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Research Paper

PARTICULATE MATTER CONCENTRATION AT THE INTERCITY BUS STATION OF SURABAYA, INDONESIA

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Abstract: Particulate matter diameter of less than ten microns (PM_{10}) was mapped at intercity bus station of Surabaya. Eight sampling points were organized where PM_{10} was collected four time intervals during peak day and measured gravimetrically. The particulate concentrations were found in the range of 161 μgm^{-3} and 373 μgm^{-3}. The busy activities of the motorized vehicles brought about increasing particulate matter concentration in departure and arrival areas, exceeding the ambient air quality standard of 150 μgm^{-3}. No correlation between number of vehicles as well as vehicle type and particulate matter concentration was found. In addition, wind parameters appeared no significant contribution to the particulate matter dispersion.

Keywords: Iso-concentration of PM_{10}, motorized vehicles, peak day, Winsurf software

INTRODUCTION

The intercity bus station of Surabaya, Indonesia, the so called Purabaya is one of the bus stations having very dense activities of various types of motorized vehicles. The effective area of the bus station of 22,500 sq-m, the number of motorized vehicles of 1,450 and the number of people involved of 35,000 daily were characterized the high frequency and load of the station. The conditions might bring about air pollution, leading to adverse effect toward human health such as death from respiratory and cardiovascular, inflammation of lung tissue in young healthy adults [1, 6]. However, there was no regular monitoring of the environment, air quality in particular. Since the size, chemical composition, and concentration of ambient PM_{10} can vary considerably from point to point and from season to season within the same area [7] and in response to the requirement of environmental management with respect to the East Java Governor's Decree No. 128/1997, this study was carried out with an attempt to map particulate matter (PM_{10}) at the entirely area of the station. This study would be a benchmark of particulate matter concentration at the intercity bus station and for comparable stations load.

MATERIALS AND METHODS

Preliminary survey was to collect data on peak days of the station. According to regular monitoring by the station manager, the peak days were Friday, Sunday and Monday. The sampling points and dues were organized in Table 1 on the peak days.

Table 1: Sampling dues

Sampling points		Sampling dues			
		Morning	Mid Day	Afternoon	Night
1	Intercity bus arrival	07.00-07.30	13.00-13.30	18.00-18.30	01.00-01.30
2	Entry point of bus station	07.45-08.15	13.45-14.15	18.45-19.15	01.45-02.15
3	Exit point of public vehicles	08.30-09.00	14.30-15.00	19.30-20.00	02.30-03.00
4	Intercity bus parking	09.15-09.45	15.15-15.45	20.15-20.45	03.15-03.45
5	City bus departure	07.00-07.30	13.00-13.30	18.00-18.30	01.00-01.30
6	Exit point of bus station	07.45-08.15	13.45-14.15	18.45-19.15	01.45-02.15
7	Exit point of private vehicles	08.30-09.00	14.30-15.00	19.30-20.00	02.30-03.00
8	Intercity bus departure	09.15-09.45	15.15-15.45	20.15-20.45	03.15-03.45

Sampling and measurement methods were referred to [2]. Instruments used for measurement in the field are high volume sampler (HVS) equipped with the filter paper; hygro thermo anemometer to measure a wind velocity, air temperature and air humidity; barometer to measure atmospheric pressure; and counter to count numbers and types of motorized vehicles. The results of the measurement were treated by Winsurf software to map the particulate dispersion patterns.

RESULTS AND DISCUSSION

Iso-concentration of PM_{10}

The Purabaya bus station consists of many sections, some of which are areas for the intercity bus arrival, public vehicles, bus parking, queuing bus, intercity bus departure, city bus departure, private vehicle parking, waiting room, offices and others. All areas in the bus station have different functions as they are made for intended purposes. Furthermore, the Purabaya bus station having A class is required to serve all types of public vehicles and passengers from almost all provinces in Indonesia. Thus, many activities resulting from the motorized vehicles in the bus station apparently contribute to the particulate concentration level. On the basis of measurement results processed using Winsurf software, the map of particulate iso-concentration on the Monday morning (06.00 –12.00) representing a maximum or peak particulate concentration is provided in Fig 1.

