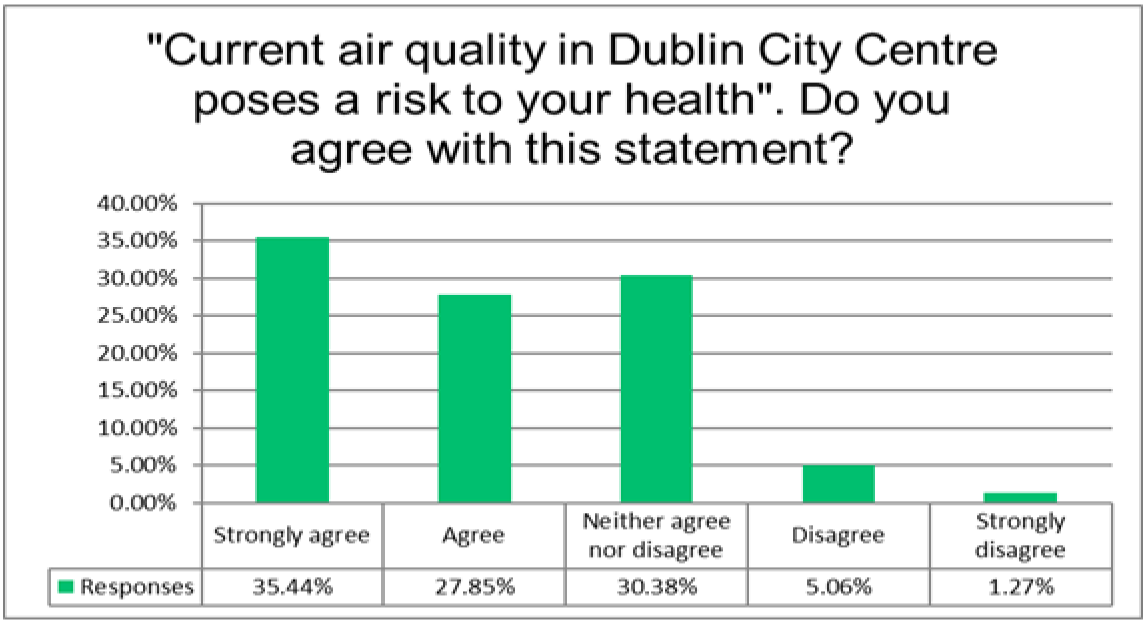


Figure G.11: Q16 – Survey results show that most of the respondents strongly agree (35%) with the statement.

- Q17

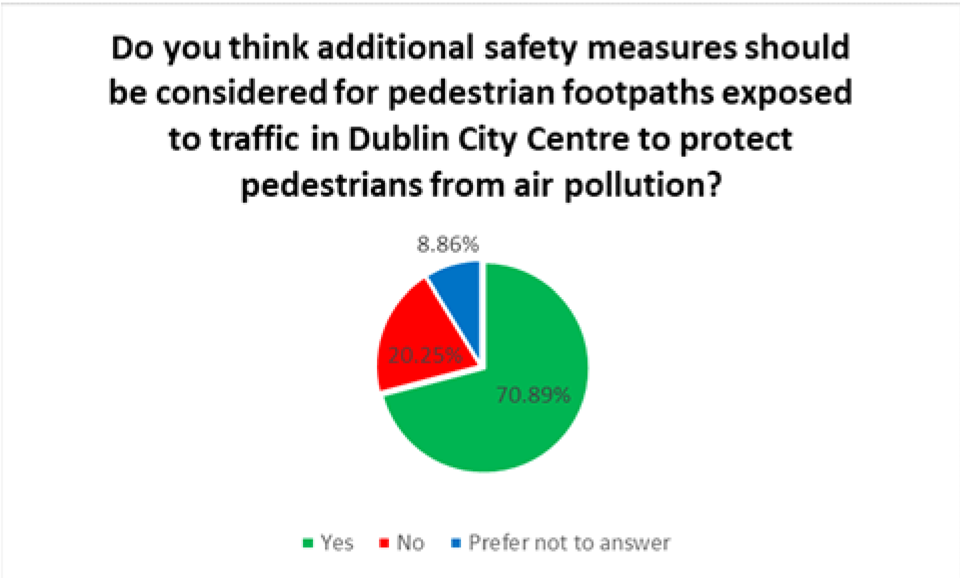


Figure G.12: Q17 – Survey results show that most of the participants (71%) think additional safety measures should be considered for pedestrian footpaths in Dublin City Centre.

