Development of Air Quality Profile in an Enclosed Kuala Lumpur Convention Centre Car Parks Area.

by

Khairul Bariyah Binti Baharuddin

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____
(Dr. Nurul Izma binti Mohammed)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

…………………………………………………

KHAIRUL BARIYAH BINTI BAHARUDDIN

ABSTRACT

Nowadays, air pollution for indoor area has caught an attention of people around the world. However, few researches have been discussing about the pollution inside car parks area. Statistics show that there are increasing of number of vehicles users, increasing the amount of pollutions. The aim of this which leads to study was to monitor the exhaust emissions released by vehicles, which are carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide and determine how the pollution released from exhaust of vehicles can influences the health of employees inside the car parks area. This problem is analysed within a case study in an enclosed Kuala Lumpur Convention Centre (KLCC) car parks area. For the observed location, the sample of air pollutants are collected in a period of 8 days which are from 1st of November 2013 to 5th of November 2013 and 15th of November 2013 to 17th of November 2013 from 0800 to 1700. The following air pollutants; carbon monoxide and carbon dioxide were measured by using Combustion Gas Analyzer and nitric oxide, and nitrogen dioxide were measured by using Toxic Gas Test Meter. Data was analysed by using the time series analysis of average 30 minutes for 1 day of data. The concentration of air pollutants than will be compared with the permissible exposure limit (PEL) to determine the effect of air pollutants trapped in car parks area to employees' health.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Transport is the fundamental to the efficient functioning of the city and its economic, social, and cultural development (Nikic, et al., 2004). Transportations are one of the most important facilities and in Malaysia, as a prosperous rapidly growing country; there are a lots of users own a private vehicle (Kamba et al., 2007). Study on transportation mode in an urban area is very important because for almost every individual living in a large and densely populated area, mobility is one of the most crucial issues in everyday life (Haryati & Sharifah, 2009). Malaysia's rapid growth in population, economy and motorization has resulted in the number of registered motor vehicles increasing by 8,321,517 over the 13-years period from 1990 to 2003 and there was a general increase of 54.6% for all motor vehicle registration in Malaysia (Nurdeen et al., 2007).

Transport also has a very big effect on the health and exhaust emissions have been serious concern all over the world (Pundir, 2007; Petrovic & Trajkovic, 2010). Many studies have reported the association between air pollution produced by exhaust emissions from vehicles can cause bad effect to the environment and human health (Takeshita, 2011; Middleton et. al, 2010; Petrovic & Trajkovic, 2010). Scientific research has proven that exhaust emissions have a lot of negative health effects and some are deadly diseases (Ibrahim et al., 2009). The number of studies conducted on the effects of air pollution to health has increased exponentially (Nikic et al., 2004). Air pollution pose a risk to human health (Sygit, 2012), including diseases of the respiratory system, asthma in children, cardiovascular diseases, birth defects, cancer, as well as premature deaths in individuals with existing heart or lung diseases (Brzeźnicki et al., 2009; Van Otterlo & De Koning, 2009; Schell & Denham, 2003;

Ito et al., 1995). Those factors contribute to significant increases in morbidity and mortality rates in populations (Roukos et al., 2009). Air pollution also gives an impact to the environment, including the formation of acid rains implicated in biodiversity loss and defacing of physical structures (Augustine, 2012). Emission of air pollutions from individual car is generally low but in city, the personal automobile is the single greatest pollution, as emissions from thousands of vehicles on the streets add up (Nikic et al., 2004).

There are two types of pollutant which are primary and secondary pollution. Primary pollutants include carbon monoxide, nitrogen and sulphur oxide is pollutants which enter the atmosphere directly from various anthropogenic sources (human activities) and secondary pollutants are formed in the reactions of the primary created pollutants (Petrovic & Trajkovic, 2010). The secondary pollutants include oxidants like ozone, and nitrogen dioxide, including host of other organic compound like peroxy-acetyl nitran (PAN) (Pundir, 2007).

The major internal combustion of the road transport engines generates carbon monoxide, nitrogen oxide, and carbon dioxide and these pollutants commonly termed as vehicle emissions (Kakouei et al., 2012; Pundir, 2007; Schwela & Zali, 1999). However, this study will only focus on carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide and their impact to employees' health.

Air quality is a measure of how good the air quality in terms of the type and quantity of pollutants contained within it (Warrington Borough Council Portal, 2012). Poor air quality is a result of a number of factors, including emissions from various sources, both natural and "human-caused" and it occurs when pollutants reach high enough concentrations to endanger human health and/or the environment (British Colombia Portal, 2013). Whereas, air quality standards is an acceptable average concentration of pollutants over a period of time. Air quality limits is a national standards or recommended as air quality guidelines as a goal for long time planning (Pundir, 2007). Table 1.1 present the air quality standards of Malaysia Ambient Air Quality Guidelines.

Table 1.1: Malaysia Ambient Air Quality Guidelines

(Department of Environment, 2013)

Substance	**Averaging Time**	**Malaysia Ambient Air Quality Guideline**	
		ppm	**(μg/m^3)**
Ozone (O_3)	1 hour 8 hour	0.10 0.06	200.0 120.0
Carbon Monoxide (CO) **	1 hour 8 hour	30.0 9.0	35.0 -
Nitrogen Oxide (NO_X)	1 hour 24 hour	0.17 0.04	320.0 10.0
Sulphur Dioxide (SO_2)	1 hour 24 hour	0.13 0.04	350.0 105.0
Particulate Matter (PM_{10})	24 hour 12 month	-	150.0 50.0
Total Suspended Particulate (TSP)	24 hour 12 month	-	260.0 90.0
Lead (Pb)	3 month	-	1.5

Note: ** (mg/m_3)

Since there is no indoor air quality guideline proposed by Department of Environment Malaysia, concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide in this study will be compared with the permissible exposure limit standardize by Occupational Safety and Health Administration (OSHA) and World Health Organization (WHO) over 8 hours' work shift (Centers for Disease, Control and Prevention, 2012). These permissible exposure limits is chosen for this study because this study concern about the exposure of air pollutants to the employee who work inside these car parks. Table 1.2 shows the permissible exposure limit for carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide.

Table 1.2: Permissible Exposure Limit (PEL)

(Centers for Disease, Control and Prevention, 2012 & Chaloukalou, 2012)

Pollutants	**Limit (ppm)**	**Exposure Duration**	**Sources**
Carbon monoxide	9.0	8 hours	WHO
Carbon Dioxide	5,000.0	8 hours	OSHA
Nitric Oxide	25.0	8 hours	OSHA
Nitrogen Dioxide	5.0	8 hours	OSHA

1.2 SCOPE OF STUDY

In recent years, many studies have investigated pollutants emission in open air (Jeelani, 2013) and there are a lot of researches had been done on outdoor pollution. While there are no standard for indoor air quality and many researchers suggest that additional research is needed to assess indoor pollutions exposure (Pickett & Bell, 2011). However, Indoor Air Quality (IAQ) in workplace and residential environment caught the attention of scientists and the public redundant (Marzuki et al., 2010). In fact, there are still low number of research had focusing on air pollution in an enclosed area such as enclosed car parks. Thus, this study will be focusing on air pollutants inside an enclosed Kuala Lumpur Convention Centre (KLCC) car parks area.

KLCC located at Kuala Lumpur Malaysia as the tallest twin tower in the world (KLCC, 2013; Tourism Malaysia Portal, 2013; Carbone 2011). Every single year, KLCC conduct many series of events and have been visited by thousands of visitors every day. In order to fill up all employees and visitors demand for car parks area, KLCC build up two types of parking; indoor parking which are west car park and east car park and open parking located along Jalan Pinang, Suria KLCC and KLCC Asy' Shakirin Mosque (KLCC, 2013).

The sample of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide were collected at an enclosed parking area by using Combustion Gas Analyzer and Toxic Gas Test Meter from 0800 to 1700, from 1st of November 2013 to 5th of November 2013 and 15th of November 2013 to 17th of November 2013. Results of the sample of air pollutants will be analysed by using time series analysis.

1.3 PROBLEM STATEMENT

Exhaust emissions from vehicles released to road traffic increasing days by days due to the higher number of users (Jeelani, 2013; Augustine, 2012; Schwela & Zali, 1999). Exhaust emissions from vehicles are now recognised as the major contributor to urban air pollution (Nikic et al., 2004). The combustion process inside combustion engines generated these three main emissions, which are carbon monoxide, nitrogen oxide, and carbon dioxide (Kakouei et al., 2012; Pundir, 2007; Schwela & Zali, 1999). The effects of exhaust emissions from vehicles that caused air pollution are great among infants, the elderly and the infirm (Marzuki et al., 2010; Mohammadyan et al., 2010; Rao & Rao, 1989).

KLCC is a multipurpose development area in Kuala Lumpur. Thus, this study assume that in everyday life, employees, and visitors from different type of background (example: age and health history) will come and visit KLCC for their own purpose. Statistic shows that 2,662,000 visitors from domestic visit Kuala Lumpur in 2011 and most of them select KLCC to be the first option to visit (Department of Statistics, 2013). In addition, about 25.7 million tourists visit Malaysia in year 2011 and Tourism Minister, Datuk Seri Dr Ng Yen Yen has attributed the showing to be in line with the Malaysia Tourism Plan 2020 target of achieving 36 million tourist arrivals and RM168 billion in tourism receipts by 2020 (Borneo Post Online, 2012). Therefore, selection of research location, which is KLCC is relevant due to the higher number of visitor that expected to visit KLCC, since KLCC is a Malaysian national symbolism.

