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EVALUATION OF RESUSPENSION OF ROAD DUST IN A CEMENT INDUSTIAL COMPLEX AREA

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ABSTRACT: Re-suspended road dust is an important contributor to ambient particulate matter (PM) particularly in an area where fugitive dust is significant emission source. This study evaluate PM-10 and PM-2.5 emissions as fugitive re-suspended dust from the road network in the Thai's Pollution Control Zone. Emissions of road dust are determined by using the analysis of silt loading and physical characteristics of the roads located in the study domain. Diurnal profile of vehicles travelling on each roads were used to calculate temporal variation of the emission data. Diurnal pattern of PM-10 ambient concentration measured from curbside station in the study area was used to reveal the contribution of road dust emissions to particulate concentration in the air. Results indicated that road dust greatly influenced the temporal profile of PM-10 concentrations in this area. Therefore, the effort to control particulate emissions in this Pollution Control Zone should also give a priority not just only to the industrial sources but also to mobile source emissions particularly from those re-suspended road dust.

Keywords: Road dust, PM-10, PM-2.5, AERMOD, Emission rate

1. INTRODUCTION

Non-exhaust traffic induced particle emissions are known to contribute significantly to the total concentrations of inhalable airborne particulate matter in the size range <10 µm (PM-10) [1]. The evidence on airborne particulate matter (PM) and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries [2]. Particulate matter, is a complex mixture of extremely small particles and liquid droplets. The size of particles is directly linked to their potential for causing health problems. Once inhaled, these particles can affect the heart and lungs and cause serious health effects [3].

In Thailand, PM-10 concentrations monitored in several places had been higher than both of its 24-hour and annual standards (> 120 and > 50 µg/m^3, respectively). Fig. 1 presents the status of PM-10 measured nationwide over the decade (from 2003 – 2013). The worst polluted area from PM-10 of the country is at Na Phra Lan Sub-district, Saraburi Province (Fig. 2). This area is located in the central region where it is home to the cement manufacturing complex of the country. Due to the problem of very high concentration of PM-10, this area had been designated as "the Pollution Control Zone" by the Thai government since 2004 with an objective to set up specific action plans as well as budgets to combat with this problem.

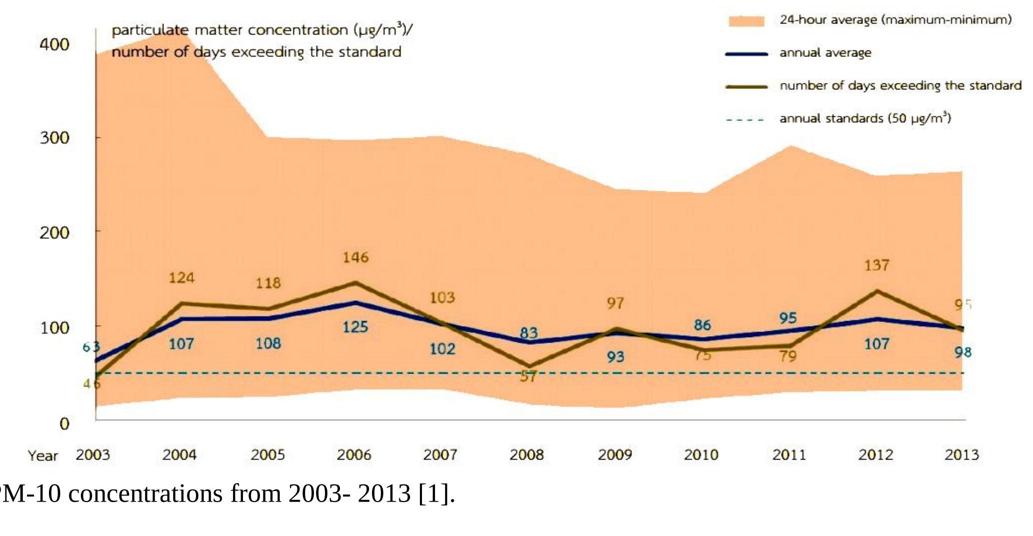

Fig.1 PM-10 concentrations from 2003- 2013 [1].