- Q18

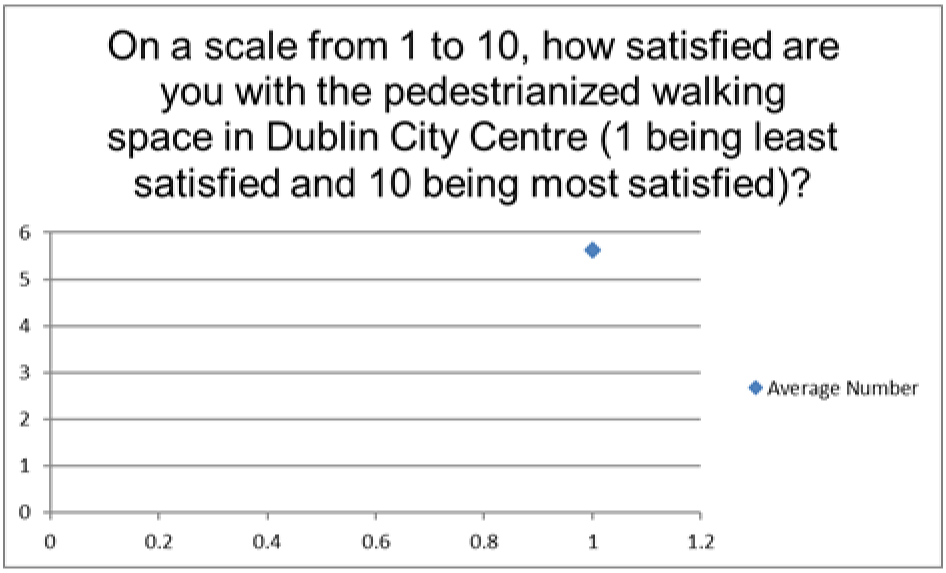


Figure G.13: Q18 – Survey result indicates that participants are mostly satisfied with pedestrianized walking space in Dublin City Centre.