Indoor air quality is not regulated, and the level of indoor pollutions was not widely known (Picket, 2011). This study intends to focus in KLCC enclosed car park area due to the protection of employees' health and since KLCC car parks area is an enclosed area. Although visitors usually spend only a few minutes inside enclosed car parks area, the impact of exhaust emissions is a matter of concern because employees are likely to be at high risk since they exposed to air pollutants during their working day (Chaloulakou et. al, 2002). Development and use of statistical and other quantitative methods in the environmental sciences have been a major communication between environmental scientists and statisticians. Therefore, the final result of this research will come out with the analysis of air quality profile of carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide released by vehicles inside the car parks area.

1.4 OBJECTIVE

i. To monitor the exhaust emissions from vehicles such as carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide in an enclosed KLCC car park area.
ii. To analyse carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide in an enclosed KLCC car parks area by using time series model.
iii. To identify potential health risks of exhaust emissions from vehicles to employee.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Enclosed car parks are usually underground and require mechanical ventilation to reduce the level of air pollutants that trap inside the car parks area (Krarti & Ayari, 2001). Car parks ventilation systems should be designed to ensure that the car park air quality guidelines are met under all circumstances. Ventilating enclosed car parks are operates to bring in air of sufficient quality from the exterior and extracting the polluted air from the space. The polluted air then treated in order to dilute and reduce the contaminants in the air below the limit permitted by regulations (Lopez et al., 2013).

There are two types of engine systems are used in motor vehicles (Bhatia, 2007); i) Otto cycle spark ignition (SI) reciprocating internal combustion engines (ICEs) and ii) diesel cycle compression ignition (CI) ICEs. In spark ignition (SI) engines, petrol or gasoline is used as fuel, while in compression ignition (CI) engines; diesel is used as fuel (Fast-hand.Info, 2013; Jain, 2011). The USA recorded that the amount of nitrogen oxides release from vehicles emissions was 50% and between 80 to 90% of carbon monoxide. The diesel vehicles by themselves contributed about 32 and 87% of total nitrogen oxide and smoke, respectively (Pundir 2007).

The emissions of gases in vehicles are performed through three systems; exhaust fumes (around 60%), petrol evaporation from the reservoir and carburettor system (around 20%) and oil system (around 20%) (Petrovic & Trajkovic, 2010). The amount of pollutants emitted depend on several factors such as engine design, operating conditions, ambient conditions, fuel type, and exhaust after treatment (Pundir, 2007).

2.2 CARBON MONOXIDE (CO)

Carbon monoxide is the cause of more than one-half of the fatal poisonings reported in many countries. Fatal cases also are grossly under-reported or misdiagnosed by medical professionals (Raub et al., 1999). The recommended limits for occupational exposure, which range from 25.0 to 50.0 ppm (30–60 mg/m^3) carbon monoxide worldwide (Commission of the European Communities, 1993; Cook, 1987), are intended to protect healthy employees from the adverse effects of carbon monoxide during a typical 8 hours working day. It was found that large amounts of CO generated from exhaust emissions are accumulated as a result of insuficient or malfunctioning ventilation inside the garages (Duci et al., 2003)

2.2.1 Characteristics of Carbon Monoxide (CO)

Carbon monoxide is formed due to deficiency of oxygen during combustion (Petrovic & Trajkovic, 2010; Pundir, 2007; Elsom & Longhurst, 2004; Rao & Rao, 1989). Carbon monoxide is a colourless, odourless, tasteless gas, highly toxic and lighter than air (Pundir, 2007; Elsom & Longhurst, 2004; Petrovic & Trajkovic, 2010). Carbon monoxide is classified as an asphyxiant because it is highly poisonous gas (Rao & Rao, 1989). The potential health signification of carbon monoxide to human is quite significant, thus keeping the carbon monoxide concentration below a standard limit is an important issue (Chaloulakou et al., 2002).

2.2.2 Effects of Carbon Monoxide (CO)

Carbon monoxide has a strong affinity for combining with the haemoglobin of the blood to form carboxyhaemoglobin, COHb (Rao & Rao, 1989; Goldsmith, 1986). This statement is supported by Elsom & Longhurst (2004); carbon monoxide interferes with blood’s ability to carry oxygen to the cells of body when inhaled and formation of COHb can seriously reduce the amount of oxygen conveyed throughout the body. Carbon monoxide has the ability to combine with haemoglobin 200-250 times than oxygen, thus makes carbon monoxide dangerous even at low concentration (Chaloulakou et al., 2002). In normal body of human being, the background level of COHb is in the range of 0.5% but an increase in COHb to about 2.5% in human body with exposure to 200.0 ppm for two to three hours, a person begins to experience headache, fatigue, nausea, and dizziness (Health & Safety Ontario, 2011; Encyclopedia of Children's Health, 2013). Exposure to high concentration of carbon monoxide which is greater than 150.0 ppm can cause a sudden death by anoxia (Chaloukalou et al., 2002).

2.3 CARBON DIOXIDE (CO_2)

Carbon dioxide is an essential ingredient in the cycle of life on earth. Plants directly use carbon dioxide in the process of photosynthesis where combined with water, it is converted into sugars and oxygen. Plants use carbon dioxide to fuel their growth, and humans and animals breathe in the oxygen, consume plant matter, and exhale carbon dioxide. Carbon dioxide only directly becomes a problem to human if atmospheric concentrations continue to grow to toxic levels (Ndoke, 2006).

2.3.1 Characteristics of Carbon Dioxide (CO_2)

Carbon dioxide is one of the major exhaust vehicles emissions from combustion of petrol which contain a mixture of paraffin and aromatic hydrocarbon. Petrol then combusted with controlled amounts of air producing completes combustion product of carbon dioxide and water (H_2O) (Baldauf et al., 2004; Elsom & Longhurst, 2004). Eq. 1 demonstrates the combustion of hydrocarbon into carbon dioxide and water.

$$\text{Hydrocarbons in gasoline} + O_2 \longrightarrow CO_2 + H_2O + \text{Heat} \qquad \text{(Eq.1)}$$

2.3.2 Effects of Carbon Dioxide (CO_2)

Inhaling carbon dioxide may cause rapid breathing, rapid beating of the heart, headache, sweating, shortness of breath, dizziness, mental depression, visual disturbance, shaking, unconsciousness, and death. (Centers of Disease Control and Prevention, 2012). At high concentration, carbon dioxide may irritate the eyes, nose and throat and may affect vision by inducing proptosis, mydriasis, yellowed vision and transient blindness (Grant, 1986). Exposure to high concentration of carbon dioxide also may induce cardiopulmonary effect of human body (Halpern et al., 2004).

Carbon dioxide always related with worldwide pollution problems; greenhouse (Nilrit et al., 2013). Greenhouse happen when carbon dioxide in air is transparent to the sunlight and after a long time it produced a heat-balancing infrared rays emitted by earth and results in warms the earth (Kakouei et al., 2012). As this energy is retained, the earth temperature will gradually increase time by time and results in greenhouse effect.

2.4 NITROGEN OXIDE (NO_x)

The main source of nitrogen oxide is the combustion of fossils fuel, (Elsom & Longhurst, 2004; Salahi & Geranfar, 2004) diesel and gasoline powered vehicular engines and coal and oil-fired power plant also part of nitrogen oxide main sources (Ebtakar, 2006). The high temperatures and pressures in engines create a favourable condition for the formation of nitrogen oxide (Ehsani et al., 2010). There are seven types of oxide of nitrogen which is N_2O, NO, NO_2, NO_3, N_2O_3, N_2O_4 and N_2O_5 (Elsom & Longhurst, 2004; Salahi & Geranfar, 2004; Rao & Rao, 1989). The most commonly found nitrogen oxides are nitric oxide and nitrogen dioxide and these two gases are classified as pollutants (Ehsani et al., 2010; Bhatia, 2007; Rao & Rao, 1989).

2.4.1 Nitric Oxide (NO)

Nitric oxide had been recognized as a molecule relevant to air pollution (Antosova, 2012). Molecular oxygen is required for the production of nitric oxide, a pro-inflammatory mediator that is associated with osteoarthritis and rheumatoid arthritis (Fermor et al, 2007). Although nitric oxide is known to have anti-microbial, anti-inflammatory and anti-oxidant properties, various lines of evidence support the contribution of nitric oxide to lung injury in several disease models (Vliet et al., 2000).

2.4.1.1 Characteristics of Nitric Oxide (NO)

Nitric oxide is the most commonly found in nitrogen oxide as compared to nitrogen dioxide and once released into the atmosphere, nitric oxide reacts with the oxygen and oxidised to nitrogen dioxide in a polluted atmosphere through photochemical secondary reactions (Ehsani et al., 2010; Bhatia, 2007; Pundir, 2007). Nitric oxide also a colourless, odourless gas produced largely by fuel combustion (Bhatia, 2007).

2.4.1.2 Effects of Nitric Oxide (NO)

The decomposition of nitric oxide from nitrogen dioxide by radiation of sun's ultraviolet can produce highly reactive oxygen atoms that attack the membrane of living cells (Ehsani et al., 2010). With the concentration of about 25.0 ppm, nitric oxide that produce nitric acid vapours can give unhealthy impact to plant that caused brown margins and brownish-black spots on leaves (Rao & Rao, 1989).

