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Study of Particulate Matter (PM_{10}) Concentration and Elemental Composition at Damansara-Puchong Highway

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Abstract. While the fate of various air pollutants in densely populated areas has always been the main focus, less attention has been given to measuring the amount and the exposures near urban highways. The detrimental effects on the environment and human health brought by particulate matter (PM_{10}) cannot deny the fact that it is crucial to investigate how much is available in the urban air. In this study, the concentration of PM_{10} and its elemental compositions were measured by sampling at the toll plaza for 8 hours, on weekdays and weekends of different months. It was found that the highest concentration of PM_{10} was obtained on the second sampling session (weekday) while the lowest was on the first sampling session which fell on a public holiday, at 192.08μg/m^3 and 77.50 μg/m^3 respectively. This showed that the readings were out of the ranges specified by the Recommended Malaysian Air Quality Guidelines. The samples were digested and analyzed by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) and mean concentration of Al, Cu, Cr, Fe, Pb and Zn were presented. In the highest concentration of PM_{10} recorded, Al was the most abundant element, followed by Cr, Fe, Zn, Cu and Pb. Meanwhile, Fe dominated the composition in the lowest PM10 measured, followed by Al, Zn, Pb, Cr and Cu.

Keywords: Air pollution, urban highway, PM_{10}, elemental composition, heavy metals

1. Introduction

Motor vehicle exhaust is known as a significant source of air pollution, especially in urban areas. Amongst the common toxic pollutants emitted from vehicular exhaust are carbon monoxide, nitrogen and sulfur oxides, particulate matter, polycyclic aromatic hydrocarbons, unburned hydrocarbons and other organic compounds (Chambers, 1976; Graedel *et al*.,1986; Rogge *et al.*, 1993).

Being one of the busiest toll plazas, the Damansara-Puchong Highway (LDP), traffic emission from the massive number of vehicles commuting on the highway is the threat to clean air in Klang Valley, particularly during peak hours of working days.

According to Afroz *et al.* (2001), increase in the number of vehicles have caused severe congestion in parts of highway network, hence the air pollutants released are higher. Air pollution is made up of at least 70% to 75% mobile source emission, in which 75% were of carbon monoxide and suspended particle matter, and 76-79% were SO_x and NO_x, originated from the private cars.

Air pollution from local traffic showed very high level of pollutants which can even be recognized without measurement. Reduced visibility, bad smell, and eye irritation caused by the air pollutants emitted from the mobile source affects the public health gradually day by day. Whilst exposure to PM_{10} varies spatially within a city (Brauer *et al.,* 2003; Jerrett *et al.,* 2005), detail analysis have shown higher risks to individuals living in close proximity to heavily trafficked roads (Miller *et al.,* 2007; Jerrett *et al.,* 2005).

The research aimed to compare the ambient air quality based on the recommended guidelines (Table 1) by measuring the concentration of PM_{10} and its elemental composition contributed by vehicular emission at the highway.

2. Methodology

2.1. Sampling of PM_{10}

PM_{10} samples were collected by Airmetric Mini-Vol sampler (static monitoring) outside the first cash toll booth that operates continuously for various heavy vehicles such as buses and trucks. Each session was conducted for 8 hours (from 7 am to 5 pm) and the sampling covered weekdays and weekends of different months.

Changes in weight of the filter paper used in the Airmetric Mini-Vol sampler before and after the sampling were calculated to obtain the mass of particulate matter, using the following formula:

$$Wg_{(\mu g)} = Fe_{(\mu g)} - Fc_{(\mu g)}$$

Wg is the weight of PM_{10} (µg)
Fe is the weight of exposed filter paper (µg)
Fc is the weight of unexposed filter paper (µg)

The concentrations of PM10 per cubic meter were calculated by the conversion equation below:

$$\boldsymbol{V}_{m3} = 0.001_{m3/l} / 1 \text{ x } \boldsymbol{Q}_{l/min} \text{ X } \boldsymbol{t}_{min}$$

V is the volume of sampled air (m^3)
Q is the average flow ($min^{-1)}$
t is the sampling duration (min)

The weather condition throughout the study was recorded and the traffic volume passing by the toll booth was also estimated.

2.2. Analysis of elemental composition of PM_{10}

The exposed filter papers were extracted with 6 ml of HNO_3 and 2 ml of H_2SO_4 to form aqua regia acid and then digested in the microwave digester. The mixture was then diluted with deionized water in a volumetric flask to 50 ml and analyzed by ICP-OES.

3. Results and discussion

3.1. Concentration of PM_{10}

The results showed that PM_{10} concentrations were inconsistent, with the lowest reading on the first sampling session, owing to the fact that it was a public holiday where most people prefer not to be on the busy highway.

The highest reading was recorded on the second sampling session, 192.08 µg/m^3 with higher number of vehicles from very early in the morning, particularly because the sampling point was the lane for heavy vehicles using diesel engines. This correlated well with the claim by Tan *et al.* (2007) that burning diesel generates more PM than other engines.

The remaining sessions have seen fluctuation in the concentrations of PM_{10} regardless of the weather conditions. Apparently, this owed to the resuspension of dust or road dust as suggested by Yatkin *et al.* (2007). Dust from the shoulder of the road, near the curbs and along the divider might have also affected the high reading on other sampling days as claimed by Vallius (2007).