- Q19

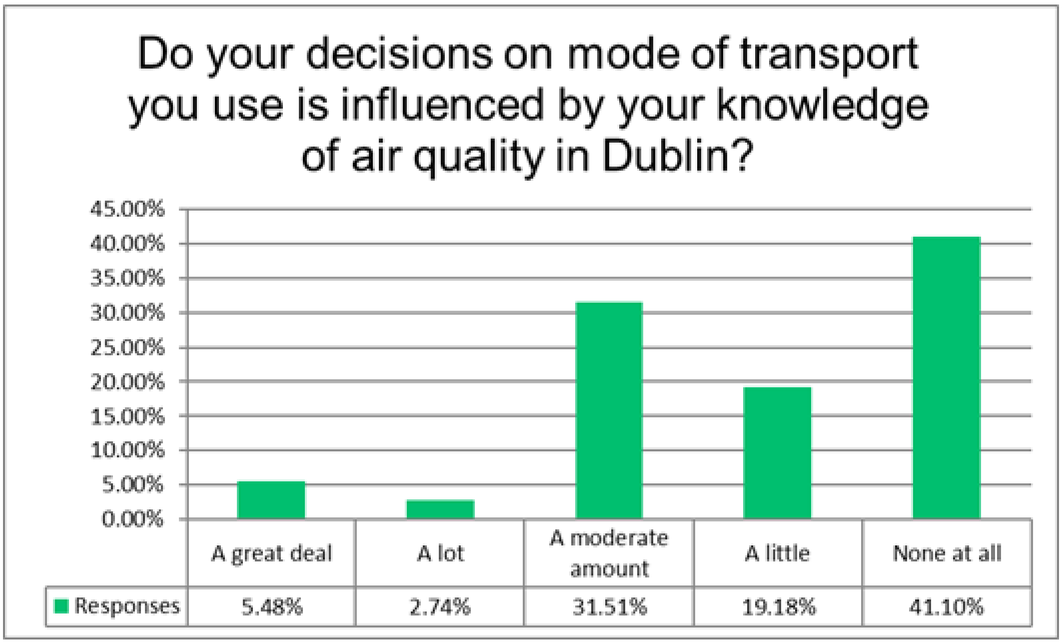


Figure G.14: Q19 – Survey results show that knowledge on air quality does not influence participants to make decisions on mode of transport (41%).

- Q20

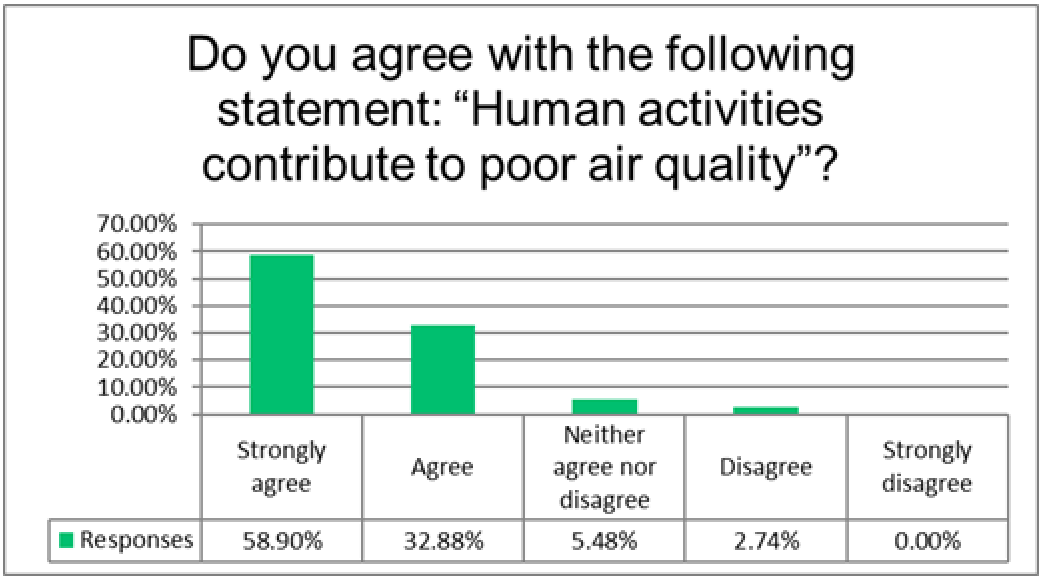


Figure G.15: Q20 – Survey results show that participants agree (59%) that human activities contribute to poor air quality.