2.4.2 Nitrogen Dioxide (NO_2)

Nitrogen dioxide is the main traffic-related urban air pollutant associated with health effects (Dedele et al., 2011). The exhaust gases of SI engines, the production of nitrogen dioxide is less than 60.0 to 70.0 ppm compared to several hundred thousand to thousands of ppm of nitric acid. In diesel engines nitrogen dioxide can constitute 10% to 30% of the total emissions of nitrogen oxides as a proved that nitrogen dioxide concentrations in diesel engine are higher than for SI engine (Pundir, 2007).

2.4.2.1 Characteristics of Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a reddish brown gas, has an irritating odour and low solubility and can be detected at concentrations of about 0.12 ppm (Bhatia, 2007; Pundir, 2007). Nitrogen dioxide is far more harmful with regard to toxicity than nitrogen oxide and it is a good predictor for traffic exposure (Laurinaviciene, 2010; Gilbert et al., 2003; Soltic & Weilenman, 2003).

2.4.2.2 Effects of Nitrogen Dioxide (NO_2)

Nitrogen dioxide has higher oxidative capabilities as it can penetrate to lung periphery also absorbed into the mucosa of the respiratory track that caused difficulties in breathing and then lead to asthma (Linaker et al., 2000; Romieu, 1999). Nitrogen dioxide may increase bronchoconstriction in asthmatics at concentration as low as 0.1 ppm (Roger et al., 1990). Nitrogen dioxide is a component of silo gas thought to cause the sometimes fatal "silo filler's disease" (Douglas et al., 1989). Allergic response on the bronchial epithelium happen when human inhales nitrogen dioxide and may predispose the respiratory tract to viral infection (Pathmanathan et al., 2003, Frampton et al., 2002). Exposing to nitrogen dioxide will reduce bronchociliar activity of human body (Helleday et al., 1995).

Nitrogen dioxide has an ability to be converted to nitrates in the atmosphere to be part of the acidic deposition or acid rain and acidic reaction produce from reaction of nitrogen dioxide also can cause corrosion to metal, damage on fibre, plastic and fabrics (Bhatia, 2007). The phenomenon of acid rain happens when nitrogen dioxide react with atmospheric water to form nitric acid (HNO_3) (Ehsani et al., 2010).

Nitrogen dioxide is a strong oxidant and in the present of ultraviolet radiations, it leads to formation of ozone via nitrogen dioxide photolysis (Pundir, 2007) as shown in Eq. 2 and Eq. 3.

$$NO_2 + hv \rightarrow NO + O \qquad \text{(Eq. 2)}$$

$$O + O_2 + M \rightarrow O_3 + M \qquad \text{(Eq. 3)}$$

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The monitoring inside an enclosed KLCC car park area was chosen. This study was based on the one monitoring location which is in Level P2 as shown in Figure 3.1. This study will monitor the carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide concentration by using Combustion Gas Analyzer and Toxic Gas Text Meter from 0800 to 1700 for 8 days from 1st of November 2013 to 5th of November 2013 and 15th of November 2013 to 17th of November 2013. This time period was chosen due to the activity of KLCC employees and visitor. Most of the employees of KLCC start their work at 0800 and ended around 1700. All the data recorded by interval 30 seconds for 8 hours. Data then presented in Chapter 5 in the form of graph by taking the average of 30 minutes from 0800 to 1700.

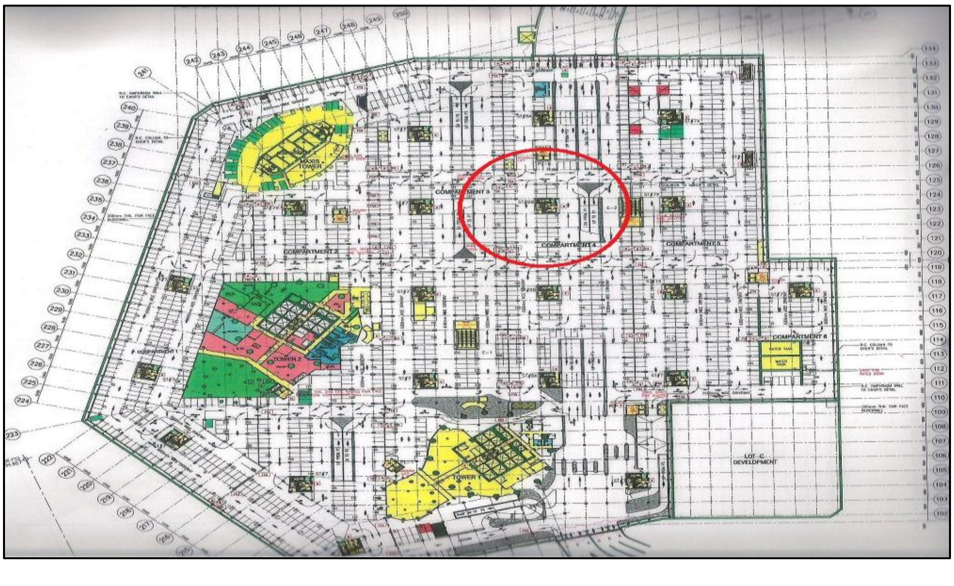

Figure 3.1: Red color indicates the location of sampling

All the data collected will be analyse by using time series analysis. Time series analysis is a collection of observations of well-defined data items obtained through repeated measurements over time. The main aim of time-series analysis is to describe movement history of a particular variable in time. Time-series analysis of air pollution environmental levels involves the identification of long-term variation in the mean (trend) and of cyclical or periodic components. Time-series analysis is a useful tool for better understanding of cause and effect relationships in environmental pollution. For this research, all the sample will be analyse by using 30 minutes average concentration for 8 hours of pollutants that present in an enclosed KLCC car parks area. Measurements to determine employees' exposure are best taken at 8 hours exposure evaluation as suggested by Occupational Safety and Health Administration.

3.2 KEY MILESTONE

The approach of this project is based on examination and understanding of the scope of work and the timing for the completion of the project. In accordance with the milestones provided in the guideline for final year project, key milestone for Final Year Project I (FYP I) and Final Year Project II (FYP II) have been summarized Table 3.1 and Table 3.2 respectively.

Table 3.1: Key Milestone for FYP I

Key Milestone	Proposed Week
Submission of Extended Proposal Defence	Week 6
Proposal Defence	Week 9
Submission of Interim Draft Report	Week 13
Submission of Interim Report	Week 14

Table 3.2: Key Milestone for FYP II

Key Milestone	Proposed Week
Submission of Progress Report	Week 8
Pre-EDX	Week 11
Submission of Draft Report	Week 12
Submission of Dissertation (soft bound)	Week 13
Submission of Technical Paper	Week 13
Oral Presentation	Week 14
Submission of Project Dissertation (hard bound)	Week 15

3.2.1 GANTT CHART FOR FYP I

Table 3.3: Gantt Chart for FYP I

NO	DETAIL / WEEK	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Title	■	■													
2	Preliminary Research Work and Literature Review		■	■	■	■										
3	Submission of Extended Proposal Defence						•									
4	Preparation for Oral Proposal Defence							■								
5	Oral Proposal Defence Presentation									■						
6	Detailed Literature Review									■	■	■	■	■		
7	Preparation of Interim Report			■	■	■	■	■		■	■	■	■	■		
8	Submission of Interim Draft Report														•	
9	Submission of Interim Final Report															•

Legend

■ Project Activities

• Key Milestone

3.2.1 GANTT CHART FOR FYP II

Table 3.4: Gantt Chart for FYP II

NO	DETAIL / WEEK	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■									
2	Submission of Progress Report									•							
3	Project Work Continues									■	■	■	■	■			
4	Pre-SEDEX																
5	Submission of Draft Report												•				
6	Submission of Dissertation (Soft Bound)													•			
7	Submission of Technical Paper														•		
8	Oral Presentation															•	
9	Submission of Dissertation (Hard Bound)																•

Legend

■ Project Activities

• Key Milestone

3.3 OVERVIEW OF COMBUSTION GAS ANALYZER

Combustion Gas Analyzer is a product released by KIMO Instrument. It is a portable instruments designed for measuring combustion gases, combustion gas temperatures and draft pressure. From the measures data, Combustion Gas Analyzer recorded variety of combustion parameters including carbon monoxide and carbon dioxide as discussed in Chapter 4. Figure 3.2 illustrates key components of the Combustion Gas Analyzer.

Figure 3.2: Combustion Gas Analyzer

3.4 OVERVIEW OF TOXIC GAS TEST METER

Toxic Gas Test Meter is a product released by GrayWolf Sensing Solution. It is available for measuring nitric oxide and nitrogen dioxide. Toxic Gas Test Meter efficiently log the data and enable enhanced documentation for the survey by recording the concentration of nitric oxide and nitrogen dioxide by using mobile computing. Figure 3.3 illustrates key components of the Toxic Gas Test Meter.

Figure 3.3: Toxic Gas Test Meter

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

Analysis on the concentration of air pollutants for carbon monoxide, carbon dioxide, nitric oxide, and nitrogen dioxide were done for 8 days from 1st of November 2013 to 5th of November 2013 and 15th of November 2013 to 17th of November 2013. The sampling was eight hours per day starting from 0800 to 1700. The location of sampling was at Level P2, as can be seen in Figure 3.1 which is in the middle of two main entrance and near to the management office where the employees and visitors enter this car parks and separates to another four level; P1, P2, P3 and P4. Figure 4.1 shows the entrance to enter other level of car parks.

