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A GIS-BASED EMISSION INVENTORY AT 1 KM -1KM SPATIAL RESOLUTION FOR PARTICULATE MATTER (PM_{10}) IN KLANG VALLEY, MALAYSIA

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ABSTRACT: *Traffic has greatly contributed to the socio-economic development as well as its inherent environmental impacts. This study estimated the emission of PM_{10} from the exhaust and nonexhaust, particularly from the use different type of vehicles in Klang valley region. The total PM_{10} emission from the region was calculated based on US-EPA and the EEA methodologies. Arc GIS is one of the most suitable methods to estimate the total PM_{10} emission and split between different vehicle types as it is determined by the kilometer covered for each vehicle category. The inventory is further used for traffic account, activity data and a domain size of 50 km×50 km, with cell resolution of 1km × 1km to spatially disaggregate these emissions. The results show that nearly 54% of the PM_{10} emitted in the region emitted from cars. The results also revealed that nearly 61% of the PM emissions emitted from exhaust. Exhaust and Non-exhaust PM_{10} emissions are higher in the central part of the Klang Valley, an area with higher volume of vehicles.*

Keywords: PM10 emission; Exhaust emission; Nonexhaust emission; Emission Inventory; Traffic

1. INTRODUCTION

Traffic is a major source of air pollution in urban areas worldwide [1]. In Asian developing countries, a fast increase in vehicle population in conjunction with a slow increase in road surface areas and improper traffic management often lead to traffic congestion, which can further deteriorate urban air quality. It has been a concern that the fuel powered vehicles that emits a complex mixture of toxic pollutants and fine particles [2]. Airborne particulate matter is one of the main environmental problems in most of the cities of the world [3].Direct traffic exhaust and industrial emissions have been considered as the main sources of particles in cities. However, recent studies show that the exhaust and nonexhaust particulate matter emissions from road traffic are also an important source of these air pollutants [4]. Non-exhaust particulate emissions involve abrasive processes such as tire wear, brake wear, and these processes can lead to the deposition of particles on the road surface. Studies conducted in different cities of the world show the importance of non-exhaust road traffic emissions. The study conducted in Beijing investigated the characteristics of resuspended road dust and its impact on the urban air concluded that resuspended road dust from traffic is one of the major sources of aerosols in Beijing [5]. Studies in Northern European countries also show that the contribution of non-exhaust road traffic emissions to the total PM_{10} emissions can be as high as 90%. Previous studies found out that the deterioration of air quality in Peninsular Malaysia has become more pronounced in recent times. This is due to the continuous dust fall-out and the increase in concentration of suspended particulate matters in the ambient air along congested roadsides. However, studies with a comprehensive emissions inventory and spatial spread of emissions still yet to develop in Malaysia. Therefore, this study is aimed to estimate the emissions inventory from exhaust and nonexhaust using gridding and interpolation procedures to disagregate the inventory into 1 km×1kmspatial resolution.

EXPERIMENTAL DETILES

The grid-based emission inventory developed in this study has been used for the generation of ambient concentration of PM10 using AERMOD model domain Figure 1. The calculated exhaust and non-exhaust emissions were distributed in a domain of 50 ×50 km with grid cell of 1km × 1km using geographical information system (GIS) for the spatial distribution of these emissions. Malaysian vehicle types were classified into 6 classes (Cars and Taxis, Vans, Medium Lorries and large vans, Heavy Lorries, Buses, and Motorcycles) according to road type (Expressway, Federal road and state road). This traffic volume was based on the road traffic volume survey conducted by the Malaysia Public Works Department (Jabatan Kerja Raya) for the year 2014 [6].

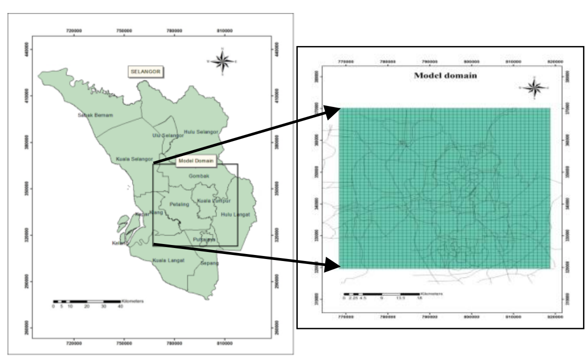


Fig (1) Model domain for the study

Estimation of the exhaust particulate matter (PM10) emissions.

Traffic has been considered as an area source. Total emission from different vehicle modes has been estimated for each grid separately. The emission of each grid has been estimated according to AP- 42[7]and the formula for emission from traffic used in the study are given below,

$$E_i = EF_{ij} \times A_{jk}$$

Where:

Ei = total emission of pollutants (PM_{10}) (g)

EF = Emission factor pollutants (PM_{10})

i = type of pollutants

j= type of fuel usage

A= Activity level for each pollutant source

For vehicular emission inventory, the relevant emission factors (in g/km units) for pollutants PM10 have been collected from available literature [1, 8,9]

$$A \text{ or } VKT = L \times AADT$$

Where:

A or VKT = Activity level for each pollutants source in each grid (km/day).