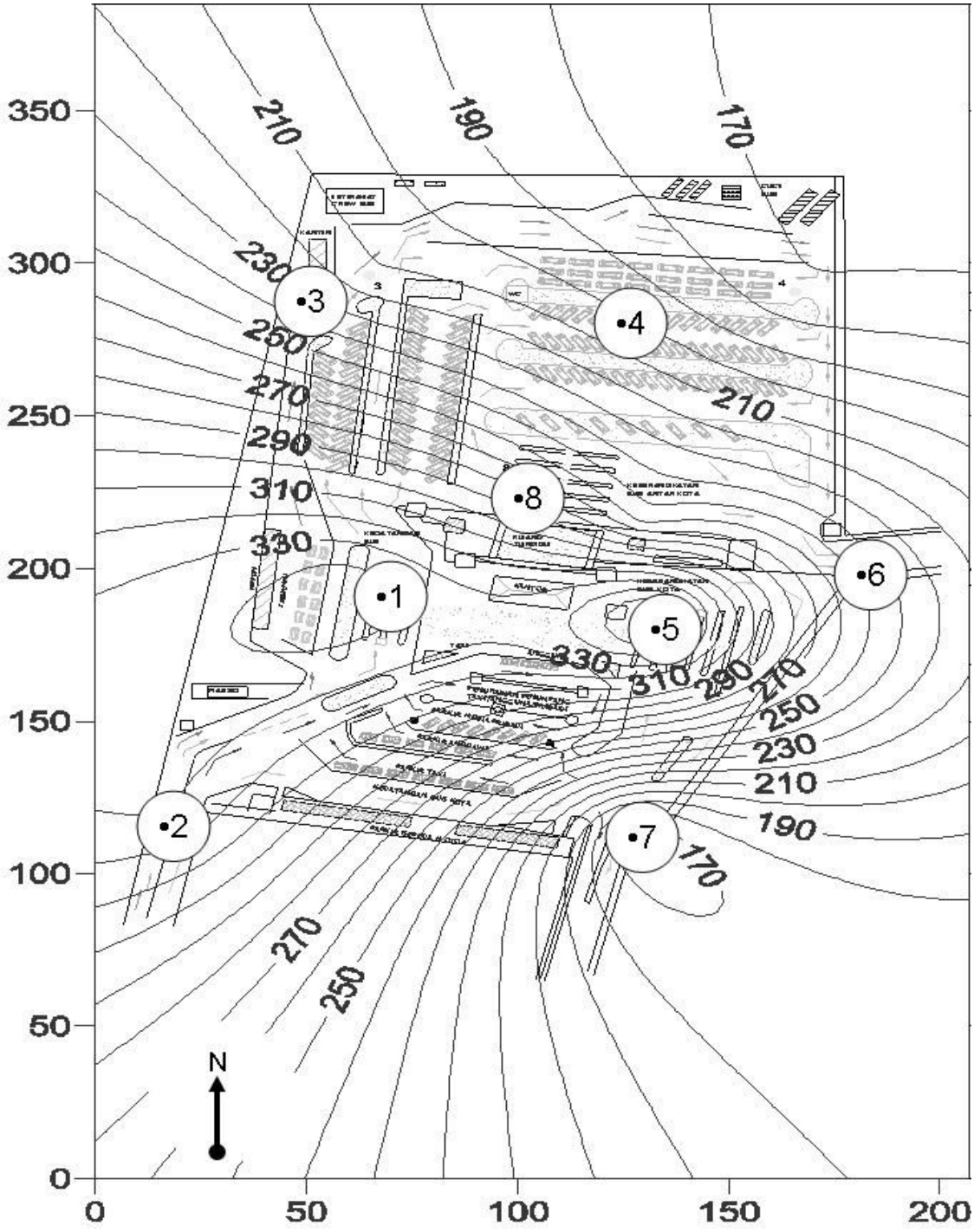

Fig. 1: The map of particulate iso-concentration

It appears that all sampling points have particulate concentration levels exceeding the ambient air quality standard (higher than 150 μgm^{-3}) as established in the Government Regulation of Republic of Indonesia No. 41/1999 [3]. The maximum particulate concentration levels occur within the city bus departure at 373 μgm^{-3}. The high concentration results from the

departing activity of 32 city buses. In other locations, for example, the entry point of the Purabaya bus station has particulate concentration level of 330 μgm^{-3} which is still lower in comparison to the city bus departure paths, but there are 543 six type-motorized vehicles as recorded passing through such a location.

It appears obviously that points 1, 2, 5, and 8, representing arrival and departure areas which directly interact with passengers have the high concentration levels of 290 - 320 μgm^{-3}. In those departure areas, there is a sharp increase in particulate concentration up to 370 μgm^{-3} for city bus paths and 300 μgm^{-3} for intercity bus paths. The main sources of pollution are the smokes emitted by buses waiting for the passengers and busses in the idle condition (the engine is on but doesn't move anywhere). The results were conformed with the work of [4] in USA that the high particulate concentrations were present in the waiting room made passengers suffer from any adverse effects contributing to their health risk.

Number of motorized vehicles and PM_{10}

On Monday morning the particulate concentration was found to be the highest (Table 2). This might be the case since on Monday morning there is a sharp increase in number of passengers coming from some other cities and begin to undertake their routine activities again after the holiday.

Table 2: Number of motorized vehicles and PM_{10}

Sampling points		Bus	Small public vehicles	Taxi	Private vehicles	Two-wheel vehicles	Number of vehicles	PM_{10} μgm^{-3}
1	Intercity bus arrival	55	-	-	-	-	55	348
2	Entry point of bus station	98	89	47	68	241	543	330
3	Exit point of public vehicles	-	49	-	-	-	49	212
4	Intercity bus parking	46	36	-	-	-	82	172
5	City bus departure	32	-	-	-	-	32	373
6	Exit point of bus station	74	52	-	-	125	251	240
7	Exit point of private vehicles	33	-	73	58	215	379	161
8	Intercity bus departure	69	-	-	-	-	69	255

It appears that the particulate concentration is the highest in city bus departure and the minimum particulate concentration was found in exit point of private vehicles. The results were shown no correlation between vehicle numbers as well as the vehicle type and particulate matter

concentration. To examine the results the measurement of wind direction and velocity was very useful to know atmospheric condition.

The velocity and the direction of the winds, the turbulence and the atmospheric stability are important meteorological phenomena for the dispersion of the atmospheric pollutants in a local scale [5]. In the research, the wind direction was estimated based on the primary data collected through observation at the bus station and the data of wind direction and velocity published by Agency of Meteorology and Geophysics (BMG) Juanda Surabaya which is next to the observation site. The wind direction and velocity were measured hourly for twenty-four hours adjusted to the time of particulate concentration measurement carried out in May 2006. The wind velocity was in the range of 5 to 9 knots and wind direction was in the range of 70 and 110 degree. By comparing the wind direction and velocity, it was shown that the direction and velocity did not strongly influence the particulate dispersion pattern at the bus station.

CONCLUSIONS

The current research revealed the density of one motorized vehicle per 15 sq-m would result in particulate matter concentration of at least 160 μgm^{-3}. Concentration variability was not correlated to the number of motorized vehicles and was not influenced by wind direction and velocity. Therefore, further study is needed to identify the primary cause of high concentration of particulate matter instead of the mentioned vehicle and wind parameters.

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