- Q21

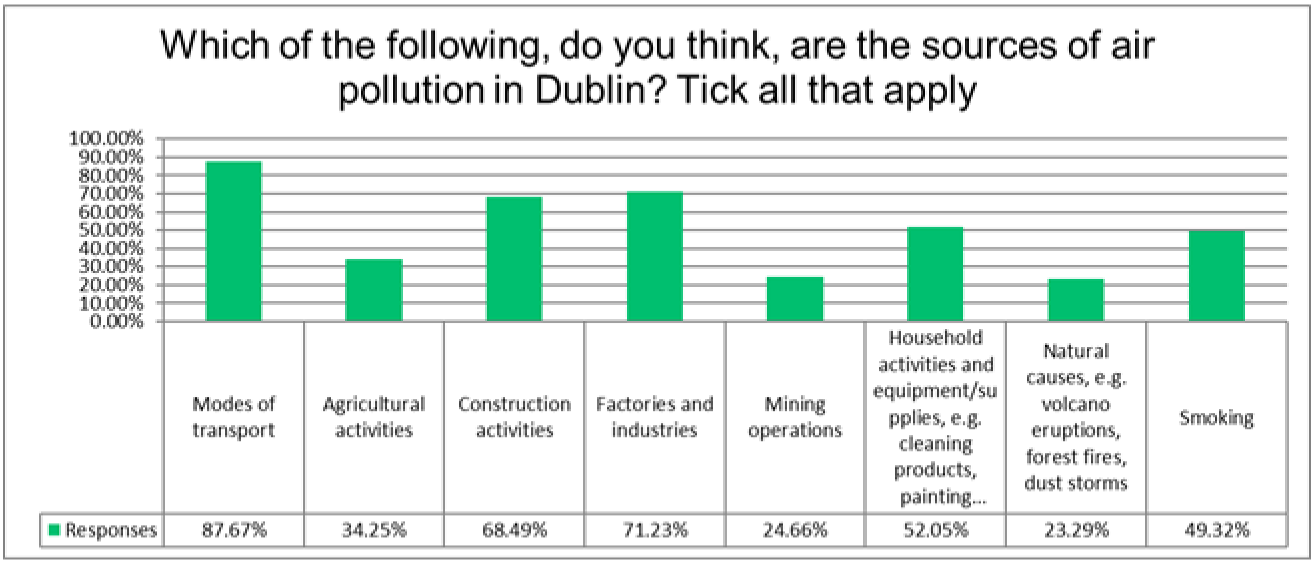
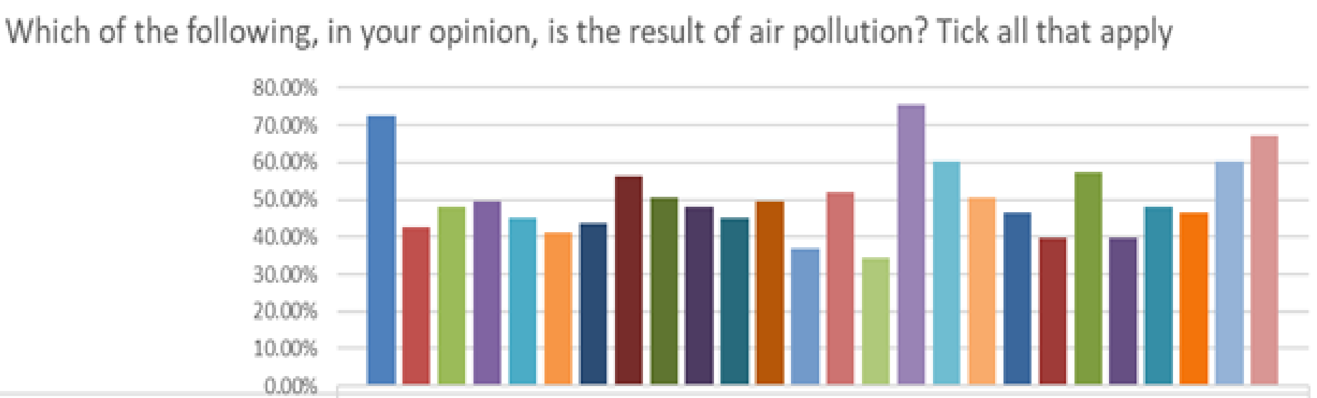


Figure G.16: Q21 – Survey results show the participant choices for which they believe are the sources of air pollution. Most of the participants have chosen modes of transport (88%).