On the sixth sampling session, the PM_{10} concentration subsided to 115.80 µg/m^3 most likely due to a heavy downpour at noon, hence depositing them onto the ground along with the rain water.

Table 1: The recommended Malaysian Air Quality Guidelines

Air pollutants	Malaysia (µg/m^3)
Particulate matter (PM_{10})	
24 hours average	150
12 months (annual)	50

Although there is no ambient air quality standards in Malaysia, all the readings obtained were out of the range of the Recommended Malaysian Air Quality Guidelines (Table 1).

This should be of concern as studies have shown that people living or spending substantial time in close proximity (of about 200 m) to heavily trafficked highways showed higher risks of exposure to these pollutants, with supporting evidence of the health hazards (Brugge *et al.*, 2007).

3.2. Elemental composition of PM_{10}

The six significant elemental compositions detected in the PM_{10} were tabulated in Table 2 below.

Table 2: Summary of the concentration of PM10 and elemental compositions for the sampling sessions.

Sampling session	Weather	PM_{10} Concentration ($\mu g/m^3$)	Mean concentrations of selected heavy metals (mg/L)					
			Pb	Zn	Cr	Al	Cu	Fe
1 (weekday)	Sunny	77.50	0.264	0.472	0.163	0.568	0.152	1.061
2 (weekday)	Sunny	192.08	0.095	0.150	0.158	0.695	0.127	0.151
3 (weekday)	Sunny	151.61	0.017	0.142	0.148	0.178	0.078	0.078
4 (weekday)	Sunny	140.83	0.029	0.226	0.096	0.178	0.093	0.200
5 (weekday)	Sunny	155.00	0.009	0.071	0.146	0.234	0.107	0.073
6 (weekday)	Rainy	115.80	0.002	0.058	0.146	0.145	0.051	0.069
7 (weekend)	Sunny	145.00	0.007	0.115	0.150	0.178	0.052	0.150
8 (weekend)	Cloudy	108.33	0.073	0.270	0.149	0.171	0.083	0.343

It was observed that Fe recorded the highest reading of 1.061 mg/L (13.2%) on the day with the highest PM_{10} concentration. Fe was also reported present in emissions from heavy duty vehicles by Vallius (2005).

Al was the most abundant element found throughout the study, followed by Cr, Fe, An, Cu and Pb. This could be due to the local traffic emission from the mechanical process such as brake abrasion and tire wear (Iijima *et al.,* 2007). High concentration of Al was related to the resuspension of road dust from the soil (Vallius, 2005).

Previous studies revealed that the most elemental composition of PM_{10} such as Pb, Zn and Cu originated from the combustion of fuel and diesel engines (Ntziachristos *et al.,* 2007; Suzuki *et al.,* 2006; Vallius, 2005; Yatkin *et al.,* 2007).

From the aspect of human health, the high population density in the neighborhood and the increasing number of vehicles using the highways with regular traffic jams may somehow cause the toll workers to experience a worse health condition due to the higher average exposure only to PM_{10}, but also harmful gasses at high concentration such as nitrogen (NOx), sulphur dioxide (SO_2) and carbon monoxide (CO_2) throughout their working hours.

Studies in Brisbane, Australia by Morawska *et al.* (1999) and Hitchins *et al.* (2000) highlighted the influence of pollutants from nearby roads, wind speed and direction on the air pollutant concentrations. Morawska *et al.* (1999) discovered higher concentrations of pollutants as the measurement is made closer to the highways. However at distance 15-200 m from the highways, no significant difference was observed along either horizontal or vertical transects, which could be due to mixing of the highway pollutants with emissions from traffic on nearby roads. Hitchins *et al.* (2000) observed that 50% reduction in the number and mass concentrations varied depending on the wind speed and direction.

4. Conclusion

Increasing population and number of vehicles used by the residents in Klang Valley especially in the areas of Bandar Sunway, Bandar Puchong, Bandar Puteri Puchong, Puchong Perdana and Puchong Prima are among the factors that contribute to the local air pollution of the sampling area. Due to the various mobile sources mainly from vehicle emission, a problem has been aggravated.

The highest concentration of PM_{10} (192.08 μg/m^3) in the second sampling session recorded Al as the main element in the PM_{10}. Meanwhile, individually, Fe dominated the elements in the PM_{10} with 1.061 μg/mL (13.2%), followed by Al, Zn, Pb, Cr and Cu. The main source of PM_{10} and its elemental compositions were believed to originate from anthropogenic sources such as combustion, mechanical process and re-suspension of dust in the air.

The study revealed that the amount of air pollutants did not fall within the range of the Recommended Malaysian Air Quality Guidelines as suggested by the Department of Environment, therefore there is a need for mitigating measures to curb the pollutants emitted from the urban highway.

Although this study did not focus on personal exposure, it can be estimated that the most susceptible people subject to effects of inhaling the airborne pollutants might be those living nearby the highways and the toll plaza workers. Hence, there is a need for more research, but also a need to begin to explore options for protecting the health of the workers and the environment.

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6. References

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