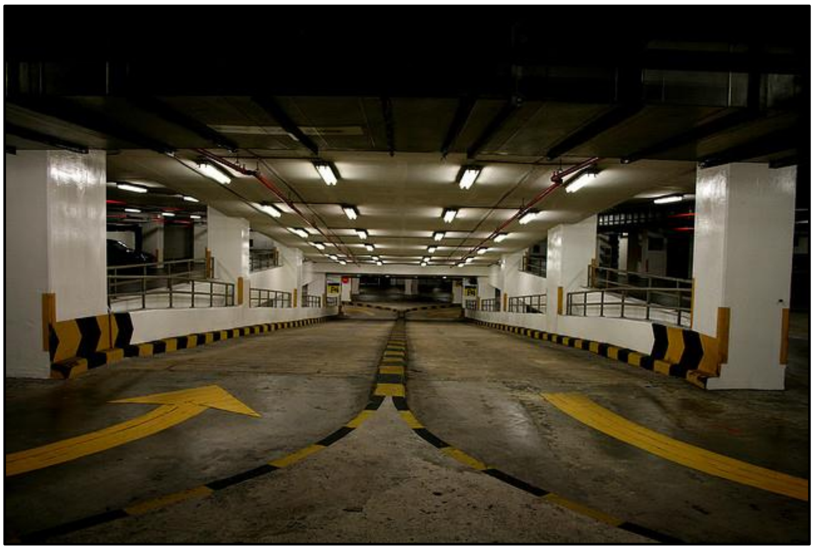

Figure 4.1: Ramp to enter another level of car parks

The interval taken to record each concentration of air pollutants was 30 seconds. Total data collected for one day was 960 data. The data then presented in graph by taking the average of data for every 30 minutes. Only six selected days will be discussed and divided into three parts; two during weekdays, two during weekends and two during public holidays. The rest of the sampling days which is in Figure A-1 and Figure A-2 will be presented in Appendix. The result was expected to be variety in term of the level of concentration for each air pollutants every day.

4.2 CONCENTRATION OF AIR POLLUTANTS ON WEEKDAYS

Figure 4.2 illustrates the concentration of air pollutant on Monday, 4th of November 2013 during working day. The concentration of carbon dioxide at 0800 was 692.0 ppm and 6.0 ppm for carbon monoxide. At 1000, the concentration of carbon dioxide was 610.5 ppm and decreased to 572.9 ppm at 1030. The concentration of carbon dioxide started to increase from 1030 to 1400 with higher concentration of 1000.4 ppm. From 1430 to 1700, concentration of carbon dioxide started to decrease from 936.5 ppm to 809.8 ppm.

The concentration of carbon monoxide at 0800 started with lower concentration which is 6.0 ppm and increased to 10.2 ppm at 0900. At 1000, the concentration of carbon monoxide started to decrease to 5.7 ppm and 5.3 ppm at 1030. From 1100 to 1400, concentration of carbon monoxide increased from 7.6 ppm until it reached the highest concentration on that day with 15.8 ppm. The concentration of carbon monoxide then decreased to 15.1 ppm at 1430 and 11.3 ppm at 1700.

Figure 4.2 also demonstrates that the concentration of nitric oxide at 0800 to 1130 was 0.0 ppm. At 1200, the concentration of nitric oxide started to appear with 0.1 ppm and increase to 0.2 ppm at 1230 until 1300. The concentration of nitric oxide kept increasing at 1400 with 0.3 ppm and 0.5 ppm at 1530. At 1600, the concentration of nitric oxide decreased to 0.3 ppm until 1700.

For the concentration of nitrogen dioxide at 0800 was zero ppm and increased to 0.4 ppm at 0830. At 0900, the concentration of nitrogen dioxide was 0.5 ppm and decreased to 0.1 ppm at 0930. The concentration of nitrogen dioxide then reduced to zero ppm at 1000 for one and half hours. At 1200, the concentration of nitrogen dioxide was 0.1 ppm until 1500. However, the concentration of nitrogen dioxide reduced again to 0.0 ppm at 1530 to 1700.

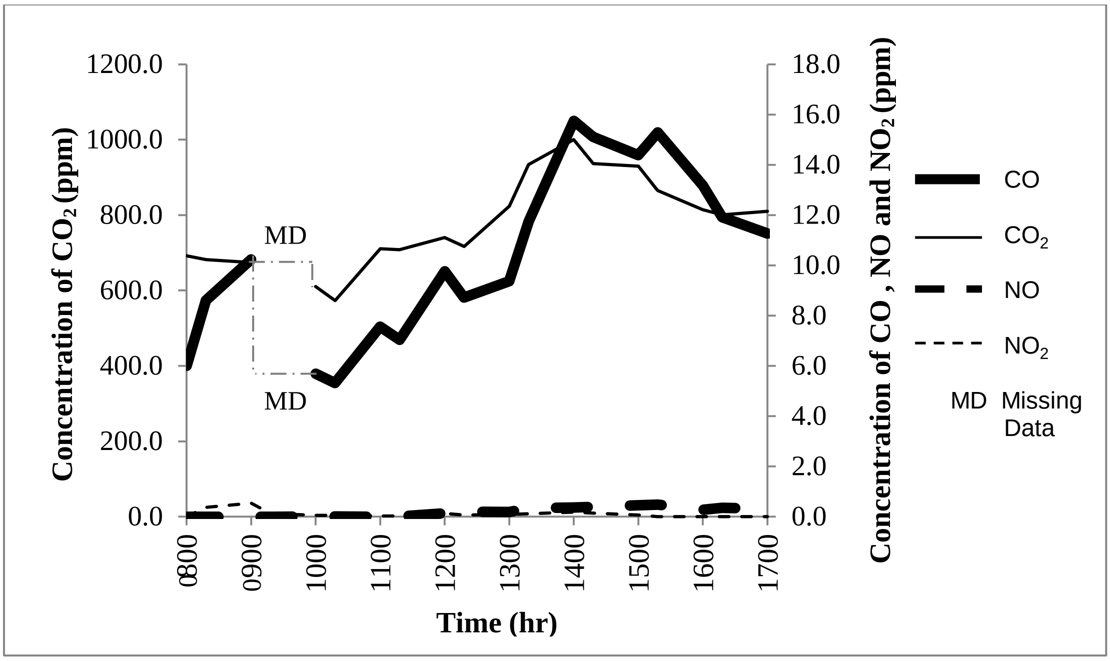

Figure 4.2: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 4th of November 2013

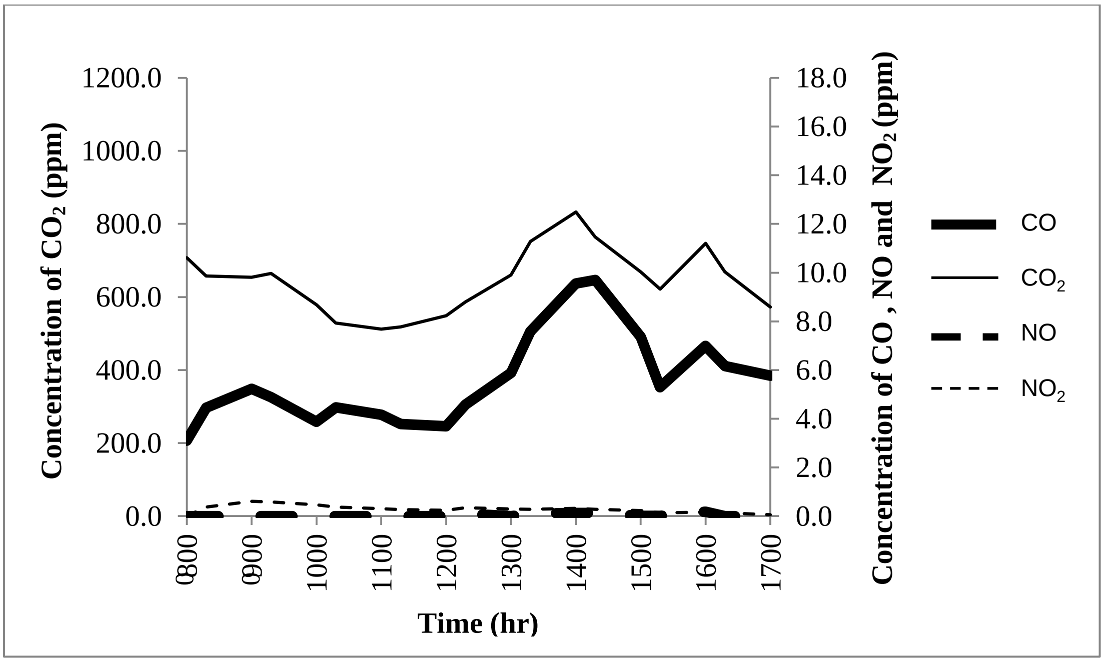

Figure 4.3: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 15th of November 2013

As shown above in Figure 4.3, the concentration of pollutants was taken on Friday, 15th of November 2013. The concentration of carbon dioxide was 707.0 ppm at 0800 and kept decreasing to 512.4 ppm at 1100. The concentration of carbon dioxide started to increase at 1130 which was 518.4 ppm until it reached the concentration of 832.3 ppm at 1400. After that, the concentration of carbon dioxide decreased to 764.6 ppm at 1430 until 572.9 ppm at 1700.

Concentration of carbon monoxide in Figure 4.3 demonstrates that the concentration of carbon monoxide was 3.1 ppm at 0800 then increased to 5.2 ppm at 0900. The concentration of carbon monoxide was between the range of 3.9 ppm and 5.9 ppm from 1000 to 1300. Then, it started to increase to 7.6 ppm at 1330 and continuously increased to 9.6 ppm and 9.7 ppm at 1400 and 1430. The concentration of carbon monoxide then decreased to 7.4 ppm at 1500 until 5.8 ppm at 1700.