- Q22



Temperature increase	72.60%
Increased precipitation	42.47%
Sea-level rise	47.95%
Increased storms and rainfall	49.32%
Increased likelihood of river and coastal flooding	45.21%
Water shortages	41.10%
Increased droughts	43.84%
Negative impacts on water quality	56.16%
Changes in the distribution of species	50.68%
Early migration of species	47.95%
Impacts on fishery industry	45.21%
Increased wildfires	49.32%
Increased pest infestation	36.99%
Snow and ice are melting, and frozen ground is thawing	52.05%
Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus	34.25%
Increased indoor/outdoor air pollution	75.34%
Increased adverse health effects	60.27%
Increased waste management issues	50.68%
Increased forest degradation	46.58%
Impacts on agricultural industry	39.73%
Impacts on vegetation	57.53%
Decreased food availability	39.73%
Increased occurrences of acid rain	47.95%
Impacts on sea-life	46.58%
Depletion of the ozone layer	60.27%
Increased smog and soot	67.12%

Figure G.17: Q22 – Survey results show participant choices for which they believe result in air pollution. The most popular choice was increased outdoor/indoor air pollution (75%) and temperature increase (73%).

- Q23

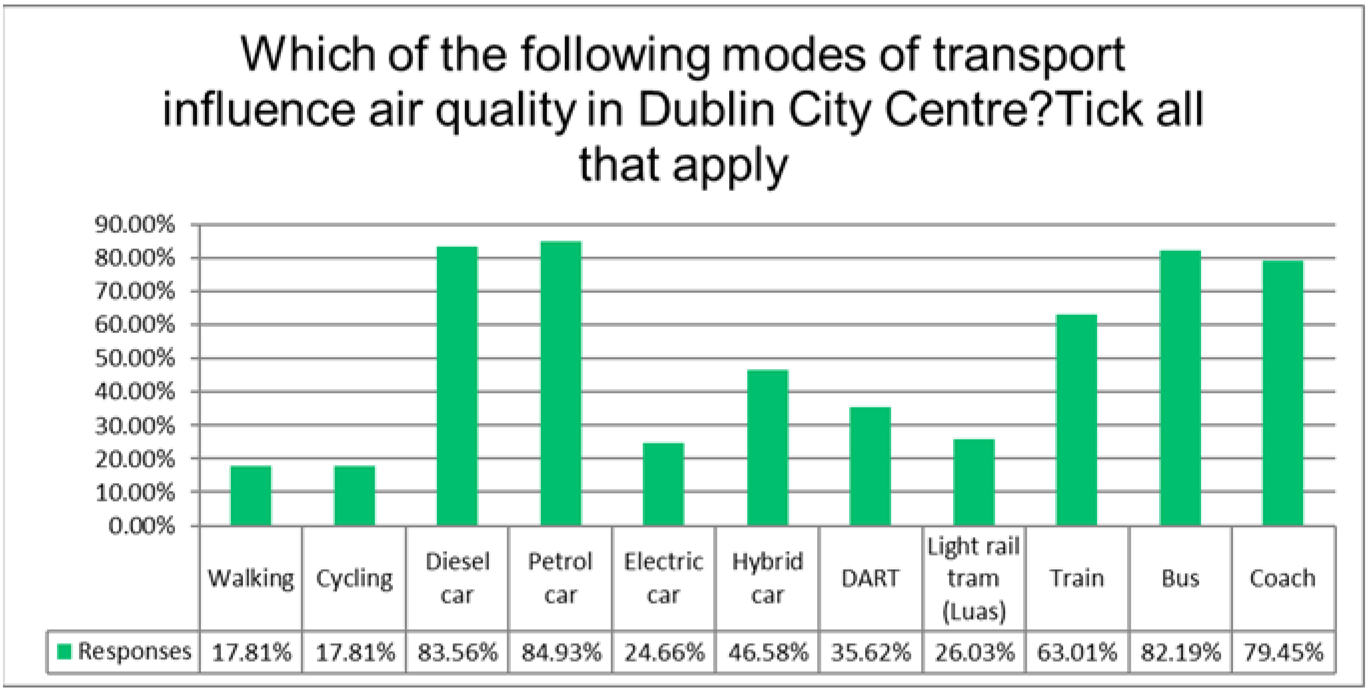


Figure G.18: Q23 – Survey results indicate participant transport mode choices for which they believe influence air quality the most. Most of the participants selected petrol car (85%) and diesel car (84%).