L = Road length (km) in each grid.

AADT = Annual average daily traffic (traffic volume/ day).

Estimation of the non-exhaust particulate matter (PM_{10}) emissions

Emission factors for PM_{10} from resuspension:

The non-exhaust particulate matter traffic emissions (E) were estimated from emission factors (EF) and vehicle activity data (A). The basic equation is:

$$Ei = EF \times A$$

The particulate emissions factor from resuspension on a paved road surface was estimated using (USEPA method):

$$EFpr= K\times (SL)^{0.91}\times(W)^{1.02}\times(1 – P/4N)$$

Where:

EFpr = Particulate emission factor for a paved road (g/VKT)

k = Particle size multiplier (g/VKT; from AP-42, table 13.2.1-1)

sL = Road surface silt loading (g/m2)

W = Average weight of the vehicles traveling the road (ton)

P = Number of wet days with at least 0.254 mm of precipitation during the average period

N = Number of days in the average period (91for seasonal).

The road surface silt loading is a key parameter for the estimation of particles resuspension emissions in a paved road which was (0.1 g/m2 to estimate the particulate emission factor for a paved road), K = 0.62 g/vkm [9, 10].

Emission factors for PM_{10} from brake and tire wear

The particulate emissions from tire and brake wear were estimated using (EMEP/Air method)

$$E_{sj} = N_j\times M_j\times EF_{sj}$$

Where:

E_{sj} = Total emission (g) from pollutant for each grid.

N_j = Number of vehicle in define class in each grid.

M_j = Average of milege driven (km) per vehicle in each grid.

EF_{sj} = Mass emission factor (g/km).

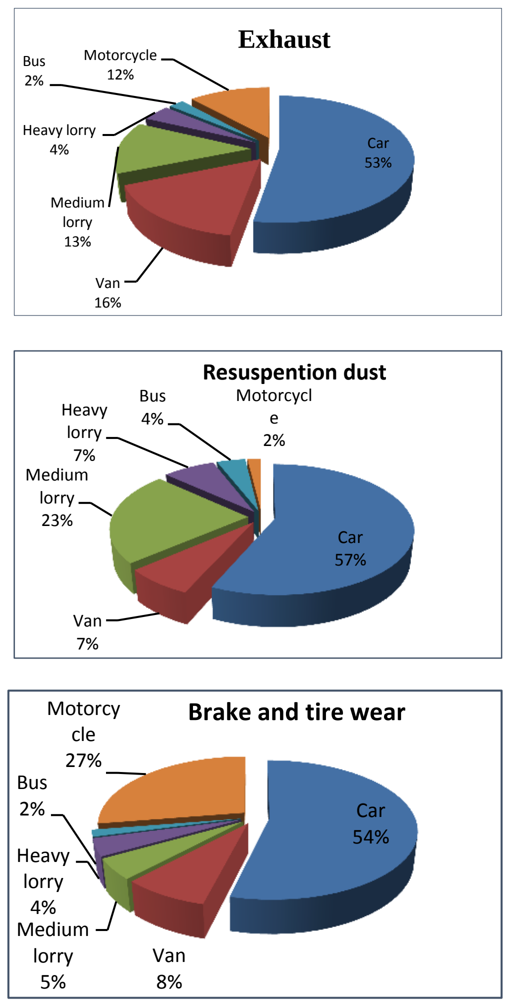
s = Non exhaust emission source (tire and brake wear).

j = vehicle category.

3. RESULTS AND DISCUSSION

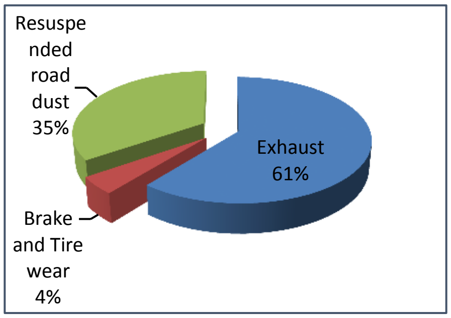
The estimation of PM_{10} emission inventory for transportation was based on the traffic information such as traffic volume and road length of each road survey provided by Malaysia Public Works Department [6]. The study shows that the highest PM10 emissions from exhaust and non-exhaust produced by car were represented for exhaust (53%), resuspended dust (57%), brake and tire wear (54 %) respectively. While bus and heavy lorry showed lower contribution to exhaust and nonexhaust PM_{10} emission in Klang Valley region (see Figure 2). The result from activity factor is less the othevehicles, which explains their low contribution to exhaust and nonexhaust PM.excited species of plasma not only reacts with liquid at solid-liquid interface but also at plasma-liquid interface. The excessive physical status The contribution of different source types of exhaust and non-exhaust emission (re-suspended dust, brake and tire wear) to PM_{10} within Klang valley region is shown in Figure 3. This shows that exhaust accounts for approximately 61% of PM10. While resuspended dust and brake and tire wear emissions account for 35.9 % and 4%, respectively.