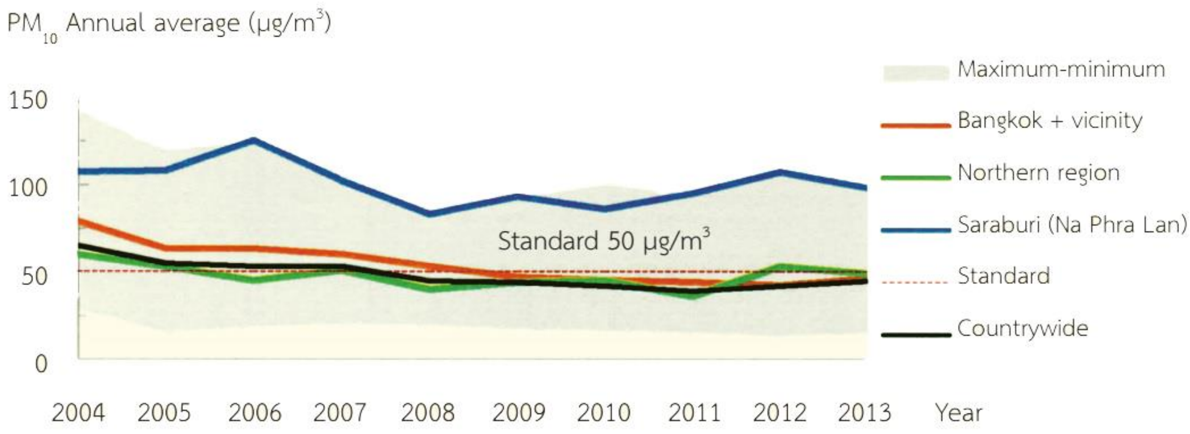

Fig. 2 Spatial comparison of PM-10 measured nationwide in Thailand. [1]

High concentrations of ambient PM-10 in this area are contributed from activities related to cement manufacturing processes. However, it is suspected that PM-10 measured in the community area are also contributed by the re-suspended road dust. It is well recognized that traffic and road transport are main sources to ambient PM-10 concentrations especially at hot spots in urban environment [4]. Particulate emissions from road transport include tail exhaust, products of wearing processes and re-suspended road dust [5]. Particulates emitted from exhaust of diesel engine are relevant to speed of the vehicle [6] Field measurements in urban areas or megacities shown elevated levels of PM-10 in the vicinity of roads coming from the contribution from re-suspended particles from paved roads [7]. In urban areas fugitive dust emissions due to vehicles travelling on roads is the most important source of rude particles.

Emissions from road transfer climb from both exhaust and non-exhaust sources. The most important sources of non-exhaust PM are wearing of brake and tyre element of machine vehicles and wearing of the road surface itself. An additional non-exhaust source is the suspension or re-suspended of previously placed material from the road surface road dust by vehicle induced confusion, tyre crop and the turbulent achievement of the wind. In addition to direct tailpipe emissions of particulates, mobile sources are also accountable for fugitive dusts such as those re-suspended from road.

This study assessed PM-10 and PM-2.5 emissions of re-suspended dust from the road network in the Na Phra Lan Pollution Control Zone. Emissions of road dust are determined by using the analysis of silt loading and physical characteristics of the unpaved and pave roads located in the study domain. Then emission faction of PM-10 and PM-2.5 re-suspended from road are developed and further be used as input data for interpretation of their ambient concentration using the air pollution dispersion model. This study presents results of the diurnal profile of emissions of PM-10 and PM-2.5. Calculated emission data were compared with ambient PM-10 concentration measured from the curbside of the road. The finding of this study assist in elucidate the contribution of re-suspended road dust to the dust concentration in this pollution control zone.

2. METHODOLOGY

In this study, amount of PM-10 and PM-2.5 emitted from re-suspension of road dust in the Na Phra Lan Pollution Control Zone was estimated. The study domain covered area of 3 x 3 km^2 was centered at the Na Phra Lan ambient air monitoring station of the Pollution Control Department (reference point). There were 5 major roads within the study domain as illustrated in Fig. 3.