- Q24

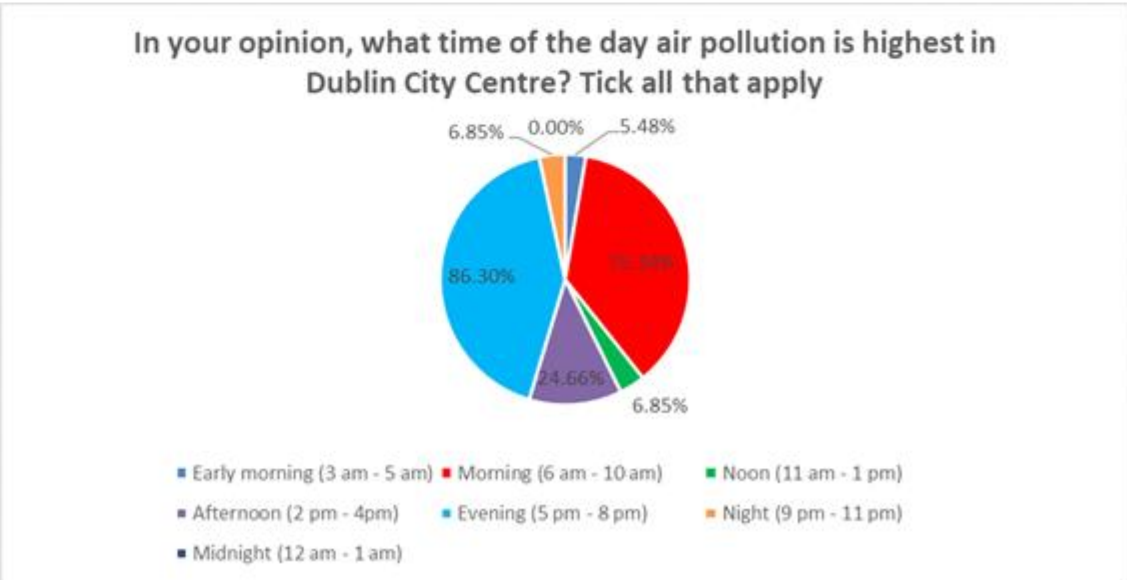
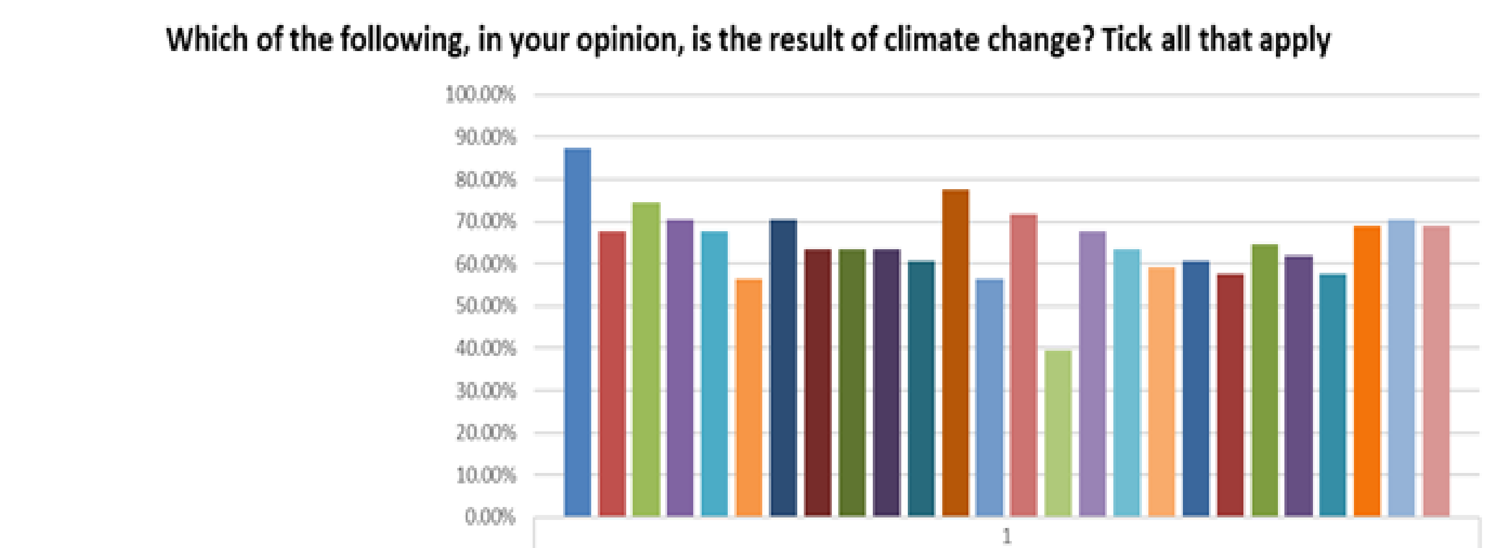