Figure 4.3 also illustrates that the concentration of nitric oxide was 0.0 ppm from 0800 to 1229, 1500 to 1559, and 1630 to 1700. The concentration of nitric oxide with 0.1 ppm only can be seen at 1230 and 1330 to 1459. The higher concentration of nitric oxide on that day was 0.2 ppm and it occurred at 1600.

The concentration of nitrogen dioxide started with 0.0 ppm at 0800 then increased to 0.4 ppm at 0830. It continuously increased with 0.6 ppm from 0900 to 0959. At 1000 to 1459, the concentration of nitrogen dioxide was within the range of 0.3 ppm to 0.5 ppm. From 1530 to the end of the sampling day, the range only between 0.1 ppm and 0.2 ppm.

4.3 CONCENTRATION OF AIR POLLUTANTS ON WEEKENDS

Figure 4.4 indicate the concentration of pollutants recorded on Sunday, 3th of November 2013. The concentration of carbon dioxide in the morning from 0800 to 1059 was in between 584.2 ppm and 455.0 ppm. The highest concentration of carbon dioxide on this day was at 1430 with 951.3 ppm followed by 905.5 ppm at 1530. After that, the concentration of carbon dioxide started to decrease to 820.8 ppm at 1600 continuously until 664.0 ppm at 1700.

At 0800, the concentration of carbon monoxide is 0.0 ppm, where the KIMO AM1300 need to be stabilize before reading the concentration of carbon monoxide and it resulted to record the concentration of carbon monoxide with 0.0 ppm. After stabilized, the concentration of carbon monoxide recorded at 0830 was 5.3 ppm and decreased to 3.8 ppm at 0900. From 0930 to 1229, the concentration of carbon monoxide was within the range of 5.5 ppm tp 4.8 ppm. At 1200, the concentration of carbon monoxide increased to 8.6 ppm and continued to increase until 12.0 ppm at 1430. There are sudden drop for the concentration level at 1500 with 8.4 ppm and started to increase back to 12.5 ppm at 1530. The concentration of carbon monoxide reached it higher level on that day with concentration of 13.6 ppm at 1600 then at 1700, it reduced to 8.4 ppm.

The concentration of nitric oxide started with zero ppm at 0800 until 1200. At 1230, the concentration of nitric oxide was 0.1 ppm until 1359. The range of 0.2 ppm to 0.3 ppm can be seen for the concentration of nitric oxide starting from 1400 to 1700.

Apart from that, as can be seen in Figure 4.4, the concentration of nitrogen dioxide was recorded at 0830 with 0.1 ppm and increased to 0.4 ppm at 0900. Then, it reduced to 0.3 ppm at 0930 and continuously decreased to 0.1 ppm until 1430. After that, the concentration of nitrogen dioxide recorded was zero ppm until 1700.

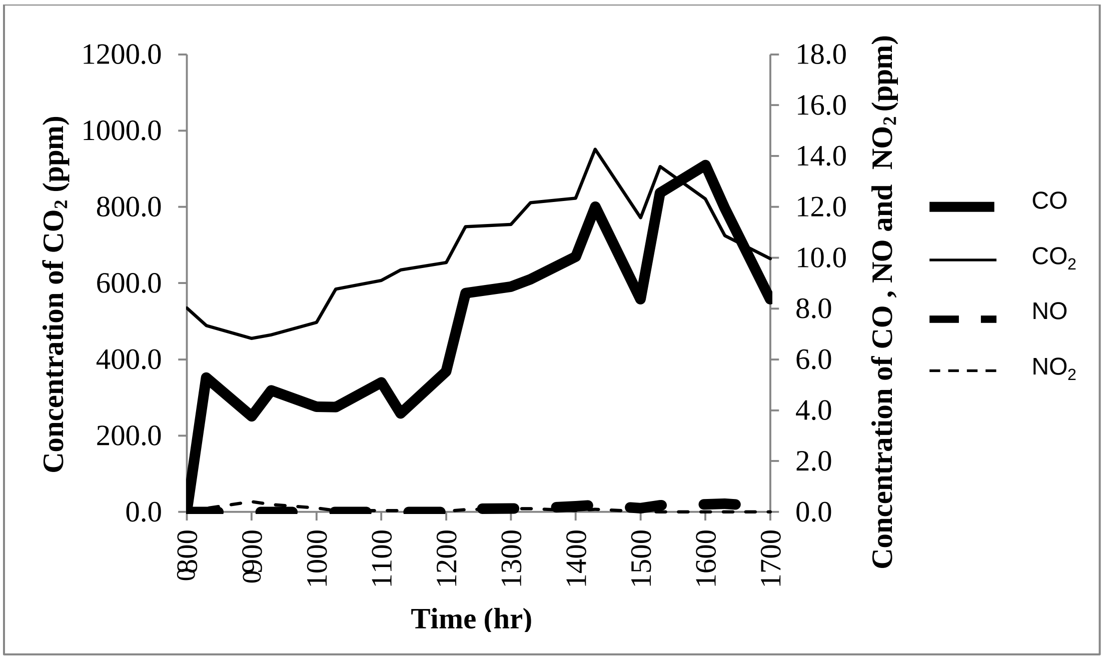

Figure 4.4: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 3rd of November 2013

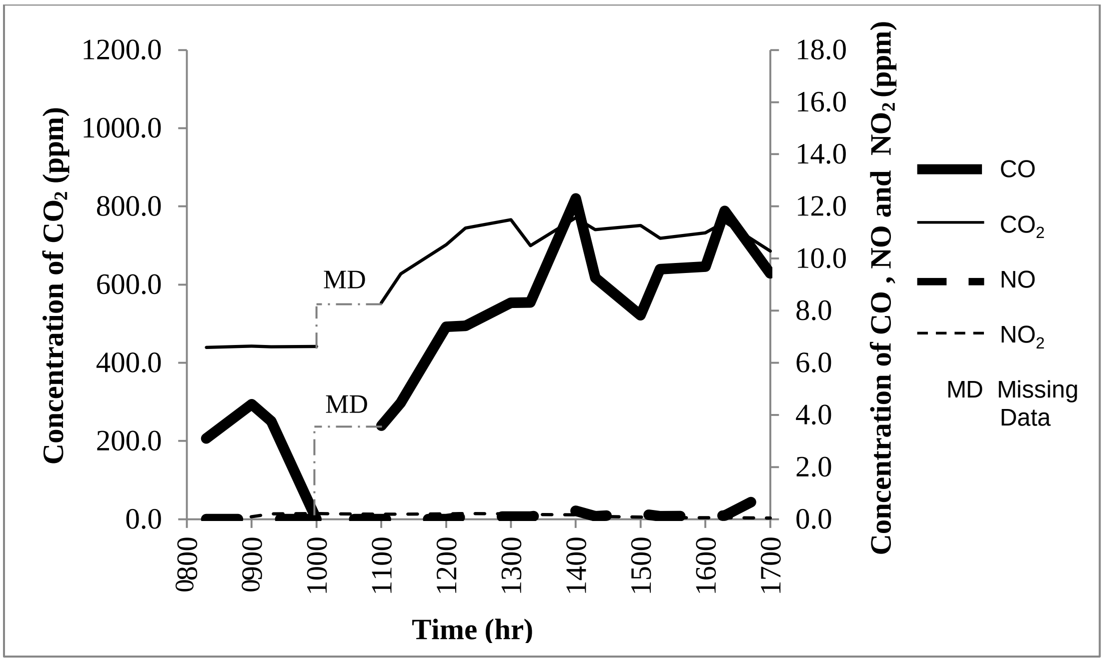

Figure 4.5: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 17th of November 2013

Similarly for Figure 4.5, the concentration of air pollutants also recorded on Sunday, 17th of November 2013. The data started to be collected at 0830 for all air pollutants. The concentration of carbon dioxide was between the range of 440.0 ppm from 0830 to 10.00. At 1100, it started to increase to 553.3 ppm and reached it higher concentration at 1400 with 770.9 ppm. The concentration of carbon dioxide then decreased to 740.2 at 1430 and increased back at 1630 with 760.2 ppm. At 1700, the concentration of carbon dioxide was 685.7 ppm.

The concentration of carbon monoxide at 0830 was 3.1 ppm. At 0900, the concentration of carbon monoxide was 4.4 ppm and reduced to 3.8 ppm at 0930. The data at 1000 was not valid since there was a sudden stabilization for the instrument that resulted to the concentration of zero ppm. At 1100, the concentration recorded was 3.6 ppm and it kept increasing until 12.3 pm at 1400. The concentration of carbon monoxide was between the range of 7.8 ppm and 9.7 ppm from 1430 to 1600. After that, it increased to 11.8 ppm at 1630 and dropped back to 9.4 ppm at 1700.

According to Figure 4.5, the concentration of nitric oxide was zero ppm from 0800 to 1229. From 1230 to 1630, the concentration of nitric oxide was 0.1 ppm. There was a sudden increased of the concentration of nitric oxide to 1.0 ppm.

At 0830, the concentration of nitrogen dioxide was 0.0 ppm. The concentration of nitrogen dioxide was 0.2 ppm from 0930 to 1400. Then, it reduced to 0.1 ppm from 1430 to 1700.