Fig. 3 Major roads within the study domain

Sampling locations in each road were designed according to their length and distant between road conjunction/intersection. Criteria of selection of sampling points are presented in Fig. 4. Totally, there were 21 dust sampling locations in these roads. The road dusts were collected directly from road pavement by manual sweeping of the dust. The dust sample plot used in this study was patterned after the ASTM-C-136 method. It had been designed with a rectangular-shaped leading edge. The sample plot was made of Acrylic plastic and had the size of 0.3 x 0.3 m^2 with 0.15 m wing. At least 3-5 plots were sampled at the same sampling location. Collected samples at each sampling locations were then put in the same plastic bag (composite sampling).

In this study, the emission rates of PM-10 and PM-2.5 emitted from re-suspended road dust was calculated following the US.EPA AP-42 (section 13.2.1 and 13.2.2). The data collected on-site included amount of dust in the study plot, and diurnal profile of number and type of vehicles traveling on the roads within the study domain. Details are as followed.

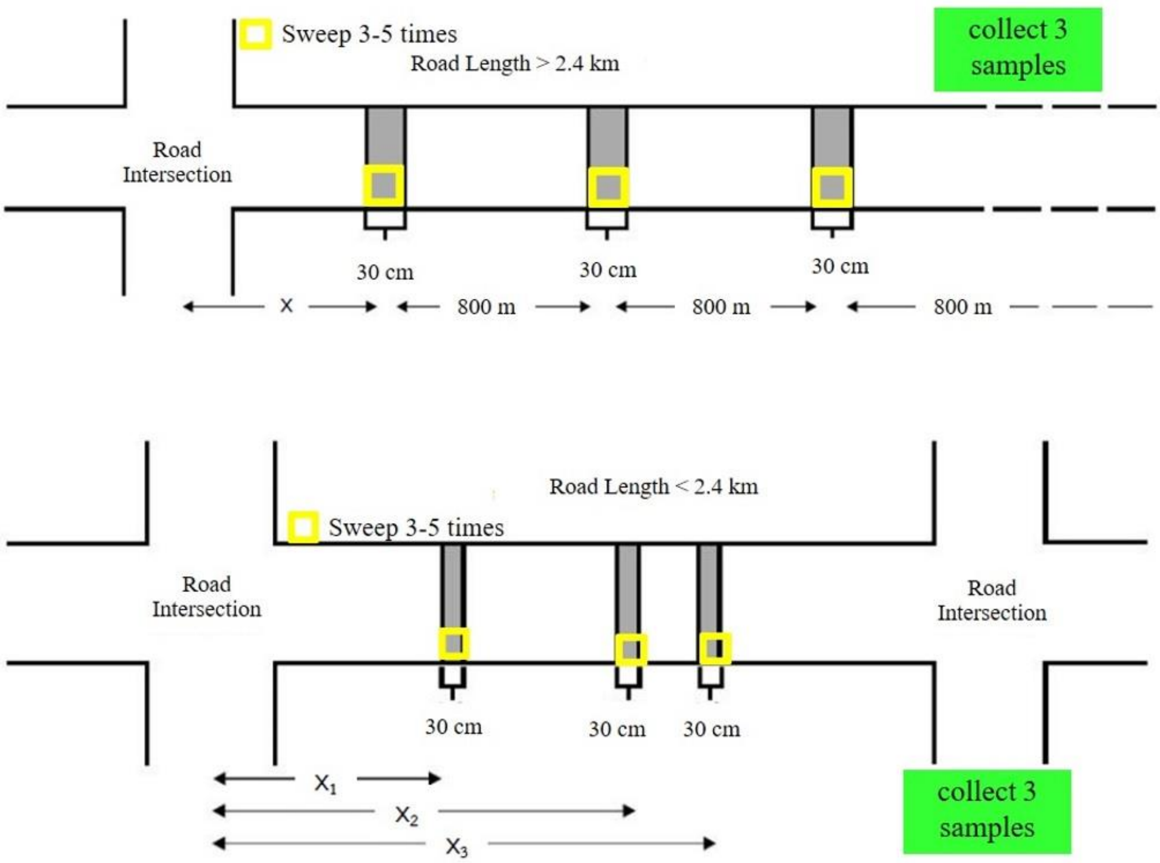

Fig. 4 Locations of sampling points [8].