Figure G.19: Q24 – Survey results show that most of the participants think that air quality is the worst during morning (75%) and evening times (86%).

- Q26



	1
Temperature increase	87.32%
Increased precipitation	67.61%
Sea-level rise	74.65%
Increased storms and rainfall	70.42%
Increased likelihood of river and coastal flooding	67.61%
Water shortages	56.34%
Increased droughts	70.42%
Negative impacts on water quality	63.38%
Changes in the distribution of species	63.38%
Early migration of species	63.38%
Impacts on fishery industry	60.56%
Increased wildfires	77.46%
Increased pest infestation	56.34%
Snow and ice are melting, and frozen ground is thawing	71.83%
Increased epidemics, e.g. AIDS, Zika, Malaria, Coronavirus	39.44%
Increased indoor/outdoor air pollution	67.61%
Increased adverse health effects	63.38%
Increased waste management issues	59.15%
Increased forest degradation	60.56%
Impacts on agricultural industry	57.75%
Impacts on vegetation	64.79%
Decreased food availability	61.97%
Increased occurrences of acid rain	57.75%
Impacts on sea-life	69.01%
Depletion of the ozone layer	70.42%
Increased smog and soot	69.01%

Figure G.20: Q26 - Survey results show participant choices for which they believe result in climate change. The most popular choice was temperature increase (87%).

- Q28

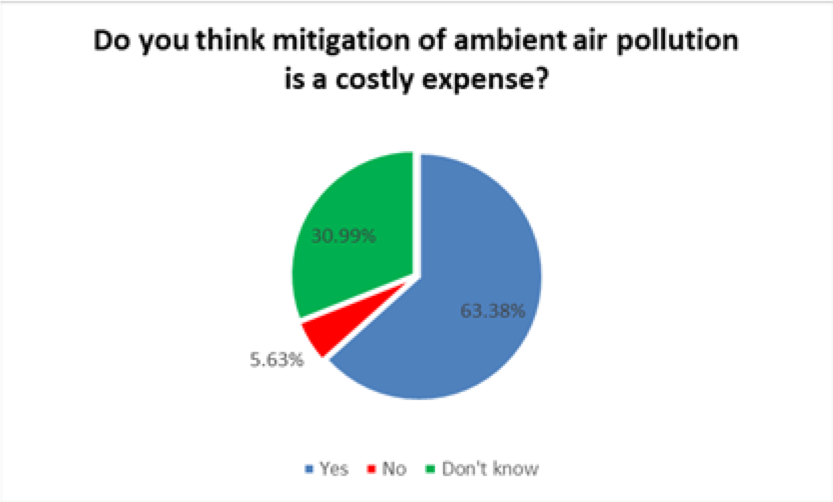


Figure G.21: Q28 – Survey results show most of the respondents think mitigation of air pollution could be a costly expense (63%).