4.4 CONCENTRATION OF POLLUTANT ON PUBLIC HOLIDAYS

Figure 4.6 shows that the concentration of air pollutants on Saturday, 2nd of November 2013. In the morning, the concentration of carbon dioxide was high, which was 626.0 ppm then reduced to 495.0 ppm at 0830. The concentration of carbon dioxide then increased to 508.7 ppm at 0930 and continuously increased until it reached 1006.6 ppm at 1500. After that it started to decline to 972.8 ppm at 1530 and at the end of the day and became 892.4 ppm.

At the beginning of the day, the KIMO AM1300 need to be stabilized before recording the concentration thus resulted to 0.0 ppm for the concentration of carbon monoxide. After stabilized, the concentration of carbon monoxide recorded as 3.8 ppm at 0830. At 0930, the concentration of carbon monoxide started to increase to 4.9 ppm until in the afternoon 1330, the concentration recorded was 14.8 ppm. The higher concentration recorded on that day was 16.1 ppm at 1500. Starting from 1600, the concentration of carbon monoxide started to reduce from 14.8 ppm to 12.7 ppm at the end of the day.

In the morning, there is no concentration of nitric oxide being recorded until 1130 which 0.1 ppm was detected for about two hours. Then, it increased to 0.2 ppm at 1330 to 1500. The concentration of nitric oxide at 1530 till 1700 was 0.3 ppm.

Different with nitrogen dioxide, in the morning the concentration of nitrogen dioxide was high with the range of 0.5 ppm and 0.7 ppm from 0830 to 0929. After that it started to reduce to 0.4 ppm at 0930 and continuously decreasing to the range of 0.1 ppm to 0.2 ppm starting from 1000 to 1430. In the evening, the concentration of nitrogen dioxide recorded was zero ppm.

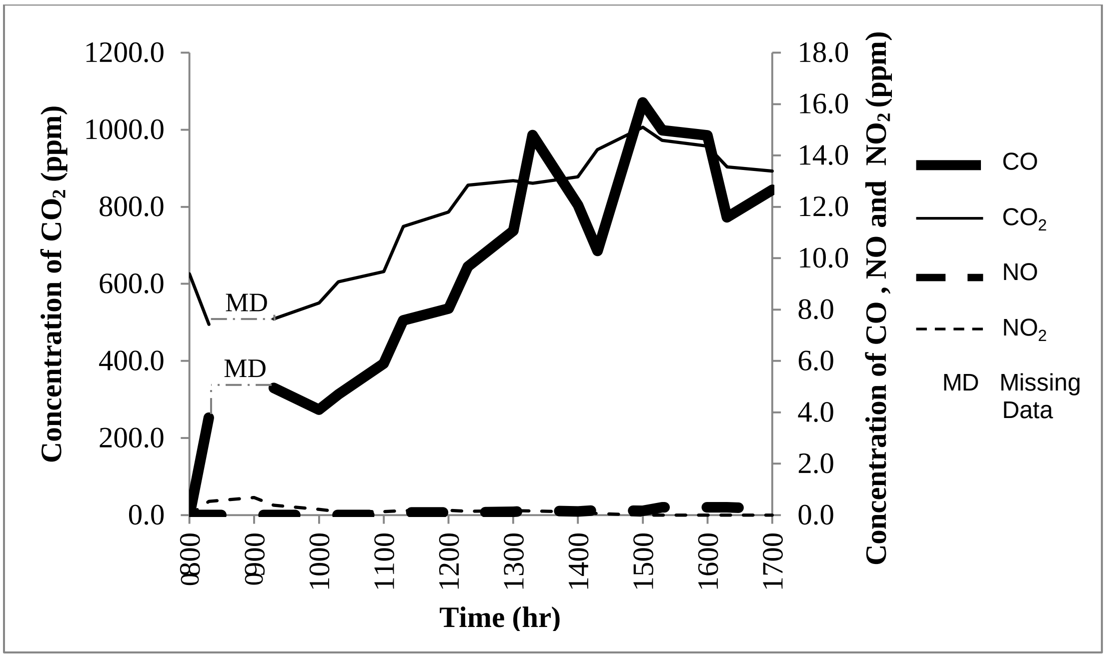

Figure 4.6: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 2nd of November 2013

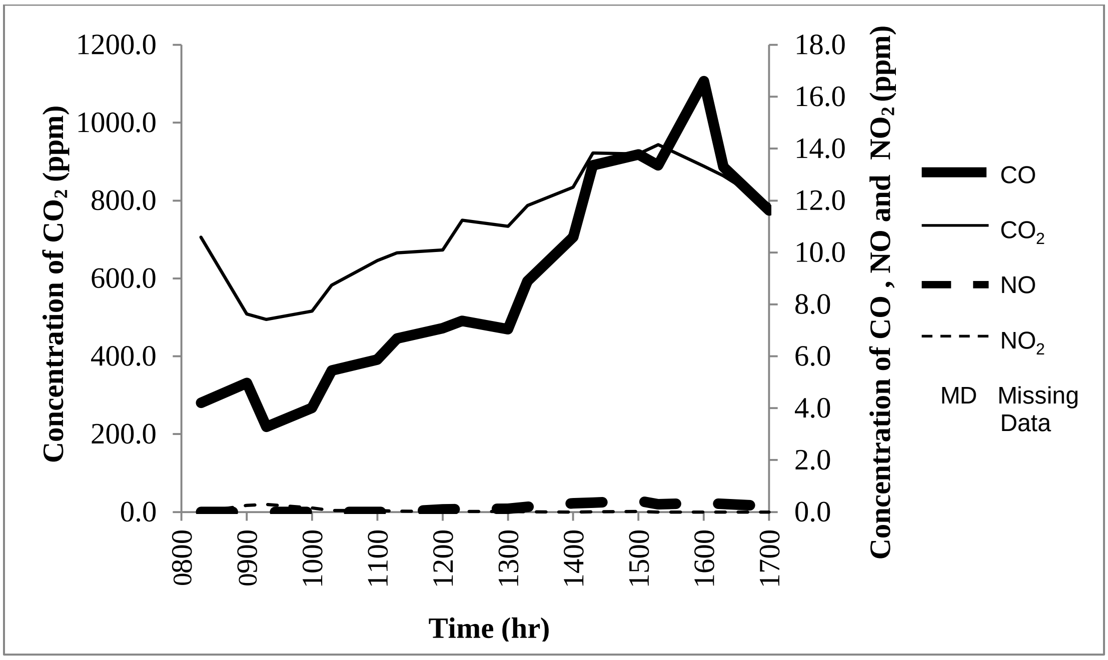

Figure 4.7: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 5th of November 2013

As illustrated in Figure 4.7, the concentration of air pollutants on that day was recorded on Tuesday, 5th of November 2013. On this day, the sampling of the air pollutants started at 0830. 706.0 ppm was recorded at the beginning of the day for the concentration of carbon dioxide. After that, at 0900 to 1030 the concentration of carbon dioxide at the range 494.7 ppm to 582.3 ppm. Then it started to increase to 645.7 ppm at 1100 and continue to increase until at 1530, the highest the concentration of carbon dioxide for today was recorded with 943.7 ppm. Next, it started to reduce till the end of sampling day, it decreased to 789.4 ppm.

Figure 4.7 shows that the concentration of carbon monoxide was 4.2 ppm at 0830 and increased to 5.0 ppm at 0900. Then it reduced to 3.3 ppm at 0930. After 1000, the concentration of carbon monoxide continuously increased from 4.0 ppm at 1000 to 16.6 ppm at 1600. At 1630, the concentration of carbon monoxide reduced to 13.3 ppm and 11.6 ppm at the end of sampling hours.

As shown in the Figure 4.7, there is zero ppm of nitric oxide can be found until 1159. At 1200, the concentration of nitric oxide was 0.1 ppm for two hours and increased to 0.2 ppm, 0.3 ppm and 0.4 ppm from 1330 to 1500. The concentration on nitric oxide then reduced to 0.2 ppm at 1700.

The concentration of nitrogen dioxide on this day only can be found from 0900 to 1100 with 0.3 ppm at 0900 to 0959 and 0.1 ppm at 1000 to 1100. The rest of the day, the concentration of nitrogen dioxide recorded was zero ppm.

4.5 OVERALL DISCUSSION

As can be seen in Figure 4.2, Figure 4.5 and Figure 4.6 there was a missing data for the concentration of carbon dioxide and carbon monoxide. This occurred when there was a sudden loss of battery energy for Combustion Gas Analyzer and the data could not be saves during that time of sudden switch off.

As illustrated in graphs, the concentration of carbon monoxide and carbon dioxide was lower in the morning and higher in the afternoon. This is because visitors choose to visit KLCC in the afternoon and also the employees started to leave KLCC car parks for their lunch hour break. For the concentration of nitric oxide and nitrogen dioxide as can be seen in the graphs, if nitric oxide was higher nitrogen dioxide is going to be vice versa.

The concentration of air pollutants for both Figure 4.2 and Figure 4.3 was recorded during working days. However, the concentrations of all pollutants in Figure 4.2 were higher compared to Figure 4.3. On 5th of November 2013 it was a public holiday. So, visitors who are also an employee at other company usually take this opportunity to use their annual leaves to combine it with public holiday. Thus, they can bring their family for a vacation. In this case, visitors brought their family to KLCC. This explained the reason that caused the concentration of air pollutants on Figure 4.2 was higher than in Figure 4.3.

Data presented in Figure 4.4 for the concentration of carbon monoxide was higher as compare to Figure 4.5. On Friday, 3rd of November 2013, visitors take a chance to use their annual leaves since the day before that was a public holidays and the day after that was a weekend. For Sunday on 17th of November 2013, since it was Sunday most of visitors prefer to stay at home to have a rest compare to go to anywhere since tomorrow is a working day.