2.1 Silt Analysis

Dust emissions from paved and unpaved roads have been found to vary with the "silt loading" present on the road surface as well as the average weight of vehicles traveling the road. The term silt loading refers to the mass of silt-size material (equal to or less than 75 µm in physical diameter) per unit area of the travel surface. The total road surface dust loading consists of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading.

Several open dust emission factors have been found to be correlated with the silt content (< 200 mesh) of the material being disturbed. The basic procedure for silt content determination is mechanical, dry sieving. For sources other than paved roads, the same sample which was oven-dried to determine moisture content is then mechanically sieved. The broom swept particles are weighed in a container, which was tarred before sample collection. After weighing the sample to calculate total surface dust loading on the traveled lanes, the broom swept particles were combined as a composite sample [8]. The samples were dried in an oven at 130^0C to remove moisture and were equilibrated in the desiccator prior be sieved.

Collected dust were then sieved using mechanical shaker (model: Retsch AS200) through the 200 mesh screen (75 µm) for 10 minutes. The total net weight and net weight of particle < 200 mesh were used to calculate percent of silt using equation (1). Results of percent of silt measured from each road are as presented in Table 1

$$\%\text{Silt} = \frac{\text{Net Weight} <200 \text{ mesh}}{\text{Total Net Weight}} \times 100 \qquad (1)$$

Table 1 Percent of silt on each road

Roads	Silt (g/m^2)	% Silt
Phaholyothin	5.38	2.79
Saraburi-Lomsuk	0.78	1.80
Kung Khao Kaew	38.11	3.49
3385	1.22	1.12
3034	1.33	1.92

2.2 PM-10 and PM-2.5 Emissions

The PM-10 and PM-2.5 emitted from re-suspended road dust were calculated by equation 2.

$$E = k \times sL^{0.91} \times W^{1.02} \quad (2)$$

where; EF is particulate emission factor (having units matching the units of k), k is particle size multiplier for particle size range and units of interest shown in table 2, sL is road surface silt loading (grams per square meter; g/m^2), and W is average weight (tons) of the vehicles traveling the road.

Table 2 Empirical constants used in the calculation

Size range	Particle Size Multiplier k (g/VKT*)
PM-2.5	0.15
PM-10	0.62

* VKT = vehicle kilometer traveled

3. RESULT AND DISCUSSION

Diurnal variation of emission rates of PM-10 and PM-2.5 from each roads are presented in Fig. 5 and 6. (Fig. 7).