- Q29

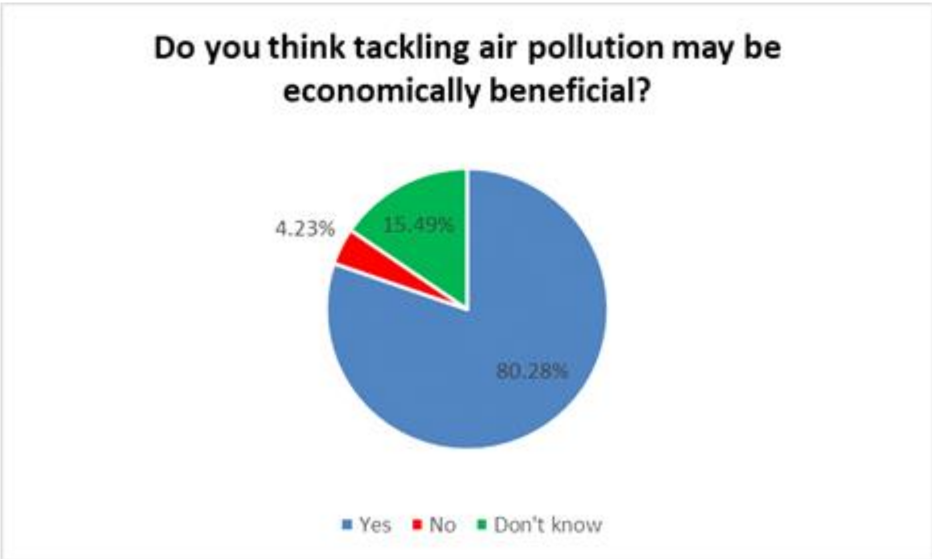


Figure G.22: Q29 – Survey results show that participants believe tackling air pollution would be economically beneficial (80%).

Appendix H

$PM_{2.5}$ results from DCC. The results were transferred onto Microsoft Excel into a table and were later used to create a graph (*Figure 3.10*). Only the dates that were assessed during this study were taken off the DCC $PM_{2.5}$ results list and added to this table for comparison.

Elapsed Time [s]	**$PM_{2.5}$ concentration (µg /m^3)**	**EU $PM_{2.5}$ Limit (µg /m^3)**
5/15/2019	11.7	20
5/17/2019	8.4	20
5/19/2019	6.1	20
5/26/2019	3.5	20
5/28/2019	3.3	20
6/1/2019	6.4	20
6/18/2019	5.2	20
6/19/2019	3.9	20
6/20/2019	3.2	20
6/21/2019	4.2	20
6/26/2019	5.9	20
7/1/2019	3.5	20
7/2/2019	4.4	20
7/3/2019	4.6	20
7/10/2019	3.3	20
7/11/2019	3.3	20
8/11/2019	3.8	20
8/21/2019	3.1	20
8/24/2019	9.2	20
8/25/2019	11.9	20
8/26/2019	4.8	20
8/27/2019	3.6	20
8/28/2019	2.7	20
9/2/2019	4.2	20
9/3/2019	2.6	20

9/10/2019	6.2	20
9/11/2019	4.5	20
9/12/2019	3.2	20
9/15/2019	3.4	20
9/17/2019	7.3	20
9/19/2019	9.4	20
9/20/2019	6.9	20
9/23/2019	4.6	20
11/3/2019	9.5	20
11/4/2019	6.6	20
11/5/2019	5.9	20
11/7/2019	5.5	20
11/10/2019	5.1	20
11/11/2019	6.1	20
11/14/2019	5.1	20
11/15/2019	5	20
11/18/2019	14.4	20
11/26/2019	5.9	20
11/27/2019	12.2	20
11/29/2019	10.8	20
12/1/2019	23	20
12/4/2019	7.3	20
12/5/2019	3.3	20
12/6/2019	4.2	20
12/7/2019	3.6	20
12/8/2019	5.4	20
Average:	**6.1**	

Table H.1: $PM_{2.5}$ results from DCC - workings