Figure 4.6 and Figure 4.7 both shows the concentration of air pollutants during public holiday. On 2nd of November 2013, it was a Deepavali celebration for Hindu believers and on 5th of November 2013; it was an Awal Muharram for Islamic religious. In the afternoon of public holidays started from 1330, the concentration of carbon dioxide was higher compare to the morning proved that visitors taking this chance on public holidays to bring their family visit KLCC for their own purpose. As can be seen on Figure 4.6, there a sudden increased in the concentration of carbon dioxide and carbon monoxide. This is because near to the location of sampling, there are one car that left idle for ten minutes thus it released higher concentration of carbon dioxide and carbon monoxide.

Figure 4.8 illustrates that the standard limit for carbon monoxide proposed by World Health Organization (WHO) was 9.0 ppm for 8 hours exposure (Chaloulakou et al., 2002). Based on the graph, it shows that the concentration of carbon dioxide inside the car parks exceed the standard limit in the evening and below the standard limit in the morning. In conclusion, the concentration of carbon dioxide higher than 9.0 ppm was not exposed to employee for continuous 8 hours duration.

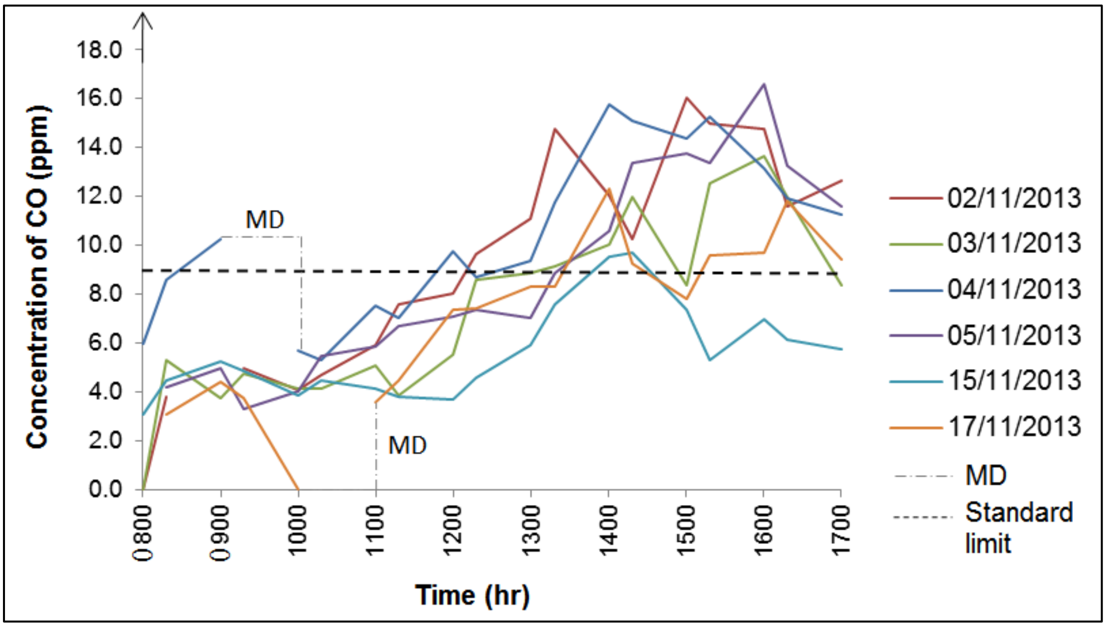

Figure 4.8: Concentration of carbon monoxide with the standard limit by WHO

In researched paper done by Chaloulakou et al. (2012), it stated that there is a lot of air quality guideline for enclosed parking released by many country and environment agency. Most of it focused on carbon monoxide because it is generally considered to have a severe impact to human's health. Table 4.1 shows the air quality criteria proposed by Greece, British Building Regulation, Federal Republic of Germany, ACGIH TLV, NIOSH REL, OSHA PEL and WHO by average periods 5 minutes, 15 minutes, 30 minutes, 1 hour and and 8 hours.

Table 4.1: Air quality criteria for carbon monoxide (Chaloulakou, 2002)

Air quality criteria for carbon monoxide	**Average Periods (ppm)**				
	5 min	**15 min**	**30 min**	**1 h**	**8 h**
Greece (Occupational)	-	300	-	-	50
Bristish Building Regulation	-	100	-	-	50
Fed. Republic of Germany (Occupational)	-	-	60	-	30
ACGIH TLV	-	-	-	-	25
NIOSH REL	200	-	-	-	35
OSHA PEL	200	-	-	-	50
WHO	-	87	52	26	9
New Zealand	-	90	-	-	10

The current OSHA standard for carbon dioxide is 5,000.0 ppm for 8 hours work shift and NIOSH has recommended that the permissible exposure limit be changed to 10,000.0 ppm for 10 hours per day (United States Department of Labor, 2013). The concentration of carbon dioxide recorded inside KLCC enclosed car parks area was below this both standard limit which the highest concentration recorded was 1000.6 ppm. Figure 4.9 shows the concentration of carbon dioxide for each day. Overall concentration of carbon dioxide was below the standard limit which is 5,000.0 ppm.

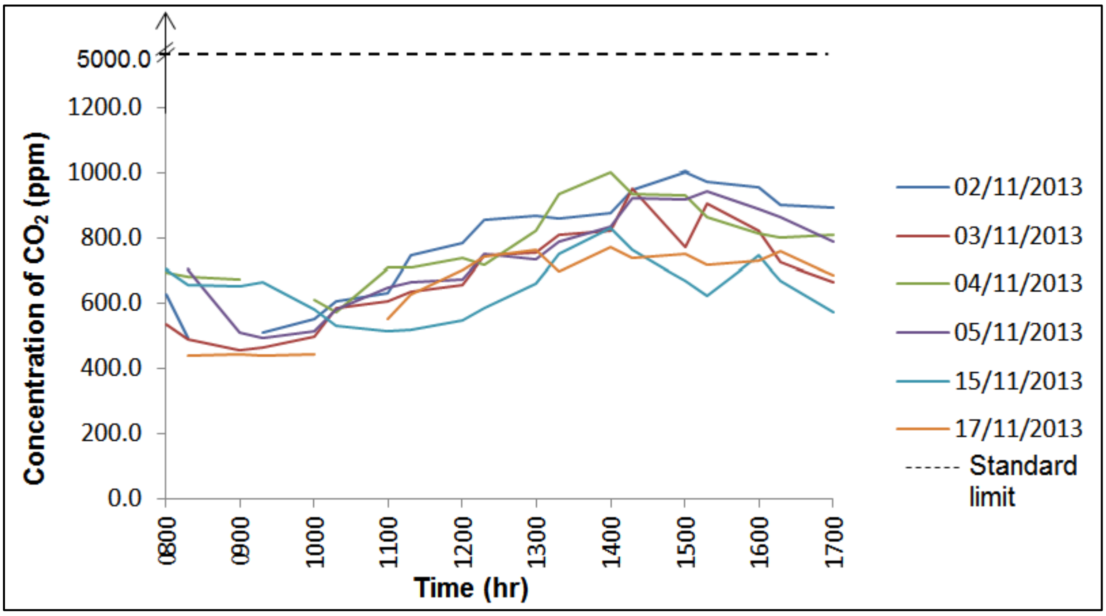

Figure 4.9: Concentration of carbon dioxide with the PEL by OSHA

The permissible exposure limit for nitric oxide proposed by OSHA is 25.0 ppm of air averaged over an 8 hours work shifts and 25.0 ppm for NIOSH standard for 10 hours per day (Centers for Disease Control and Prevention, 2012). The concentration of nitric oxide recorded on KLCC car parks area was in between range 0.1 ppm and 0.4 ppm. These concentrations were below the standard limit provided by OSHA and NIOSH. Figure 4.10 shows the concentration of nitric oxide for each day. Overall concentration of nitric oxide was below the standard limit which is 25.0 ppm.

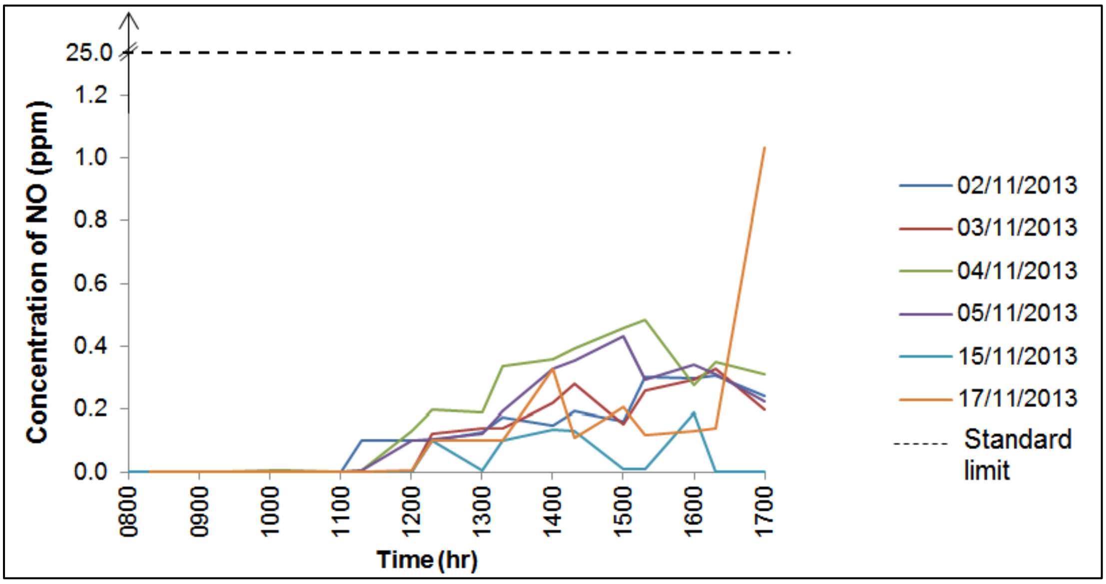

Figure 4.10: Concentration of nitric oxide with the PEL by OSHA

The maximum concentration for nitrogen dioxide is 1.0 ppm for 5 minutes (Environmental Protection Department, 2005). NIOSH also stated that the recommended exposure limit (REL) is 1.0 ppm. Based on the concentration recorded for nitrogen dioxide, all the concentration was below 1.0 ppm. The highest concentration recorded was 0.6 ppm. Figure 4.11 shows the concentration of nitrogen dioxide for each day. Overall concentration of nitrogen dioxide was below the standard limit which is 1.0 ppm.