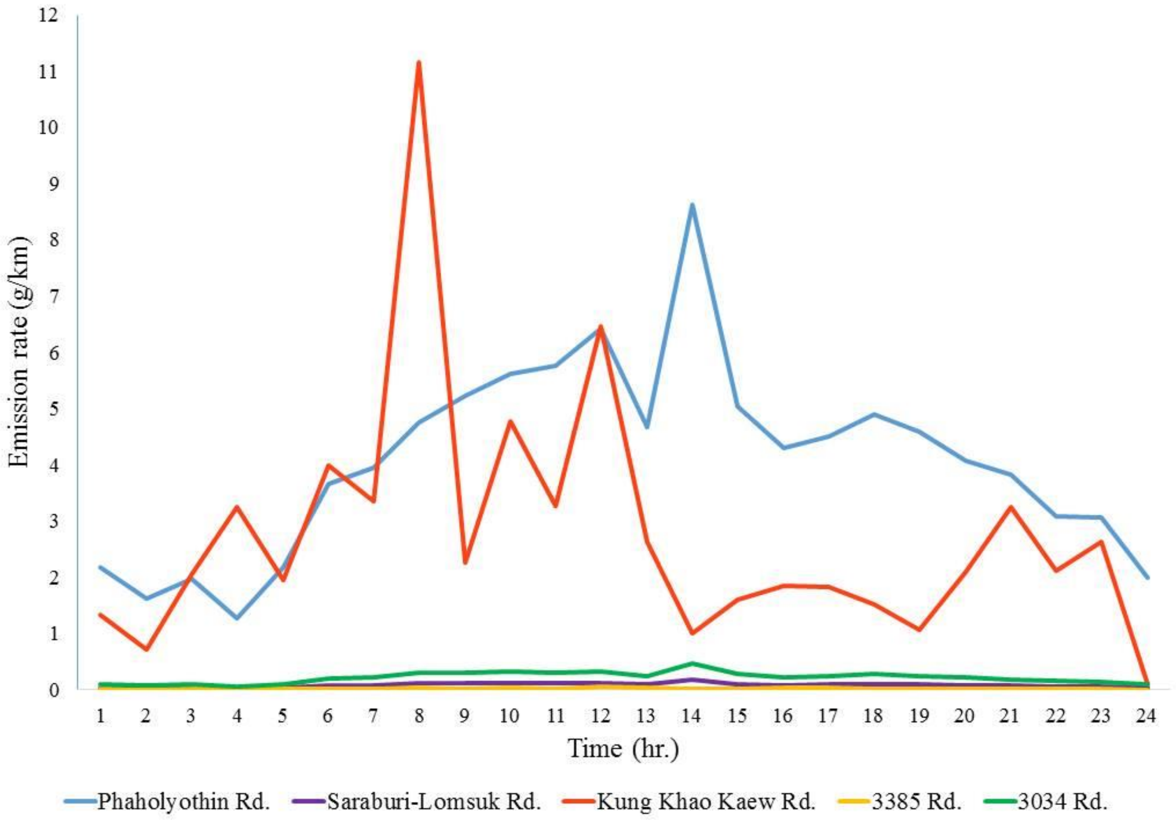

Fig. 5 Emission rate of PM-10 from re-suspended road dust

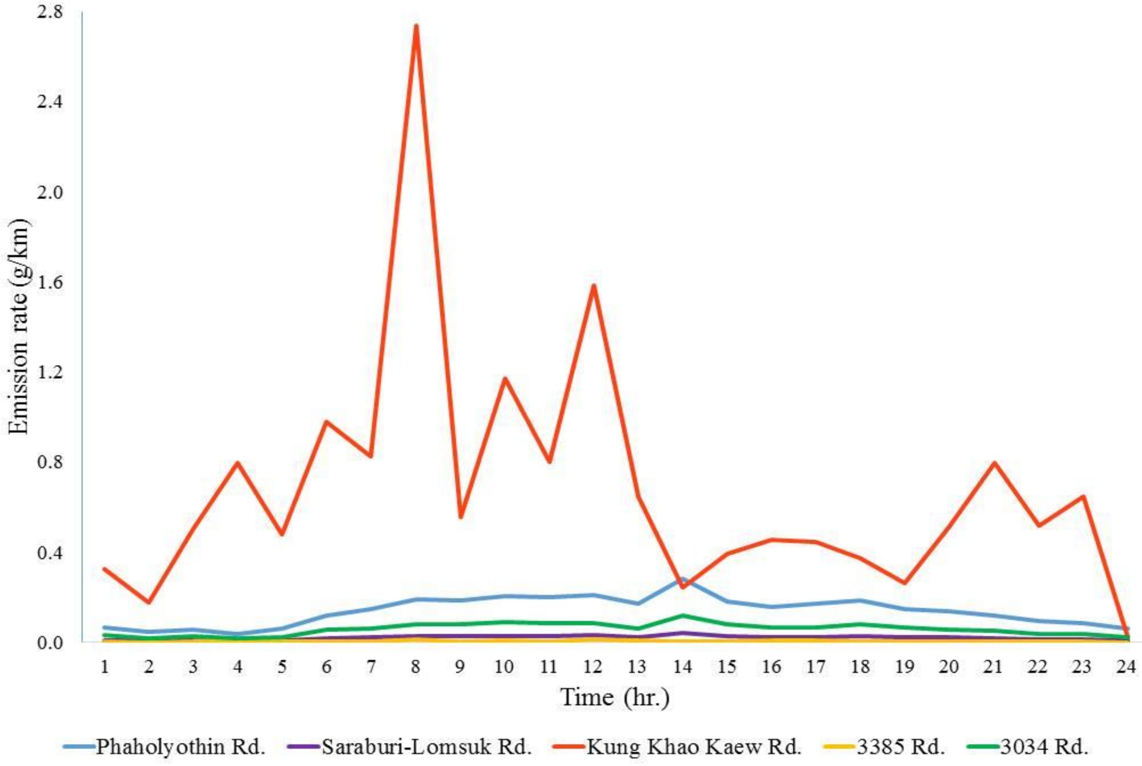

Fig. 6 Emission rate of PM-2.5 from re-suspended road dust

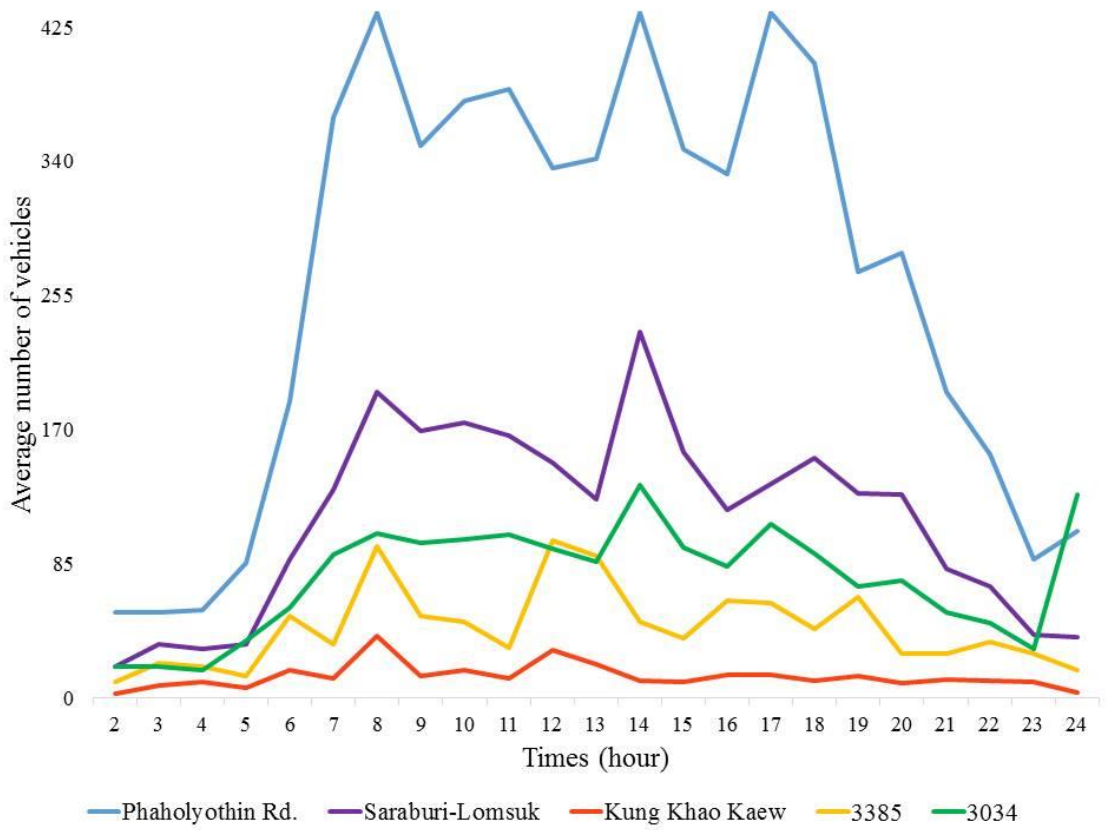

Fig. 7 Total number of vehicles travelling on each road

The diurnal profile of PM-10 emission rate estimated from Phaholyothin road was used to evaluate the influence of re-suspended road dust to particulate concentration in the study area. Hourly average of PM-10 concentrations measured from the curbside of this road during the sampling period were compared with its emission profile as presented in Fig. 8. It should be noted that there were no activities related to cleaning of the road during the dust sampling period. Results clearly indicated the contribution of re-suspended road dust to the PM-10 concentration. These results suggested that the efforts should be made in controlling not only emissions from industrial sources but also those released as re-suspended road dust in this Pollution Control Zone. For the reduction of daily concentration of PM-10 to meet its legislative ambient air quality standard, the silt loading on the road surface should be removed.

One of the possible mitigation action is scheduling the cleaning period of the road during morning and evening times.