The contribution of different source types of exhaust and non-exhaust emission (re-suspended dust, brake and tire wear) to PM_{10} within Klang valley region is shown in Figure 3.This shows that exhaust accounts for approximately 61% of PM_{10}.While resuspended dust and brake and tire wear emissions account for 35.9 % and 4%, respectively.



Fi g (2) Contribution of different vehicle categories to PM_{10} exhausts emissions in Klang Valley in 2014

Table 1shows the estimated emissions of PM_{10} by exhaust and nonexhaust (resuspended dust and brake and tire wear) in Klang Valley. The total PM10 emission inventory from exhaust and nonexhaust (resuspended dust and brake and tire wear) emission was (238,555 and 142,274 g/day) respectively. The results also show that the contribution of exhaust emission is relatively higher than that of nonexhaust emission. The high amount of PM_{10} emission was due to increase in vehicles on the road thereby increasing pollution on the environment. These results are lower than the PM_{10} fraction found by [12-14].



Fig(3) The contribution of different vehicle categories to PM includes exhaust emission and non-exhaust emissions (resuspension dust, tire and break ware).

Table 1. Estimated PM_{10} and heavy metals emissions by exhaust and nonexhaust in klang valley region

Emission	PM_{10}/g/day
Exhaust	11,661.34
Non-exhaust	7,489.09

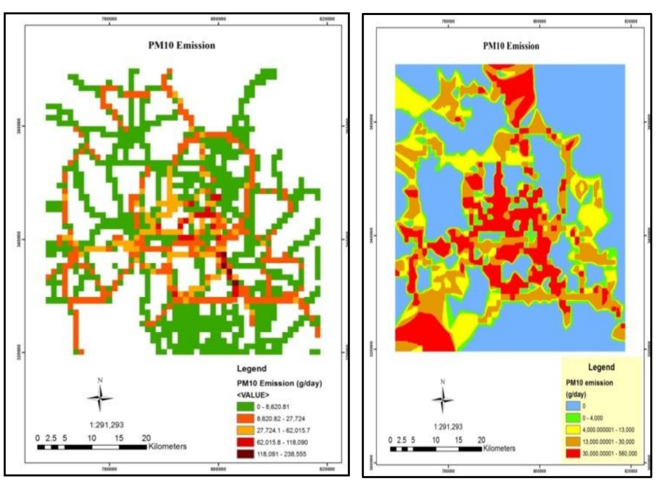


Fig 4 Gridded and interpolated emissions inventory of PM_{10} (g/day) from exhaust in Klang Valley 2014

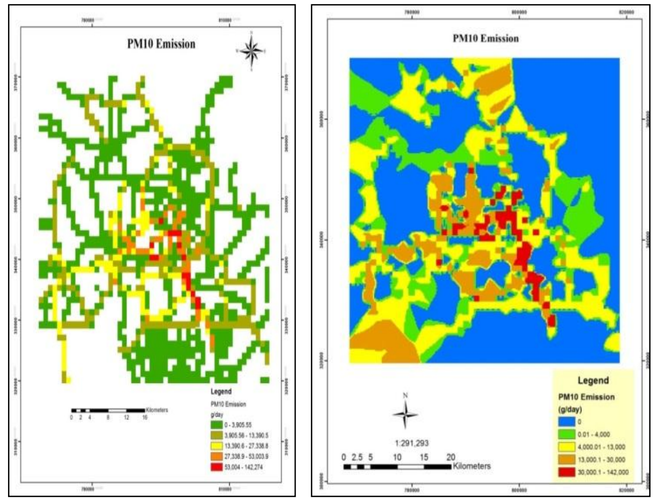


Figure 5: Gridded and interpolated emissions inventory PM_{10} (g/day) from non-exhaust in Klang Valley 2014

The spatially disaggregated PM_{10} emissions shown in Fig (4, 5). Most of the cells with the highest exhaust and non-exhaust PM10 emissions were found to occur precisely in the central and south of the Klang Valley region. 0These areas have high population density, together with heavy traffic density.

4. CONCLUSIONS

Exhaust and Non-exhaust PM_{10} emissions were estimated for Klang Valley region. Emissions from Exhaust and Non-exhaust were also disaggregated in a domain of 50 ×50 km with cell resolution of 1km×1 km using traffic activity data. Nearly 61% of the total PM_{10} emitted in KlangvValley was found to be from exhaust emissions. PM_{10} emissions from car contributed53% of the exhaust emissions, while 57% from the resuspended dust and 54% from brake and tire wear, respectively. The spatial disaggregation using Arc GIS shows that exhaust and non-exhaust PM_{10} emissions are higher in the central and southern region of the KlangvValley due to the high volume of vehicles. This work underlines the importance of exhaust and non-exhaust particulate emissions in cities of the developing world. The results from the study also suggested that it is crucial for the environmental authorities to control this source of pollution and it is highly recommended that the scientific community improve the existing methods to estimate and validate emissions to ensure a higher accuracy of air quality simulation of the region.

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