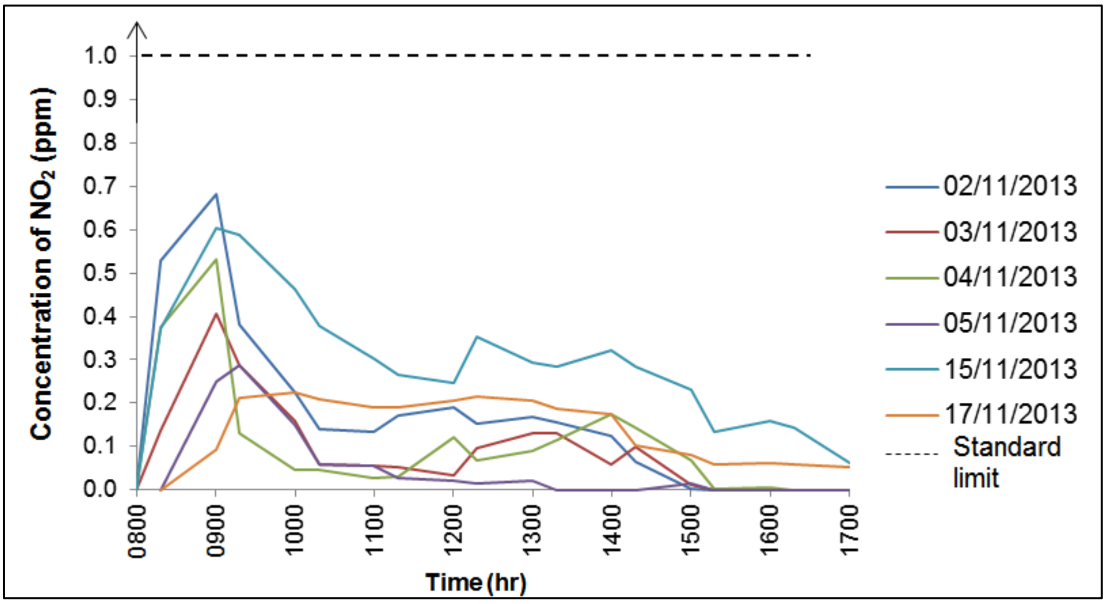

Figure 4.11: Concentration of nitrogen dioxide with the PEL by OSHA

CHAPTER 5

CONCLUSION

Results of an indoor pollution for an enclosed KLCC car parks area are presented in this study by using time series model. Exposure estimates for 8 hours duration are monitored, recorded and then compared with occupational limit value and recommended public health criteria. Overall of this study found that the concentrations of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide are all below the standard limit. Thus, these pollutants are acceptable for employees' health who works at the enclosed car parks area. For concentration of carbon monoxide and carbon dioxide, even though it is higher than the standard limit at the afternoon, still the concentration of carbon monoxide and carbon dioxide was not continuously above the standard limit for 8 hours duration. However, higher concentration of carbon monoxide and carbon dioxide in the afternoon could have an adverse effect on employees' health since they stay in a longer- term in these locations. KLCC Management should ensure that their ventilation working all the times so that the accumulated pollutants inside these car parks can be reduced, thus protect the health of their employees. In conclusion, all the objectives of this study are achieved.

Further research is needed to determine the maximum acceptable pollutants levels within an enclosed car parks area since there is no indoor air quality guideline proposed by Department of Environment Malaysia. In addition, more testing area is required since this study is only focusing in Level P2. Thus, the study can compare the concentration of air pollutants at Level P1, P3 and P4.

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APPENDIX

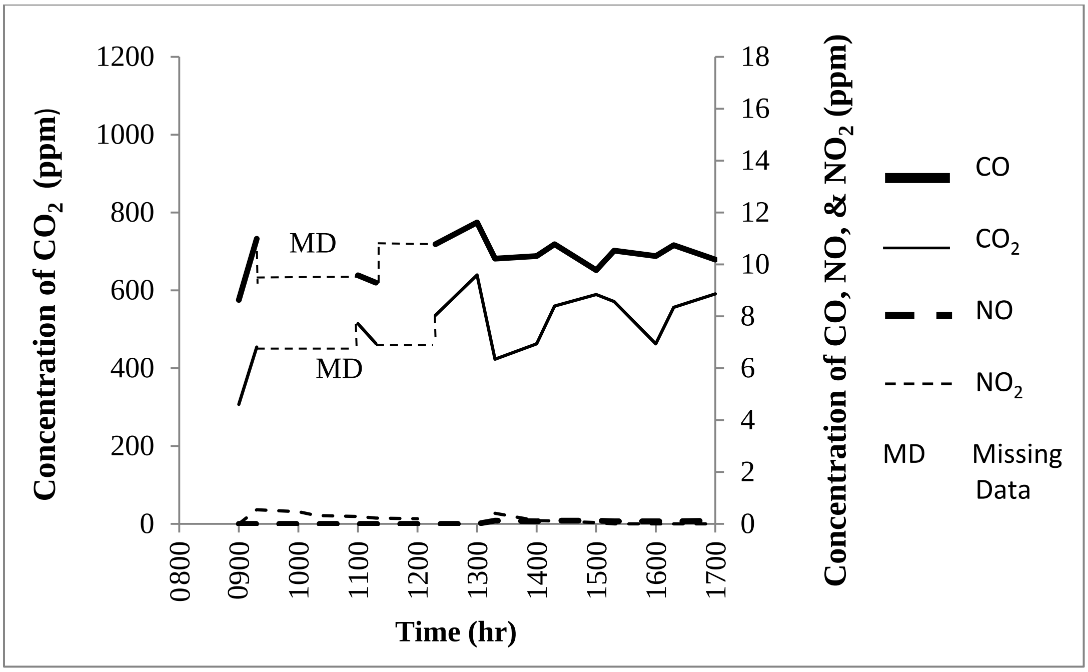

Figure A-1: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 1st of November 2013

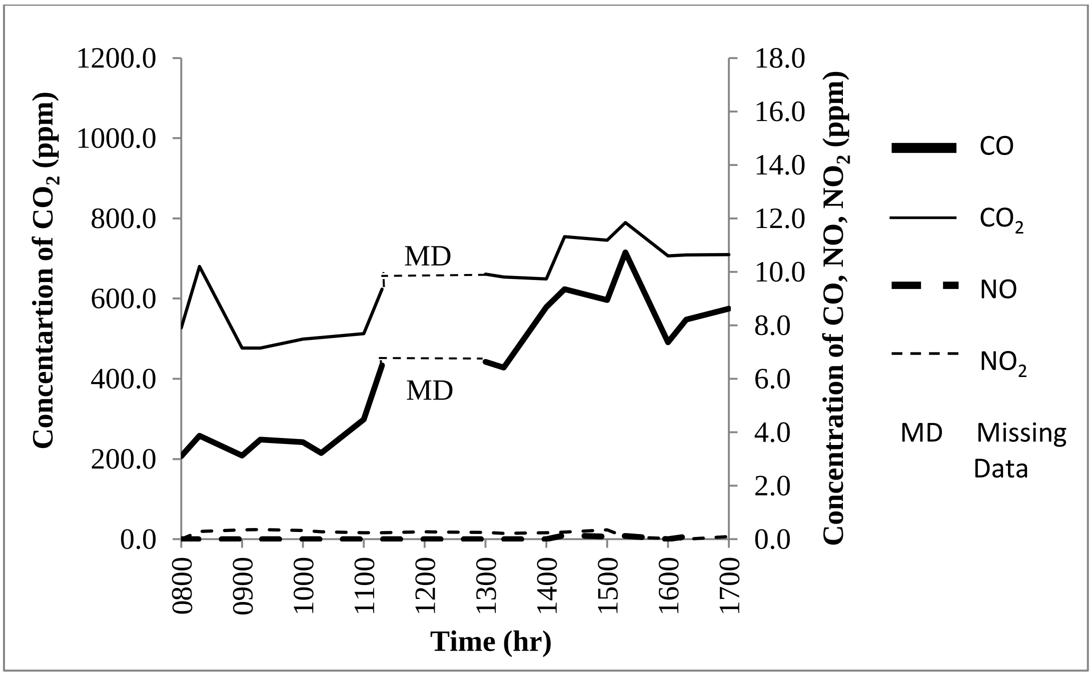

Figure A-2: Concentration of carbon monoxide, carbon dioxide, nitric oxide and nitrogen dioxide vs time on 16th of November 2013