Table 3 Emission rate of worst case

Roads	Worst case emission rate (g/km)	
	PM-10	PM-2.5
Phaholyothin	35155	8002
Saraburi-LomSuk	3782	1165
Kung Khoa Keaw	27784	39017
3385	616	265
3034	6273	3069

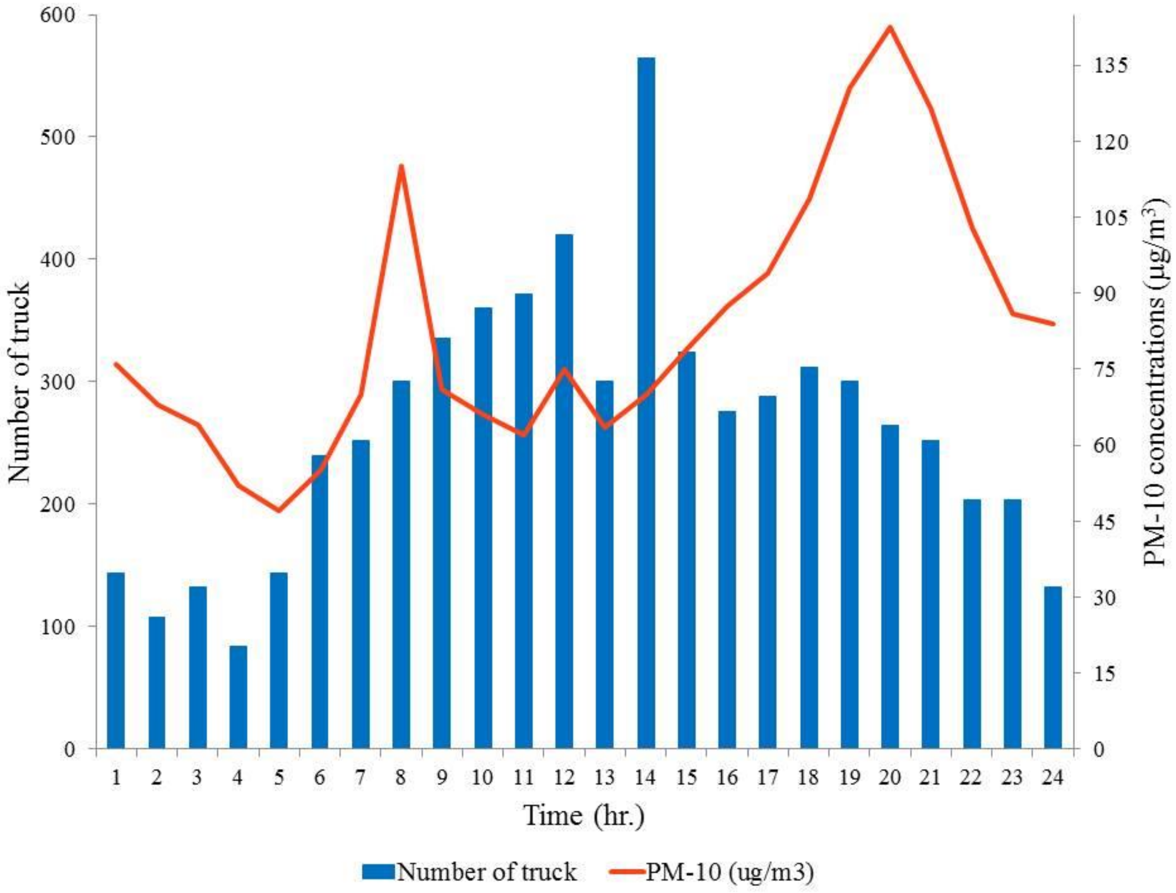

Fig. 8 Diurnal variation of PM-10 concentrations and PM-10 emissions from re-suspended road dust

4. CONCLUSION

Emission rates of PM-10 and PM-2.5 released from re-suspended road dust were evaluated for an area designated as Pollution Control Zone in Thailand. Direct measurement of particle deposition on the road surface was carried out covering entire roads within the zone. These data were evaluated for amount of PM-10 and PM-2.5 emissions following the concept of analysis of the silt content. Results revealed the diurnal profile of amount of particulate emissions with respect to number of total vehicle and contribution of heavy duty truck travelling in this area. It also provided the information that the PM-10 concentrations measured in this area was associated with amount of re-suspended road dust.

5. ACKNOWLEDGEMENTS

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